Cheshire West & Chester Council

Climate Emergency Strategy Support

November 2019

Anthesis

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Introduction & Context

Introduction

This work is being commissioned by the Officer Working Group at Cheshire West and Chester Council (CW&CC).

Aim

The aim of this body of work is to provide an evidence base to inform the Council's planning in response to the Climate Emergency Declaration (21st May 2019), with particular reference to the following aspects of the resolution:

- Determine the earliest date before 2045 that CW&CC and the borough as a whole can be carbon neutral;
- revise its targets to meet that date, ideally to 2030, to demonstrate leadership in the borough; and
- aid the cross-party Taskforce established in response to the Declaration in understanding the implications and new opportunities presented by climate change.

The resolution also commits CW&CC to bringing a report to present to at a Climate Summit. This public event plans to announce the initial response to the Climate Emergency Declaration, as well as present findings from the first meetings of the Taskforce and an Advisory Panel made up of industry experts. A longer term action plan will subsequently be developed throughout 2020, with implementation currently scheduled for early 2021.

Objectives

To better understand:

- The borough's carbon footprint using a location-based accounting approach;
- use this information to determine the proportion of emissions that can be influenced locally without the action of regional or national actors;
- potential pathways and options required to better align activities with the aim of carbon neutrality as early as possible before 2045, distinguishing between local, regional and national action where possible; and
- gaps in data where further work is needed.

To aid CW&CC in the following areas:

- Providing a more informed basis for future action plan development which also serves to inform and direct existing local projects; and
- encourage confidence in the mandate for climate action, thus facilitating the establishment of a robust governance structure which can deliver objectives over a long term cycle.

Introduction & Context

Context

Local and National Policy Drivers

Tackling the climate crisis is a long-standing issue in the UK, reflected in the legally binding target in the 2008 Climate Change Act:

"It is the duty of the Secretary of State to ensure that the net UK carbon account for the year 2050 is at least 80% lower than the 1990 baseline."

In May 2019, CW&C Council passed a Climate Emergency resolution, calling for the determination of the earliest date before 2045 that the borough can be carbon neutral, and to revise its targets to meet that date. CW&C Council also established a six-month timeline to formulate a response to the Declaration.

Evidence of Need

The full council resolution came about as a response to the Intergovernmental Panel on Climate Change (IPCC) special report on the impacts of global warming of 1.5 °C above pre-industrial levels, issued in October 2018. The report stated that in order to remain within a 1.5 °C increase, governments would have to cut emissions of greenhouse gases by 45% by 2030.

The UN Environment Programme then published their 2018 Emissions Gap Report, which found that the Nationally Determined Contributions were insufficient to ensure that global temperature rises stays below 1.5°C, and that nations must triple their efforts in order to meet even a 2°C target. It also found that global emissions had increased in 2017 after 3 years of stagnation.

A key finding of the report is that: '…non-state and subnational action plays an important role in delivering national pledges. Emission reduction potential from non-state and subnational action could ultimately be significant, allowing countries to raise ambition.'

Research by the Global Carbon Project issued in December 2018 reported that global carbon emissions are on course to rise by a further 2.7% in 2018, an increase on the rise seen in 2017.

The above evidence makes clear that immediate and drastic action is required to avoid global warming to dangerous levels, whilst encouraging sub-national policy measures and action as a necessary means of reducing emissions.

References

- Council motion to declare a Climate Emergency
- IPCC 1.5 Report
- Emissions Gap Report
- Global Carbon Project research

1. Current Emissions Profile

1. Current Emissions Profile
Summary

The figures and charts presented below summarise the emissions relating to area administered by Cheshire West & Chester (CW&C). There are two methods used for this estimation; one uses the Anthesis' SCATTER tool, the other uses BEIS Local Authority Emissions data. The differences between the two are explored on page 8 (see Appendix 1 for full data tables).

Figure 1: SCATTER sector inventory for direct and indirect emissions within CW&C excluding agriculture, forestry and land use

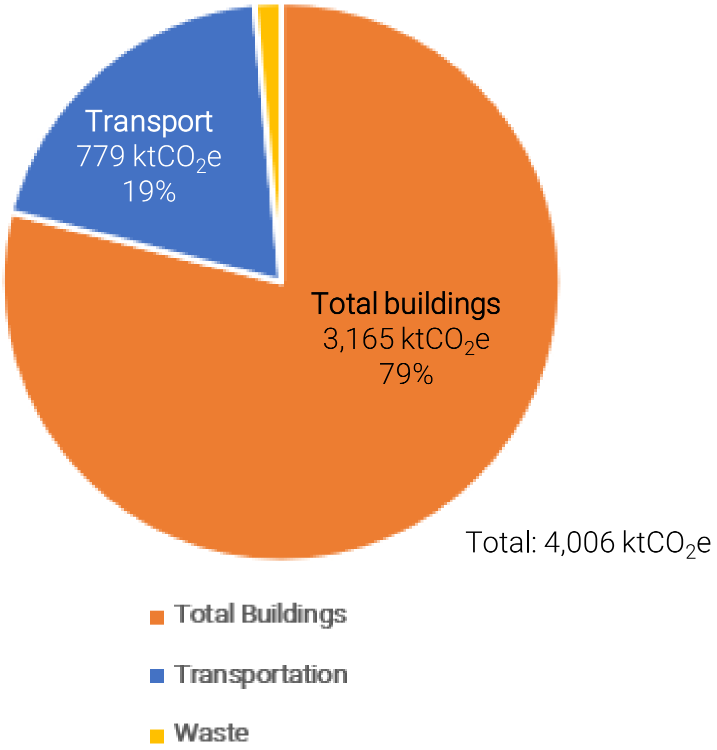


Figure 2: SCATTER sub-sector inventory for direct and indirect emissions within CW&C excluding agriculture, forestry and land use

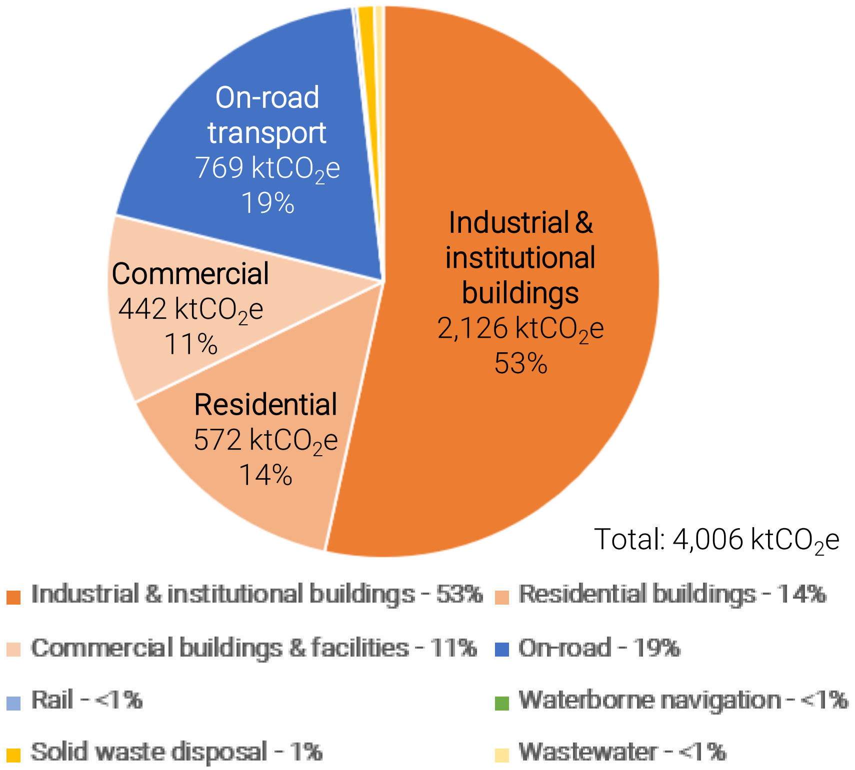
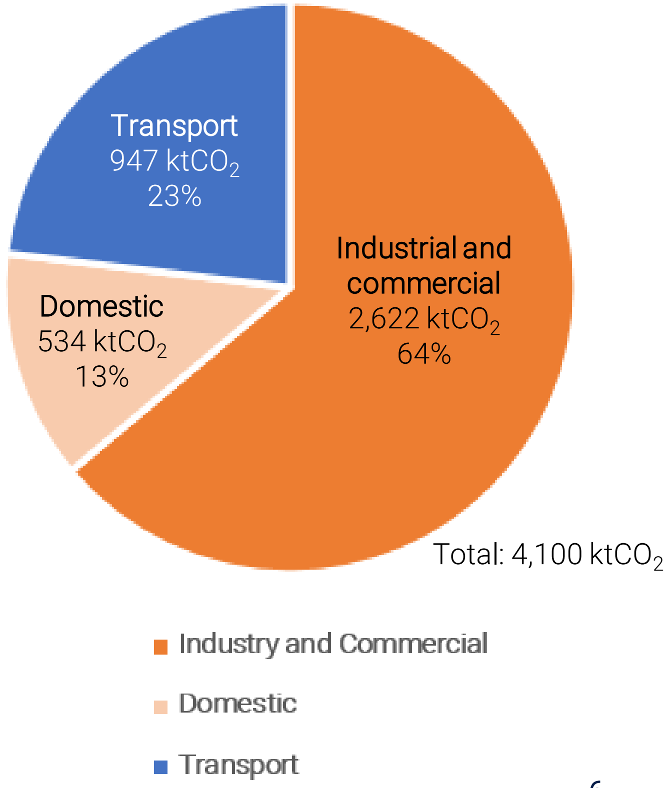


Figure 3: BEIS sector inventory for direct and indirect emissions within CW&C including land use, land use change and forestry, 2017



1. Current Emissions Profile

CW&C Industrial Sector Focus

Emissions from industry are significant: The majority of CW&C's emissions result from industrial and institutional stationary energy. This group includes those in-boundary emissions arising from the region's industrial corridor situated to the north of Chester.

The oil refinery is the largest individual emitter: To better understand the heaviest impacts of the industrial corridor we estimated the in-boundary emissions of the Stanlow Oil Refinery in Ellesmere Port, as this is assumed to be the single largest industrial emitter. We did not seek to test this assumption, or to define or assess the contribution of other large emitters in the region, however we acknowledge that there may be other significant ones.

The largest refinery emissions impacts occur outside of the CW&C boundary: This estimation does not assess the emissions potential of the petroleum products manufactured and subsequently exported from Stanlow, since the overwhelming majority of those products are consumed out of the CW&C boundary. Instead, we have estimated emissions resulting from processes that occur at the plant itself during the refining process. To do this a representative refinery of equivalent size to Stanlow[1] was modelled with an annual total consumption equivalent to 12 million barrels of crude oil a year.[2,3]

This methodology suggests that the Stanlow Oil Refinery was responsible for approximately 20% of the district's total emissions in 2017, or around half (51%) of the emissions resulting from Large Industrial Installations:

	In-boundary emissions ($ktCO_2e$)	% of district total
Stanlow Refinery estimate	807	20%
Large Industrial Installations (BEIS)	1,598	39%

Table 1: Refinery and large industrial installation emissions relative to the district total.

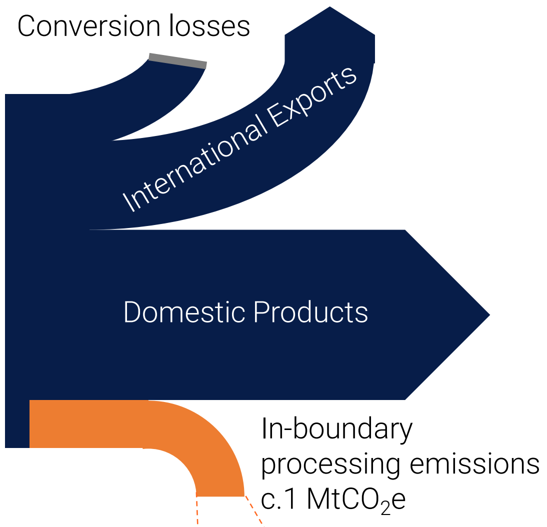


Figure 4: Stanlow's consumption can be broken down into various groupings. Only the in-boundary processing emissions have been estimated in the given figure. Diagram is illustrative only and is not to scale.

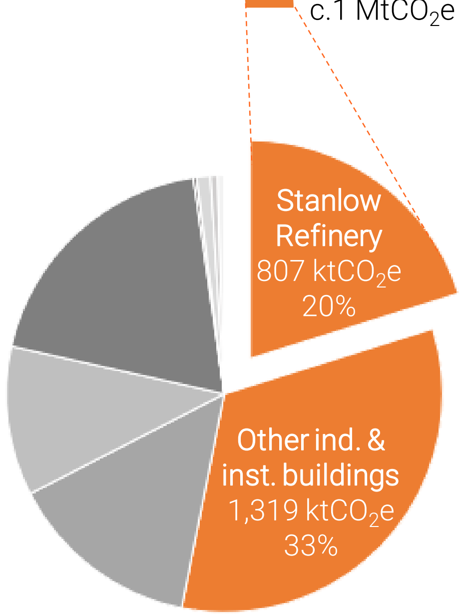


Figure 5: After scaling national processing emissions to a refinery with equivalent consumption as Stanlow, the resultant emissions are equivalent to 807 $ktCO_2e$, which is around 20% of the region's total emissions profile. This chart (right) shows this as a proportion of the SCATTER subsectors from 2017.

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1 – the refinery processing capacity as at end 2017 was taken from DUKES data.
2 – this was converted into a $MtCO_2e$ figure by using EPA conversion figures.
3 – for a full methodology please see Appendix 2.

1. Current Emissions Profile

Frequently Asked Questions

What do the different emissions categories mean within the SCATTER Inventory?

Direct = GHG emissions from sources located within the local authority boundary (also referred to as Scope 1). For example petrol, diesel or natural gas.

Indirect = GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the local authority boundary (also referred to as Scope 2).

Other = All other GHG emissions that occur outside the local authority boundary as a result of activities taking place within the boundary (also referred to as Scope 3). This category is not complete and only shows sub-categories required for CDP / Global Covenant of Mayors reporting.

The BEIS Local Emissions Summary does not differentiate between direct/indirect/other (or the various 'scopes').

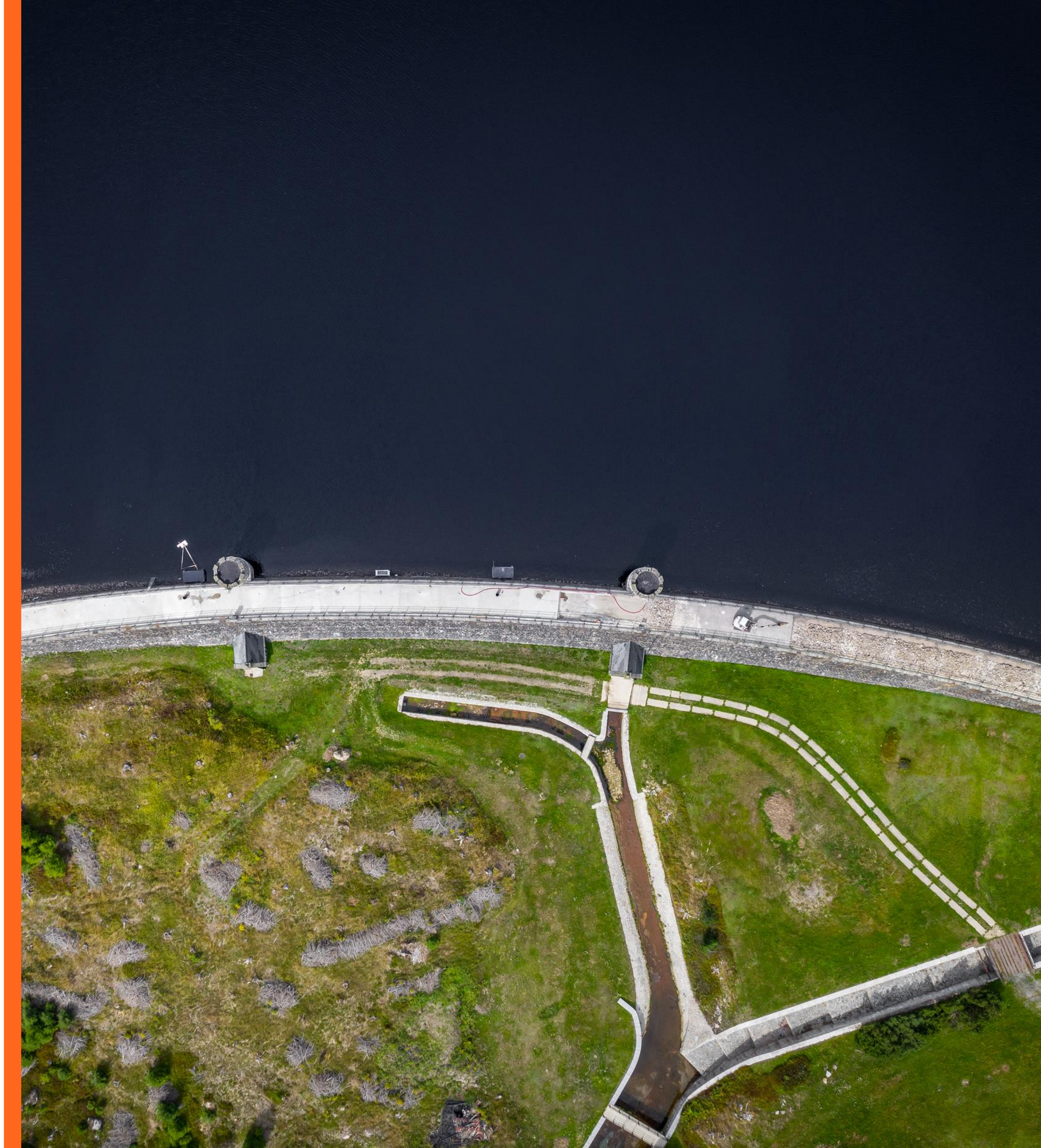
What do the different sectors and subsectors represent within the SCATTER Inventory?

- The Direct Emissions Summary and Subsector categories are aligned to the the World Resource Institute's Global Protocol for Community-Scale Greenhouse Gas Emission Inventories ("GPC"), as accepted by CDP and the Global Covenant of Mayors.
- The BEIS Local Emissions Summary represents Local Authority level data published annually by the Department for Business Energy & Industrial Strategy (BEIS).
- Stationary energy includes emissions associated with industrial buildings and facilities (e.g. gas & electricity).
- IPPU specifically relates to emissions that arise from production of products within the following industries: Iron and steel, Non-ferrous metals, Mineral products, Chemicals. These are derived from DUKES data (1.1-1.3 & 5.1).
- Waterborne Navigation and Aviation relate to trips that occur within the region. The figures are derived based on national data (Civil Aviation Authority & Department for Transport) and scaled to the Cheshire West & Chester borough.
- The full methodology available on request at http://SCATTERcities.com.

Why does the BEIS summary differ from the SCATTER summary?

- The BEIS summary **represents CO_2 only**; SCATTER also includes emissions factors for other greenhouse gases such as Nitrous Oxide (N_20) and Methane (CH_4). These are reported as a CO_2 'equivalents (e)'.
- The BEIS summary **does not provide scope split**; SCATTER reports emissions by scope 1, 2, and 3 (i.e. direct, indirect or other categories).
- **The BEIS summary categories are not directly consistent or mapped to the BEIS LA fuel data** which is available as a separate data set. SCATTER uses published fuel data and applies current-year emissions factors, whereas the BEIS data calculations scale down national emissions in each transport area. Specifically with regard to road transport, BEIS data splits total emissions across road type; SCATTER uses fuel consumption for on-road transport per LA.
- **Different treatment of 'rural' emissions** i.e. Agriculture, Forestry and Other Land Use (AFOLU) and Land Use, Land Use Change & Forestry (LULUCF) categories are derived from different underlying data sets and have been explored further within Section 5 of this report.

2. District Energy System Pathways



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2. District Energy System Pathways

Summary

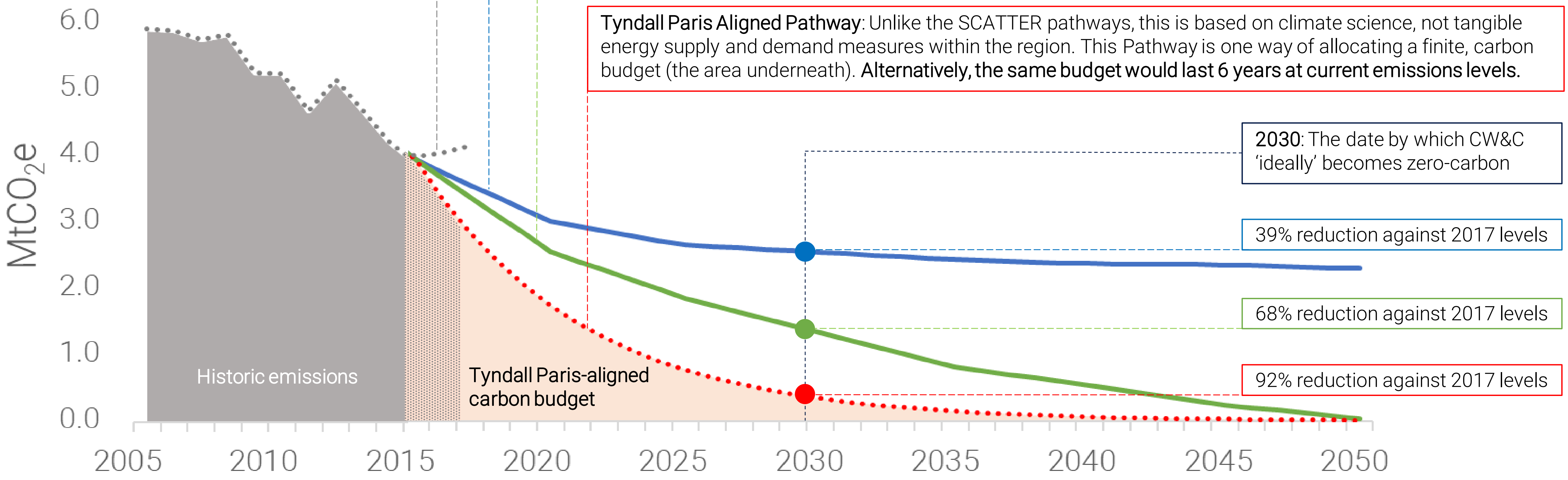
Figure 6: CW&C Carbon Budget and Pathways for the District-Wide Energy System, annotated. See Appendix 3 for a comparison with similar local authorities.

BEIS/SCATTER Overlap: The SCATTER model base year is 2015[1]. More recent data has since been published by BEIS (grey dotted line), enabling early comparison (shaded region). **Emissions have increased in the CW&C district since 2015.**

SCATTER Level 1: Assumes minimal action beyond current, national policy (where sufficiently defined by sector or measure) and nationally led decarbonisation of the electricity grid. This will still require a significant level of effort locally.

SCATTER Level 4: Assumes that the region goes significantly beyond national policy and national grid decarbonisation, across both energy supply and energy demand measures.

Tyndall Paris Aligned Pathway: Unlike the SCATTER pathways, this is based on climate science, not tangible energy supply and demand measures within the region. This Pathway is one way of allocating a finite, carbon budget (the area underneath). **Alternatively, the same budget would last 6 years at current emissions levels.**

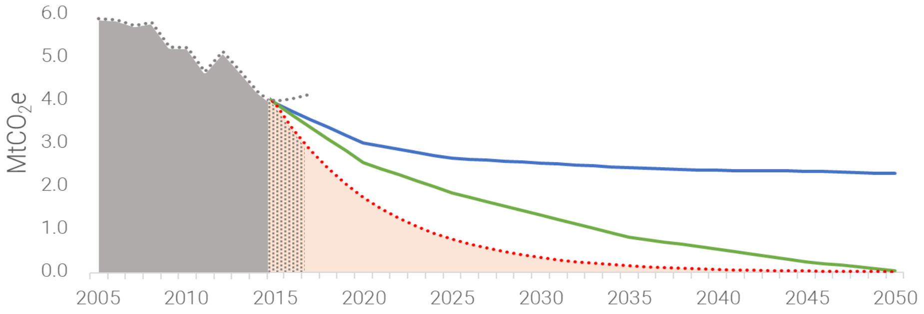


1 – Local Authority emissions & energy consumption data is published 2 years in arrears. SCATTER Tool operates from 2015 base year, with adjustments made using 2016 & 2017 BEIS Local Authority Emissions data. SCATTER projections are also scaled – see Appendix 4.

2. District Energy System Pathways

SCATTER Model

Figure 7: CW&C Carbon Budget and Pathways for the district-wide energy system



SCATTER "Level 1' Pathway – Assumes the selected region doesn't take much action beyond current, national policy and nationally led decarbonisation of the electricity grid.[1]

SCATTER "Level 4" Pathway – Assumes the selected region goes significantly beyond national policy and National Grid assumptions, across both energy supply and demand measures. Many assumptions aligned with the legacy DECC 2050 Pathways calculator 'Level 4'. See Appendix 5 for further details.

Tyndall Paris Aligned Budget – The finite, cumulative amount that the region should emit between now and 2050, based on research performed by the Tyndall Centre for Climate Change Research.[2]

Tyndall Paris Aligned Pathway – The yearly totals that must reduce 13% on average each year to keep within the budget. Note: Unlike the SCATTER Pathways, this does not specify what tangible measures could achieve this pathway, rather, it sets out what science (IPCC[3]) indicates we need to aim for.

Historic Pathway – Previous emissions totals as reported within the BEIS Local Authority Emissions data sets.[4]

This graph shows two possible future emissions pathways over time, as modelled by the SCATTER pathways tool. This tool focuses on energy system (fossil fuel consumption) emissions reductions within the CW&C borough. The pathways do not represent reductions outside of the CW&C district boundary (i.e. consumption based emissions) or emissions from Land and Agriculture (Section 5).

Both Pathways can be compared against the Tyndall Centre for Climate Change Research's Paris Aligned Budget. This is derived from climate science[3] and applies a method for scaling down global carbon emissions budgets that are 'likely' to keep temperature change "well below 2°C and pursuing 1.5°C", to local authority regions. Unlike the SCATTER pathways, this is based on climate science, not tangible energy supply and demand measures in region. The cumulative nature of CO_2 reinforces the need for to take a 'budget' approach, where any annual shortfalls accumulate over time. This Pathway is just one way of allocating a finite, carbon budget (the area underneath the curve). Alternatively, the same budget would last only 6 years if emissions remain at current levels. This highlights the need for urgent action **now**.

Gaps exists between the SCATTER Level 4 Pathway and the Tyndall Paris Aligned Pathway / zero carbon axis is because modelling assumptions are based on present day evidence & judgment. Such assumptions are not intended to constrain the future ambition to close the gap.

What do 'Carbon Neutral' and 'Net Zero' mean?

'Carbon neutral' or 'net zero' typically mean the same thing: That some carbon/GHG emissions remain but are then 'netted off' or off-set through carbon dioxide removal. Such removal may occur due to Negative Emissions Technologies (NETs) such as biomass energy with carbon capture and storage, or, natural sequestration via means such as afforestation. The UK's Net Zero target includes all GHGs (not just those from within the energy system).

CW&C therefore needs define the nature and extent of 'offsetting' that is feasible within the Local Authority boundary during the course of this study.

See also, a recent blog by the Tyndall Centre for Climate Change Research on the various related terms that may often get confused or used interchangeably with 'Carbon Neutrality'.

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1 – This trajectory tracks the National Grid Future Energy Scenario (FES) "2 Degrees", 2017

2 – This is based on information not yet publicly available. Method broadly comparable with work performed for the Greater Manchester Combined Authority and the City of Manchester. Contact c.w.jones@tyndall.ac.uk for further information.

3 – Intergovernmental Panel on Climate Change, 1.5°C Special Report, 2018

4 – Data is published 2 years in arrears.

2. District Energy System Pathways

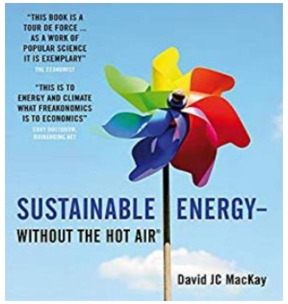
About the SCATTER model

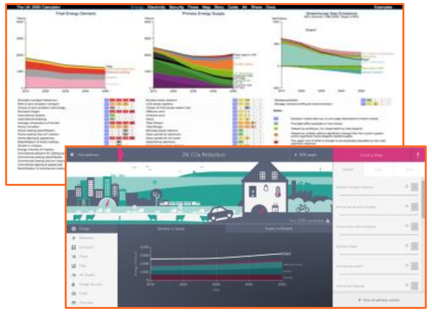
SCATTER is intended to serve as one of many information sources to help users inform their priorities for emissions reduction. Specifically with reference to the forward looking pathways modelling element, it is intended to focus on the 'what' rather than the 'how'. It is important to note that SCATTER does not intend to prescribe certain technologies or policies, and similarly does not intend to discount other methods of arriving at the same outcome, just because they do not feature in the model. The SCATTER pathways serve as 'lines in the sand', and give users an indication of whether they are likely to be on-target or off-target for a carbon neutral trajectory through the adoption of interventions to drive the transition to a low carbon economy.

Naturally, technologies, assumptions and approaches to energy models are evolving all the time, and we would welcome the opportunity to receive feedback and/or collaborate on refinements of SCATTER in the future. Please share any feedback with scatter@anthesisgroup.com.

Basic principles

Sir David MacKay's 'Sustainable Energy - Without Hot Air (2009)" underpins the basis for the pathways modelling. As a scientific advisor to the Department for Energy & Climate Change (DECC), now BEIS, MacKay's work led to the development of the 2050 Pathways calculator. An open source, Microsoft Excel version of this tool was published by DECC which we used as the foundation for SCATTER.





Two key modifications were made by Anthesis:

1) We scaled it down for sub-national regions: Scaling assumptions and localised data sets were built into the tool so that results were representative of cities and local authority regions, rather than the UK as a whole.

2) We pushed ambition further: Technology specifications changes were reviewed and updated where judged to be out of date and constraining ambition. Given that almost a decade had passed since MacKay's publication and the release of the 2050 Pathways tool, we sought the counsel of a technical panel to make these updates. The technical panel comprised subject matter experts from Arup, BEIS, Electricity North West, GMCA, The Business Growth Hub, The Energy Systems Catapult, The Tyndall Centre and Siemens. We also referenced the 2050 Wiki page during the course of the update.

Many other sector specific aspects of modelling treatment and assumptions have required consideration and interpretation as we have applied the model to various cities and local authorities.

2. District Energy System Pathways

Supply & Demand

The energy system has two main components; energy supply, and energy demand. In this report, the term 'energy system' relates to energy in the form of solid, liquid and gaseous energy that is used to provide fuel, heat and electricity across buildings, transport and industrial sectors. Energy must be supplied to each of these sectors, in order to meet the demand for energy that the sectors require. Demand drives the amount of supply we need, and actors such as businesses, residents and public services all play a part in contributing to this demand.

Future demand is hard to predict. Recently published analysis within the National Grid's Future Energy Scenarios (FES) 2019 indicates that even under a scenario that meets the UK's net zero by 2050 (Two Degrees), electricity demand still increases. SCATTER's L4 Pathway on the other hand (consistent with the legacy 2050 Pathways tool), assumes that electricity demand still reduces overall. Factors such as increased electrification of heat and transport are naturally big drivers for the increase, but incentives and opportunities for demand reduction and energy efficiency measures are still significant, and could slow or tip trends in the other direction.

Reducing demand should always come first.

Economically, this usually makes sense, whether at an individual, organizational or district level. For example, energy bills can reduce and at a district level, costs associated with installing new generation assets, new grid connections and grid reinforcement works and be minimised.

Socially, there are benefits if citizens can be better off if they shift to healthier forms of transport just as walking & cycling, or increase efficiency of journeys by car sharing.

Table 2: FES & SCATTER Demand side assumptions at 2030 and 2050.

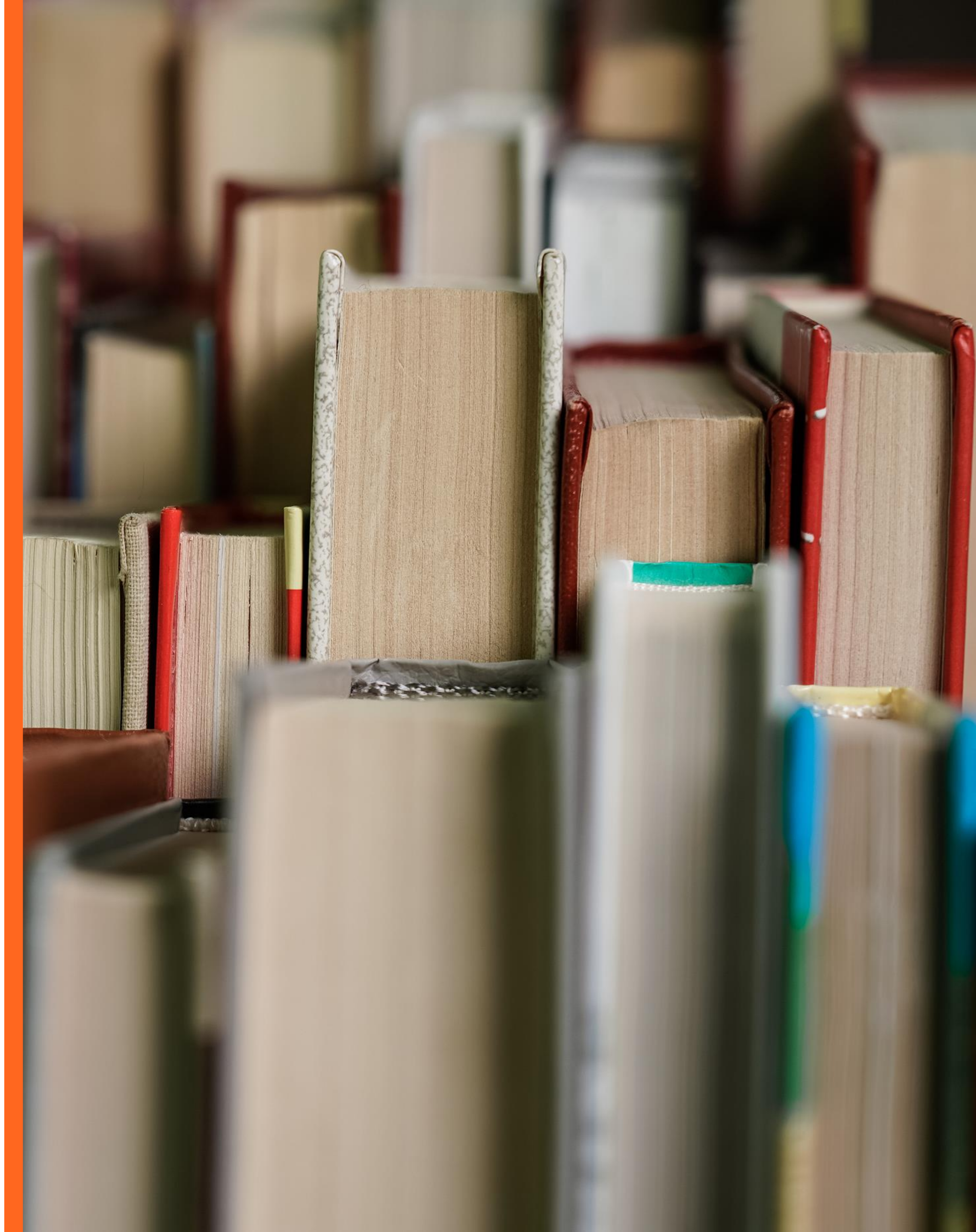
Source	Change in current[1] demand	
	2030	2050
FES Two Degrees (2019)	▲ 5%	▲ 48%
SCATTER Level 4 (L4) Pathway	▼ -43%	▼ -57%

Environmentally, emissions savings can often be achieved much quicker by implementing various demand side behaviour changes or 'quick win' efficiency measures. This can help safeguard carbon budgets and avoid placing too much reliance on slower, riskier, renewable supply infrastructure to deliver the emissions savings so critically required.

The potential for demand reduction is still huge. The International Energy Agency (IEA) estimated that efficiency measures (i.e. demand side reduction), could contribute 40% towards our emissions targets[2].

1 - FES: 2018, SCATTER: 2017 levels, electricity demand only.
2 – International Energy Agency, Energy Technology Perspectives, 2017

3. Energy System Interventions



3. Energy System Interventions

Domestic Buildings

The following tables provide proxies for the nature and extent of CW&C-specific measures. These are all assumed in order to track the green SCATTER level 4 (L4) pathway as shown on page 10:

Measure	Current CW&C Context	SCATTER L4 Pathway		
		2025	2030	2050
Improved insulation	9,122 households in receipt of ECO measures (c. 6% of households) between 2013 and March 2019[1] 11.3% fuel poverty rate (c. 16,500 households)in 2016[2] 69% of homes are EPC rated D or below[3] 233 Watts/°C average heat loss per house (Referred to in the legacy 2050 Pathways tool as **thermal leakiness.** See definition opposite)	Solid wall insulation at a rate of 1,087 households a year[4] Loft insulation at a rate of 2,500 households a year Superglazing installed at a rate of 2,345 households a year New builds to PassivHaus or equivalent standard 183 Watts/°C average heat loss per house (21% reduction in thermal leakiness)	Solid wall insulation at a rate of 1,034 households a year[4] Loft insulation at a rate of 2,413 households a year Superglazing installed at a rate of 2,259 households a year New builds to PassivHaus or equivalent standard 158 Watts/°C average heat loss per house (32% reduction)	By 2050, retrofit measures have been applied to the vast majority of homes[4] New builds to PassivHaus or equivalent standard 58 Watts/°C average heat loss per house (75% reduction)
Reduction of average temperature[5]	Current average temperatures are approximately 17.3°C[6]	16.8°C	16.7°C	16.0°C

What is 'thermal leakiness'?

Thermal leakiness is a measure of how well a house **retains heat**. A house with high thermal leakiness will not retain heat very easily and will be more expensive to keep warm. Thermal leakiness varies across the ambition thresholds within SCATTER and depends on three variables, all of which will impact the Watts/°C metric:

1) Thermal conductivity of the building fabric (i.e. .'U-values' of ceilings, floors, walls and windows).
2) Ventilation (i.e. effectiveness of draught-proofing).
3) Temperature difference with the outside (i.e. the average temperature of the home based on the occupant's preference or use of smart thermostats).

Examples of good practice:

Exeter's Zero Energy Building Catalyst is supporting 80 enterprises in Devon to engage with new models of retrofit.

South West England Ready for Retrofit report assessed local barriers and enablers in order to stimulate long term growth in the retrofit market.

1 - See https://www.gov.uk/government/statistics/household-energy-efficiency-statistics-headline-release-september-2019
2 -https://www.cheshirewestandchester.gov.uk/documents/energy/home-energy/heca-report-2019.pdf
3 - https://www.gov.uk/government/statistical-data-sets/live-tables-on-energy-performance-of-buildings-certificates#epcs-for-existing-domestic-properties
4 – For a full list of retrofit measures see Appendix 6 for a list of EPC ratings see Appendix 7
5 - Reductions may be achieved through better heating controls (i.e. 'Smart thermostats') that zone the heat, as opposed to reducing comfort
6 - ECUK (2017) Table 3.16: Internal and external temperatures 1970 to 2012

3. Energy System Interventions

Domestic Buildings

Measure	Current CW&C Context	SCATTER L4 Pathway		
		2025	2030	2050
Decarbonisation of heat	c. 139,200 homes (96%) have gas systems installed, with a median consumption of 11,792 kWh p.a.[1,2] Gas boilers will be banned in **new** homes from 2025. Renewable Heat Incentive (RHI) has accredited 76 domestic applications for renewable heat systems within CW&C since 2011[3] See Appendix 8 for further detail on the type of heating technologies assumed within SCATTER	29% of all homes (c. 43,400) have new heating systems installed Majority of heating is still gas boilers (both old and new), with some heat pumps (14%) and CHP (1%)	43% of all homes (c. 65,300) have new heating systems installed Majority of heating is gas boilers. Share of heat pumps is 26% (CHP 1%)	93% of all homes (c.144,000) have new heating systems installed Majority of heating is delivered by heat pumps (77%) with gas boilers only responsible for 12% (CHP 3%)
Appliance & lighting efficiency	Consumption by domestic lighting decreased 7% between 2015 and 2018[4] National average demand per household is 2.59 MWh	Average appliance and lighting demand per household is 2.42 MWh	Average appliance and lighting demand per household is 2.12 MWh	Average appliance and lighting demand per household is 0.93 MWh
Electrification of cooking	47% electrified[5]	69% electrified	76% electrified	100% electrified

Examples of good practice:

Camden's Passivhaus project is the largest residential new-build project for Passivhaus standard properties.

Yorkshire's Zero Carbon cross-sector working group promotes zero carbon domestic buildings which underpins strategic planning policy.

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1 - https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/789771/Postcode-level-gas-2017.csv/preview
2 - Assuming 1 meter per household and 145,000 households in CW&C (from SCATTER projections)
3 - https://www.gov.uk/government/statistics/rhi-monthly-deployment-data-may-2019
4 - https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/820753/2019_Electrical_Products_Tables.xlsx
5 - based on legacy SCATTER assumptions

3. Energy System Interventions

Non-Domestic Buildings

Measure	Current CW&C Context	SCATTER L4 Pathway		
		2025	2030	2050
Commercial space heating & cooling	62% of commercial 'lodgements' have an EPC rating of D or lower[1]	16% reduction in demand against 2015 level	24% reduction in demand against 2015 level	100% reduction in demand against 2015 level
Electrification of heat	89% gas and oil-fired boilers (2015)[2] See Appendix 9 for further detail on the type of heating technologies assumed	57% gas and oil-fired boiler	46% gas and oil-fired boiler	0% gas and oil-fired boiler
Appliances & lighting	Consumption by non-domestic lighting, computers and commercial motors fell 1.7% between 2015 and 2018 Total non-domestic consumption in 2017 was 1.63 TWh	Total commercial lighting and appliance demand is 0.59 TWh	Total commercial lighting and appliance demand is 0.57 TWh	Total commercial lighting and appliance demand is 0.48 TWh
Energy used for cooking	24% electrified	46% electrified	57% electrified	100% electrified

Examples of good practice:

Bedfordshire's sustainable warehouse was accredited in 2019 as the most sustainable building of its kind in the UK.

Keynsham Civic Centre aims to be one of the lowest energy-consuming public buildings in the UK, incorporating EPC A rated measures into the design process.

1 – See Appendix 7; a 'lodgement' is assumed to represent the same unit as 'household' (for domestic buildings) and allows comparison between the two different sector's properties.
2 - BEIS Total sub-national final energy consumption, 2015, Total Domestic Fuel - Allocated according to ECUK proportions
3 - https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/820753/2019_Electrical_Products_Tables.xlsx

3. Energy System Interventions

Transport

Measure	Current CW&C Context	SCATTER L4 Pathway		
		2025	2030	2050
Distance reduction	74% of employed residents travel to work by car, with c. 15% of residents commuting out of the CW&C region[1]	Travel demand drops 17% relative to today 25% reduction in passenger miles travelled by car	Travel demand drops 25% relative to today 27% reduction in passenger miles travelled by car	Travel demand drops 25% relative to today 38% reduction in passenger miles travelled by car
Significant modal shifts	Within the Chester urban area, <10% of journeys to work were undertaken on public transport, 21% of journeys to work were on foot or by bicycle[1] 40% of households own >1 car[2] CW&C committed to exploring the feasibility of Clean Air Zones and anti-idling measures in a 2018 Low Emission Strategy but no policy measures have been announced[3]	6% reduction in the share of car transport from 2015 levels Modal share of public transport (rail & bus) is 18%	10% reduction in the share of car transport from 2015 levels Modal share of public transport (rail & bus) is 20%	22% reduction in the share of car transport from 2015 levels Modal share of public transport (rail & bus) is 29%
Modal shift of freight and increase in efficiency	71% of freight emissions in the UK are from road[4]	Road freight is 99% diesel[5]	Road freight is 98% diesel	Road freight is 93% diesel

Examples of good practice:

Bath's BreATHe project will roll out levies for higher emission vehicles within Bath city centre.

London's Mayoral Transport Strategy outlines plans for modal shifts.

Manchester's Beelines proposal to offer significant improvements to cycling infrastructure across different parts of the city

Refer to Appendix 9 for further information on assumptions on other modes of transport.

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1 – https://www.cheshirewestandchester.gov.uk/documents/parking-roads-and-travel/public-transport/transport-strategies/phase-one-reports/chester-transport-strategy-baseline-report-0913.pdf
2 - https://www.cheshirewestandchester.gov.uk/residents/transport-and-roads/public-transport/transport-strategy/transport-strategy.aspx
3 - https://www.cheshirewestandchester.gov.uk/documents/pests-pollution-food-safety/pollution-and-air-quality/low-emission-strategy-180219.pdf
4 - Department for Transport Statistics - Table TRA3105 Heavy goods vehicle traffic by axle configuration and road category in Great Britain, 2015
5 – SCATTER assumptions in this area do not include hydrogen as freight fuel and are left unmodified from the legacy DECC 2050 Pathways calculator

3. Energy System Interventions

Transport

Transport Glossary
EV - Electric Vehicle
PHEV - Plug-in Hybrid Electric Vehicle
HEV – Hybrid Electric Vehicle

Measure	Current CW&C Context	SCATTER L4 Pathway		
		2025	2030	2050
Shift to zero carbon cars	Plans to improve the public EV charging infrastructure have been outlined in the Low Emissions Strategy	51% EV, 13% PHEV, 36% petrol/diesel	75% EV, 14% PHEV, 11% petrol/diesel	100% EV
Shift to zero carbon buses	Plans to lobby private bus service providers and audit existing bus stock have been outlined in the Low Emissions Strategy	51% EV, 37% PHEV/HEV, 12% petrol/diesel	76% EV, 24% PHEV/HEV	100% EV
Rail electrification	GrowthTrack360 campaign is seeking £1bn in investments for a range of projects across the North-West and North Wales, including rail electrification within and around Chester KeolisAmey aim to deploy diesel-electric trains on lines through Cheshire West and will replace all existing trains by 2023	Rail is 100% electrified	Rail is 100% electrified	Rail is 100% electrified

Examples of good practice:

Edinburgh's EV Charging Plan is an ambitious plan for EV charging infrastructure.

Go Ultra Low is a national scheme aiming to inform consumers and promote the savings associated with switching to EV.

3. Energy System Interventions

Waste & Industry

Measure	Current CW&C Context	SCATTER L4 Pathway		
		2025	2030	2050
Waste reduction[1]	1.2% reduction in household waste collected between 2015 and 2018[2] 18.4% reduction in non-household waste collected between 2015 and 2018	8% decrease in household waste	12% decrease in household waste	25% decrease in household waste
Increased recycling[3]	60% of household and non-household waste is sent for reuse, recycling or composting A 'Plastics to Hydrogen' project at Ellsemere Port will treat up to 25 tonnes of waste plastics a day that would otherwise go to landfill or incineration.	67% of household and commercial waste is recycled	71% of household and commercial waste is recycled	85% of household and commercial waste is recycled

Examples of good practice:

London's Library of Things projects promote a 'borrow not buy' movement for rarely-used items.

Loughborough Food Waste Processing projects aim to improve the reliability of anaerobic digesters.

1 - Volume % relate to household waste only, and any reductions are defined in terms of weight. Other categories within SCATTER include Commercial and Industrial waste, Construction & Demolition waste, Sewage Sludge and Landfill Gas.
2 - https://www.gov.uk/government/statistical-data-sets/env18-local-authority-collected-waste-annual-results-tables
3 - Waste destinations consist of 'recycling' (one category), 'landfill', 'composting', and 'incineration or EfW'. Updates made to the original DECC Pathways Calculator in respect of EU Waste Directive 2035 Targets.

3. Energy System Interventions

Waste & Industry

Measure	Current CW&C Context	SCATTER L4 Pathway		
		2025	2030	2050
Industry efficiency	Progress in improving the efficiency of industry has been described as lagging; deployment of renewable solutions in energy consuming sectors is well below the required levels[1]	11% reduction in energy demand	16.5% reduction in energy demand	38.5% reduction in energy demand
Electrification of industry	35% of industrial energy consumption in 2018 in the UK is electric[2]	41% of industrial energy use is electrified	44% of industrial energy use is electrified	66% of industrial energy use is electrified
Carbon Capture and Storage (CCS) on industry	Tata Steel's post-combustion capture project at Winnington will launch in 2021 and capture 11% of the annual emissions of the CHP plant which amounts to 40 ktCO_2e No installed capacity for energy supply	2% of the energy supplied for industry comes from CCS (90% annual capture rate)	4% of the energy supplied for industry comes from CCS (90% annual capture rate)	42% of the energy for industry comes from CCS (90% annual capture rate)
Oil production	Stanlow Oil Refinery supplies 16% of all road transport fuels and is one of the largest refineries in Europe, covering an area of 300 football pitches	Oil production falls 18% relative to 2015 levels	Oil production falls 36% relative to 2015 levels	Oil production falls 77% relative to 2015 levels

See Appendix 10 for an industry sector focus

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1 – https://www.irena.org/DigitalArticles/2019/Apr/-/media/652AE07BBAAC407ABD1D45F6BBA8494B.ashx
2 – https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/820647/DUKES_1.1.5.xls
3 – https://www.ft.com/content/b45d94b6-97fc-11e9-8cfb-30c211dcd229

3. Energy System Interventions

Renewable Energy Supply

Measure	Current CW&C Context	SCATTER Level 4 Pathway		
		2025	2030	2050
Solar PV	0.032 GW installed capacity in 2017 with an annual output of 28 GWh[1]	0.8 km^2 of PV arrays across roof space and ground-mounted installations (equivalent to 33.4% of households) 0.3 GW installed capacity[2] 210 GWh generated per year	1.1 km^2 of PV arrays across roof space and ground-mounted installations (45.3% of households) 0.4 GW Installed Capacity 280 GWh generated per year	2.4 km^2 of PV arrays across roof space and ground-mounted installations (60% of households as well as a further 0.88 km^2 of ground mounted and commercial property installations) 0.8 GW Installed Capacity 610 GWh generated per year
Onshore wind	0.050 GW installed capacity in 2017 with an annual output of 95.6 GWh	110 Turbines installed 0.275 GW Installed Capacity (2.5 MW per turbine)	162 Turbines installed 0.404 GW Installed Capacity (2.5 MW per turbine)	408 Turbines installed 1.02 GW Installed Capacity (2.5MW per turbine)
Bioenergy supply (heat & electricity)	5 MW installed capacity in 2017	160 MW installed capacity	171 MW installed capacity	263 MW installed capacity
Solar thermal	Estimated 0.43 MW of installed capacity	0.3 km^2 solar panels for hot water Installed capacity of 102 MW	0.4 km^2 solar panels for hot water Installed capacity of 124 MW	0.9 km^2 solar panels for hot water Installed capacity of 279 MW

A note on supply technologies

SCATTER estimates values for the installed capacity of each supply technology, by taking a nationally assumed capacity figure (L1 was aligned to the 2017 National Grid's Future Energy Scenario, Two Degrees) and scaling down to region based on a local authority's size proxy (e.g. population number of households, land area). This serves as an indicator for the nature and extent of renewable supply required to future demand.

SCATTER does not account for the geographies and local contexts unique to a given local authority, which we acknowledge play a very important role in the viability of a given technology. Such assessment lies outside of the scope of the SCATTER tool.

Examples of good practice:

West Sussex Virtual Power Plant combines PV and storage across groups of property to act as a localised grid.

Kent's Cleve Hill Solar Farm produces enough power for 91,000 homes and generates over £1m a year for local authorities.

1 – https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/743822/Renewable_electricity_by_Local_Authority__2014-2017.xlsx

2 – The % of households quoted is taken from a 2.2 kW installation occupying 16m^2 of roof space and household number projections (as per the Energy Savings Trust Guidance) – a maximum of 60% of households are assumed eligible for such installations.

3. Energy System Interventions

Renewable Energy Supply

The following energy technologies operate within the SCATTER tool but have very little or no precedent within CW&C in terms of capacity or installations. Despite this, the region has some identifiable potential in some of these areas (notwithstanding the geography of the region inhibiting any hydroelectric power development). Given CW&C is approaching these technologies from a 'standing start' they are treated with the minimum ambition level within the tool (L1). For these or any of the supply technologies referenced in this section, if the technology is not feasible in the district boundary to the extent suggested, then the residual capacity is simply assumed to occur outside the boundary (with no impact to the emissions estimates).

Measure	Current CW&C Context	SCATTER Level 1 Pathway		
		2025	2030	2050
Hydro power	No installed capacity in 2017 Local geography inhibits development of hydroelectric power capacity (see note on page 22 on **supply technologies**)	24.3 MW installed peak capacity	25.5 MW installed peak capacity	37.5 MW installed peak capacity
Wave, tidal and tidal stream	No installed capacity within CW&C in 2017. The Mersey tidal barrage is north of the CW&C region 'out of boundary'. Total national generation from wave and tidal was 4.2 GWh in 2017	Energy generation from wave, tidal stream and tidal wave grows steadily to 360 GWh by 2050.		
Storage	Stublach gas storage cavern near has capacity for 450 million cubic metres of natural gas. Energy Innovation District secured £200,000 in January 2019 to research and develop various energy technologies including energy storage	2260 MW storage capacity	2300 MW storage capacity	2450 MW storage capacity

A note on 'emergent technologies'

CW&C is among the leading authorities investing in new and emergent technologies, in particular the HyNet hydrogen infrastructure projects and Tata Steel's CCS scheme at Winnington.

Due to funding constraints, SCATTER cannot currently model the potential impacts of new and emergent technologies that have yet to become established, so these emissions reductions measures are largely excluded from the tool.

1 – RHI data used for this estimate can be found. Domestic and non-domestic estimates were calculated by using national averages for the share of solar thermal applications and capacities, as well as the average capacity per solar thermal installation.

3. Energy System Interventions

Emissions Savings Summary

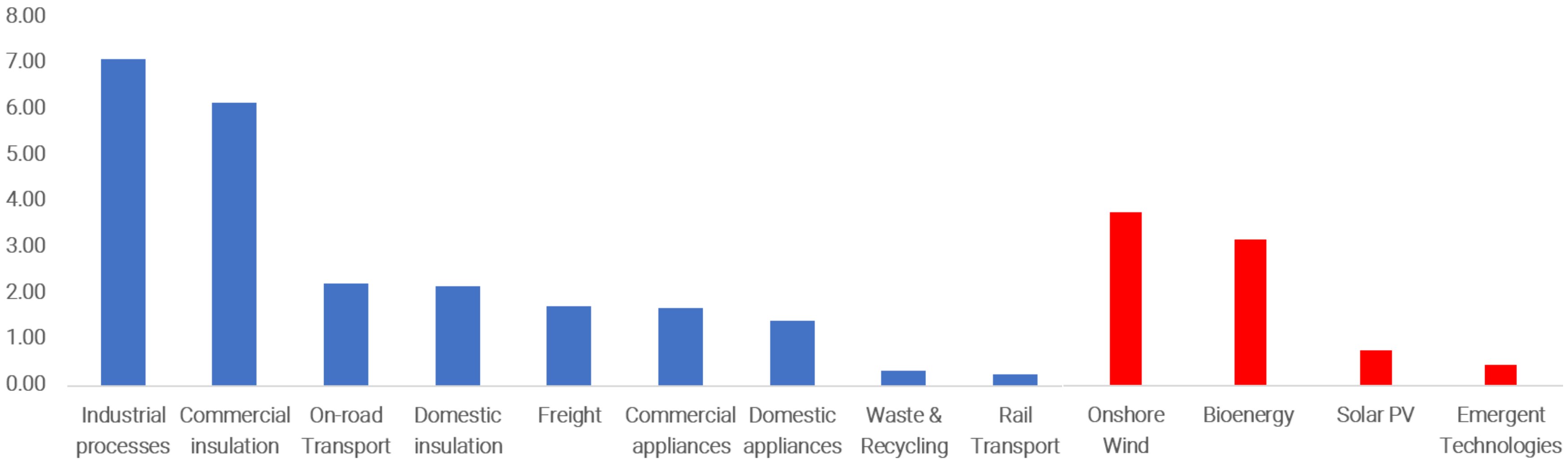
Table 3: Demand side measure cumulative savings to 2030

Demand-side measure	Cumulative saving to 2030 ($MtCO_2e$)
Industrial processes	7.11
Commercial insulation	6.17
On-road Transport	2.25
Domestic insulation	2.17
Freight	1.74
Commercial appliances	1.70
Domestic appliances	1.43
Waste & Recycling	0.34
Rail Transport	0.25

Table 4: Supply side measure cumulative savings to 2030

Supply-side measure	Cumulative savings to 2030 ($MtCO_2e$)
Onshore Wind	3.78
Bioenergy	3.18
Solar PV	0.78
'Emergent' Technologies	0.45

The estimated cumulative savings to 2030 for demand-side measures are presented below (blue, left). Supply-side measures (red, right) have also been presented, though please note the limitations of such estimates and the importance of not summing the demand and supply.



Notes:

- It is not appropriate to sum any savings presented from renewable supply with savings achieved on the demand side of the energy system, as this is may result in double counting.
- Intervention is critical on the demand side to realise emissions savings from renewable supply. For example, if heating systems are not electrified, then a decarbonised electricity grid will have limited impact. Similarly if the grid is not decarbonised, savings from Electric Vehicles will not be as great.
- 'Emergent' technologies are hydro, tidal and wave power.

3. Energy System Interventions

Emissions Savings Summary

Comparisons against base year

This section provides an indication of relative savings by sector expressed as % reductions and intensity metrics.

The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories describes how GHG inventories such as those in SCATTER can be used as a basis for performance tracking and goal setting. Progress can be assessed in a number of ways, but here a **base year emissions goals** approach and a **base year intensity goals** approach have been used.

The base year emissions goals approach compares emissions reductions relative to an emissions level in an historical baseline year (in this case, 2017 has been chosen as the most recent dataset). These emissions reductions are typically represented in percentage terms and are shown in the table below.

SCATTER sector	% reduction against 2017 by 2030
Domestic Buildings	77.6%
Non-domestic Buildings	70.2%
Transport	77.9%
Waste & Industry	59.7%
Total	67.9%

Table 5: Base year emissions goals approach to emissions tracking.

The **base year intensity goals** approach compares changes in the emissions intensity relative to an historical baseline year. Emissions intensity can be defined as the amount of emissions per unit of a given parameter; most commonly this is population. In 2017 in the UK the emissions intensity per capita was 5.3 tCO_2e. Two base year intensity goals are shown in the tables below; emissions intensity per capita and emissions intensity per unit of energy consumption.

Emissions intensity per unit of energy consumption is calculated from the ratio of projected values for net CO_2e emissions and energy demand (in TWh). The very sharp decrease in the emissions intensity per TWh accounts for changes to both the decarbonization of the energy supply as well as reduced demand.

Emissions intensity per capita is similarly calculated from the ratio of projected emissions to projected population.

Year	Emissions intensity per capita	
	tCO_2e/head	% reduction against 2017 levels
2017	12.13	N/A
2025	5.34	56%
2030	3.80	69%
2050	0.11	99%

Year	Emissions intensity per TWh	
	$MtCO_2e$/TWh	% reduction against 2017 levels
2017	0.28	N/A
2025	0.16	42%
2030	0.14	49%
2050	0.07	74%

Table 6: Intensity emissions reduction approach to emissions tracking.

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4. Cheshire West & Chester Council Influence

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4. Cheshire West & Chester Council Influence

Overview

The chart opposite illustrates that CW&C's influence is varied and complex across the different activities that occur within their own operations and also across the borough.

Influence bandings are based on Anthesis' judgment following discussion with officers, and are by no means definitive. The examples that relate to each banding are intended to highlight opportunities for CW&C to apply their influence in areas or ways previously not fully explored (e.g. by using 'convening power' and/or policy).

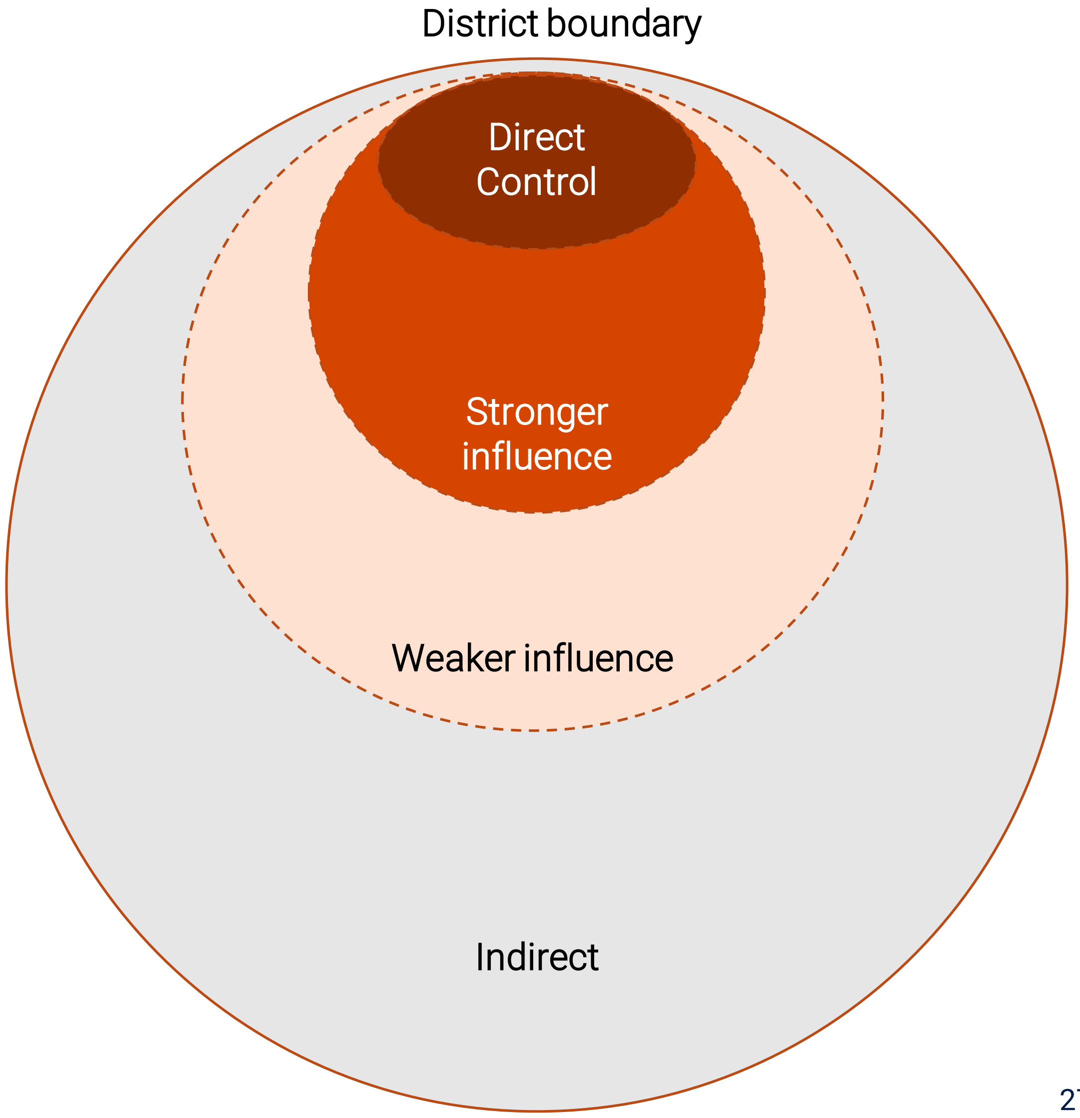
Influence extends beyond the district boundary, whereby CW&C's demand (and supply) of goods and services drive emissions in supply chains around the world. Such emissions are referred to as consumption based emissions (relative to the UK produced emissions totals).[1]

For a description of the various scopes of emissions see the FAQs on page 8.

Influence	Description
Direct Control	Emissions sources that are directly owned or operationally controlled by the Council, e.g. Council buildings and fleet.
Stronger	Owners and operators of emissions sources are clearly defined but are not directly owned or operated by the Council, e.g. emissions relating to procurement or council-led activities.
Weaker	Emissions sources do not relate to council owned or operated assets, procurement or council led activities, however some convening power may exist with specific actors in the district, e.g. emissions from local stakeholders across sectoral networks and partnerships.
Indirect	Owners and operators of emissions sources are not clearly defined, influence limited to lobbying central government or trade associations, e.g. National Grid decarbonisation, vehicle levies.

Table 7: Council influence bandings

[Chart is illustrative only and not to scale]



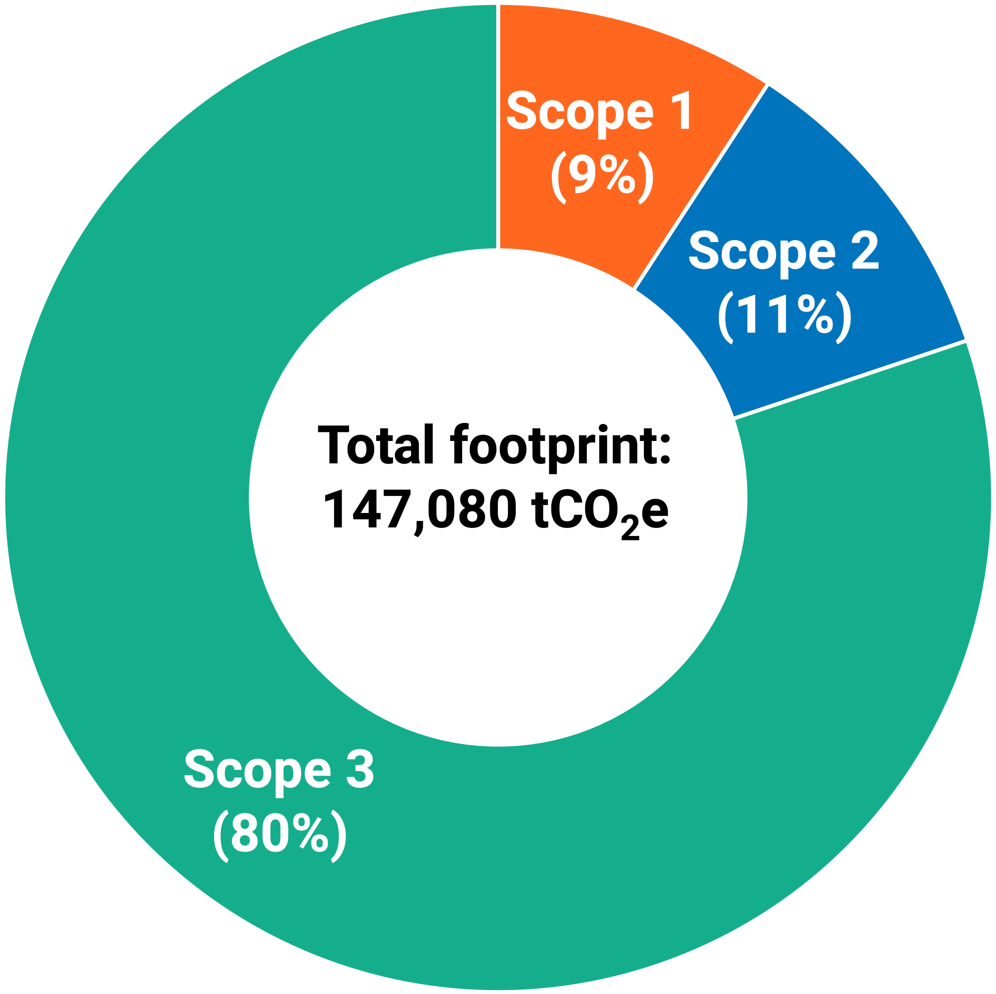
1 – https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/794557/Consumption_emissions_April19.pdf27

4. Cheshire West & Chester Council Influence

Council's Own Emissions

Summary

- The analysis of Cheshire West & Chester Council's own emissions focused on six key emissions sources, including:
    - Buildings & Other Assets
    - Commercial Properties
    - Procurement Spend
    - Employee Commute
    - Grey Vehicle Fleet
    - Business Travel
- **Scope 3** emission sources are the largest contributor to the council's own emissions accounting for **80%** of total emissions, with **Scope 1 and 2** emissions sources contributing a marginal **11%** & **9%**, respectively.
- The largest single emissions source category from Indirect, Direct and Other emissions was Scope 3 input/output emissions from **procurement spend**, contributing to **74%** of total emissions.
- In addition, a substantial proportion of emissions have been produced from Natural Gas, Electricity and Gas Oil Consumption in Buildings & Other Assets and Commercial Properties accounting for **16%** and **6%**, respectively.
- The council's **Scope 1 & 2** emissions represent **<1%** of the district's Scope 1 & 2 (Direct & Indirect emissions). It is not appropriate to directly compare the council's total footprint (i.e. Scopes 1, 2 & 3), as the proportion of Scope 3 emissions that occur inside and outside of the district boundary has not been defined. Notwithstanding this point, it would still be <3% of the district's Direct & Indirect emissions.



4. Cheshire West & Chester Council Influence

Council's Own Emissions

Table 8: Emissions breakdown by scope and activity.

Emission Source		Activity Data (2018-19)	Unit (2018-19)	tCO2e (2018-19)	% of total emisions (2018-19)
Scope 1					
Buildings & Other Assets	*Natural Gas*	49,140	*MWh*	9,088	6.18%
	Gas Oil	16,950	*Litres*	50	0.03%
Commercial Properties	*Natural Gas*	22,476	*MWh*	4,135	2.81%
	Gas Oil	86,381	*Litres*	257	0.17%
Total Scope 1 Emissions				**13,530**	**9.20%**
Scope 2					
Buildings & Other Assets	*Purchased Electricity*	41,558	*MWh*	11,763	8.00%
Commercial Properties	*Purchased Electricity*	13,822	*MWh*	3,913	2.66%
Total Scope 2 Emissions				**15,676**	**10.66%**
Scope 3					
Buildings & Other Assets	*Natural Gas - WTT*	49,140	*MWh*	1,231	0.84%
	UK Electricity - T&D	41,558	*MWh*	1,003	0.68%
	Gas Oil - WTT	16,950	*Litres*	11	0.01%
Commercial Properties	*Natural Gas - WTT*	22,476	*MWh*	575	0.39%
	UK Electricity - T&D	13,822	*MWh*	334	0.23%
Procurement Spend	*Input/Output*	287	*million GBP*	108,254	73.60%
Employee Commute	*Walk / Bicycle*	1,927,318	*Miles*	-	0.00%
	Private On-Road Transport	7,251,472	*Miles*	2,087	1.42%
	Public On-Road Transport	703,987	*Miles*	125	0.09%
	Public Off-Road Transport	865,367	*Miles*	62	0.04%
Grey Vehicle Fleet	*Average Car: Petrol*	1,113,780	*Miles*	329	0.22%
	AverageCar: Diesel	746,533	*Miles*	213	0.15%
Business Travel	*Average Car: Petrol*	7,332,918	*Miles*	2,222	1.51%
	Average Car: Diesel	4,915,037	*Miles*	1,428	0.97%
Total Scope 3 Emissions				**117,874**	**80.14%**
Total Emissions				**147,080**	

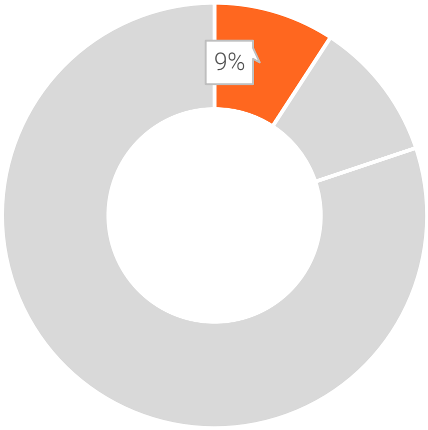
Please note that an operational control approach to GHG accounting has been used for the analysis of emissions from owned/leased buildings and assets. In reference, the GHG Protocol define operational control as an organisations 'authority to introduce and implement its operating policies at the operation' (GHG Protocol, 2019). This is demonstrative for commercial properties, such as parks and playing fields, community support centres , municipal waste recycling centres etc., which have been encompassed under the council's Scope 1, 2 and 3 emissions.

4. Cheshire West & Chester Council Influence

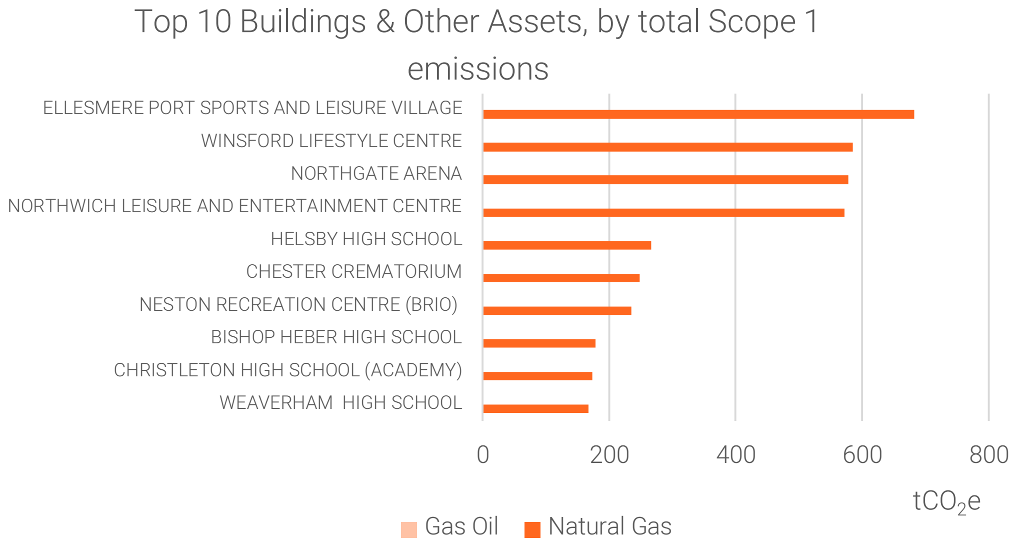
Direct Emissions (Scope 1)

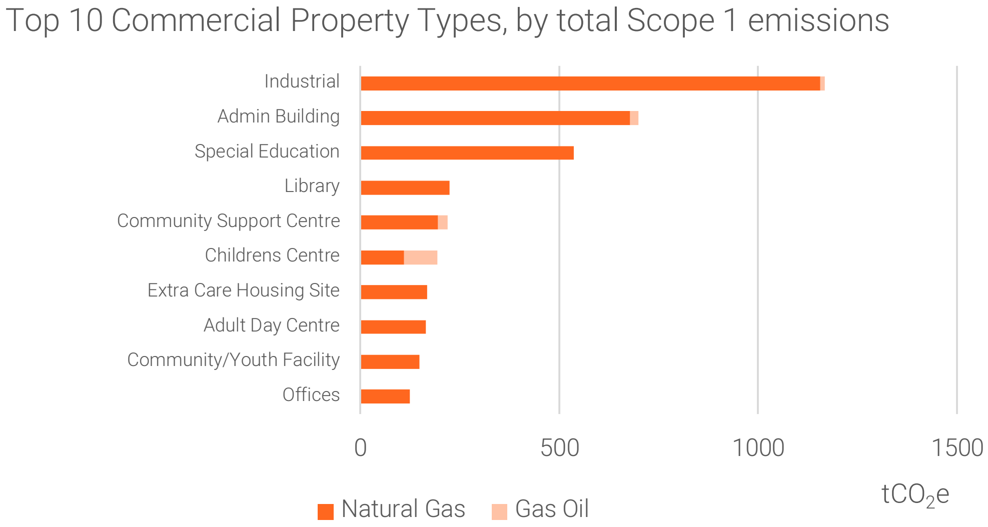
Scope 1 – Further analysis

- The analysis of Cheshire West & Chester Council's own direct emissions focused on two key emissions sources, including:
    - Buildings & Other Assets
    - Commercial Properties
- Scope 1 emissions accounted for **13,530 tCO_2e**, and **10%** of the council's own emissions for 2018-2019.



- The majority of direct emissions were sourced from natural gas consumption in buildings and other assets accounting for 9,088 tCO_2e (**67%**), and commercial properties producing 4,135 CO_2e (**31%**).
- The remainder of direct emissions are produced from gas oil consumption in buildings and other assets (**0.4%**), and commercial properties (**2%**).
- The majority of buildings/other assets and commercial properties consume natural gas, however, only **11 properties/assets** were identified as using **Gas Oil** on site, including Pinewood Children's Centre, Winsford High Street Primary, Sutton Beeches, Blacon Children's Centre, Stanlaw Abbey Children's Centre, the Tarvin Centre, Winsford Municipal Depot, Caste Park, Grosvenor Park and Central Depot.
- The top direct emissions source within the council's buildings & other assets was Ellesmere Sports and Leisure Village, accounting for **682 tCO_2e**.
- The council's own Scope 1 emissions associated with commercial buildings under operational control were estimated from the Gross Internal Area (GIA) and Building Energy Benchmarks, with the largest contributor identified as Industrial properties, accounting for 1,167 tCO_2e.





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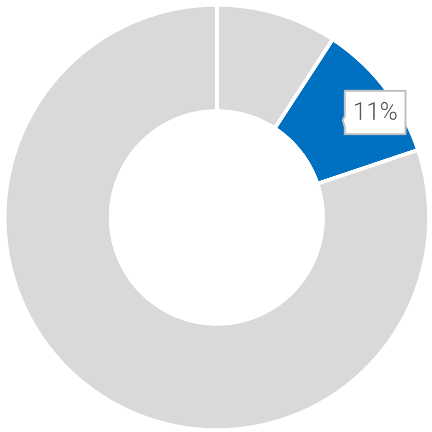
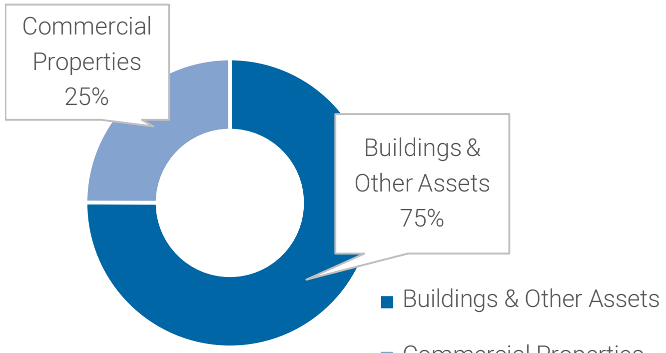
4. Cheshire West & Chester Council Influence
Indirect Emissions (Scope 2)

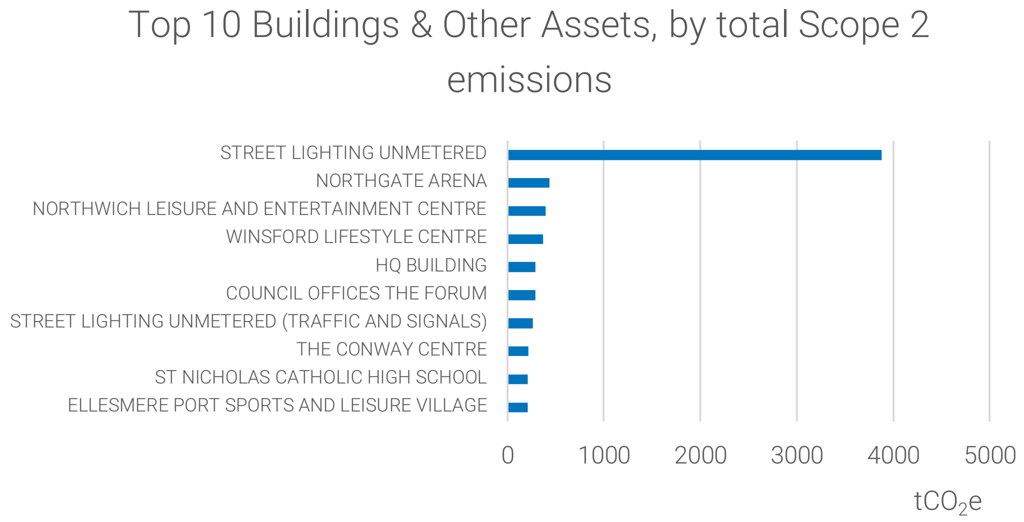


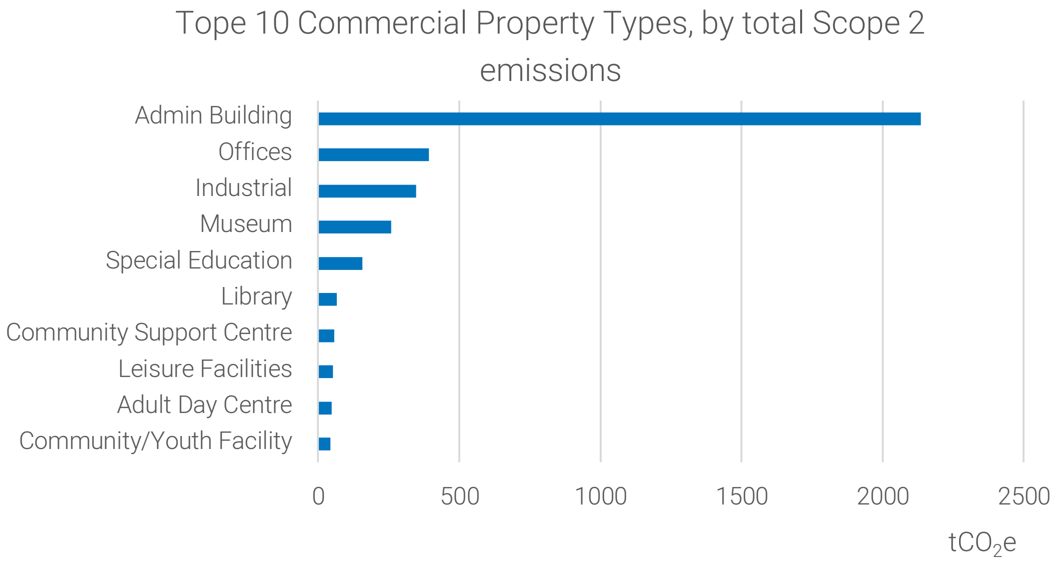
Scope 2 – Further analysis

- The analysis of Cheshire West & Chester Council's own direct emissions focused on two key emissions sources, including:
    - Buildings & Other Assets
    - Commercial Properties
- Scope 2 emissions accounted for **11,763 tCO_2e**, and **8%** of the council's own emissions for 2018-2019.



- The council's own indirect emissions are all associated with Purchased electricity from buildings and other assets and commercial properties, contributing **75%** and **25%**, respectively.
- The top direct emissions source within the council's buildings & other assets was from unmetered street lighting, accounting for **3,878 tCO_2e (33%)** of total emissions from purchased electricity consumption within this sector.
- The largest contributor to the council's own indirect emissions from commercial buildings was properties categorised as Admin Buildings, accounting for **2,135 tCO_2e.**





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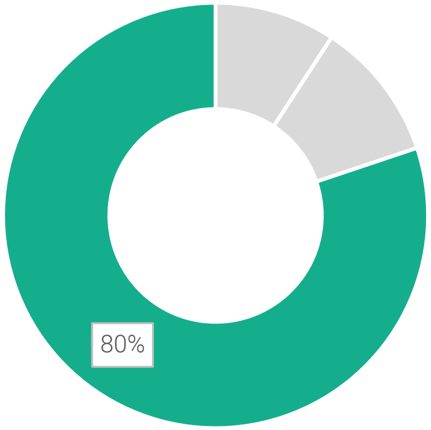
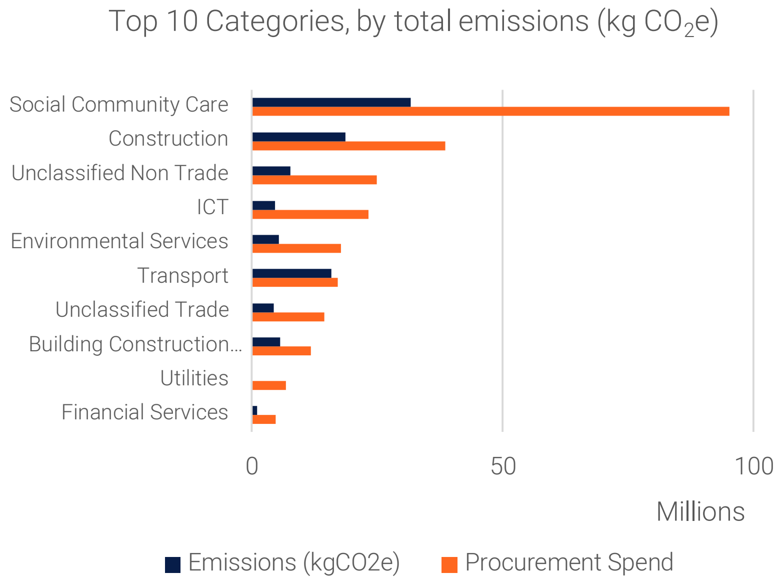
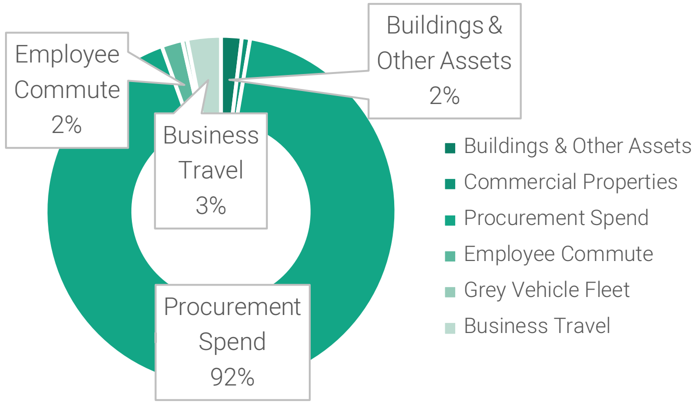
4. Cheshire West & Chester Council Influence
Other Emissions (Scope 3)

Scope 3 – Further analysis

- The analysis of Cheshire West & Chester Council's own other emissions focused on six key emissions sources, including:
  - Buildings & Other Assets
  - Commercial Properties
  - Procurement Spend
  - Employee Commute
  - Grey Vehicle Fleet
  - Business Travel

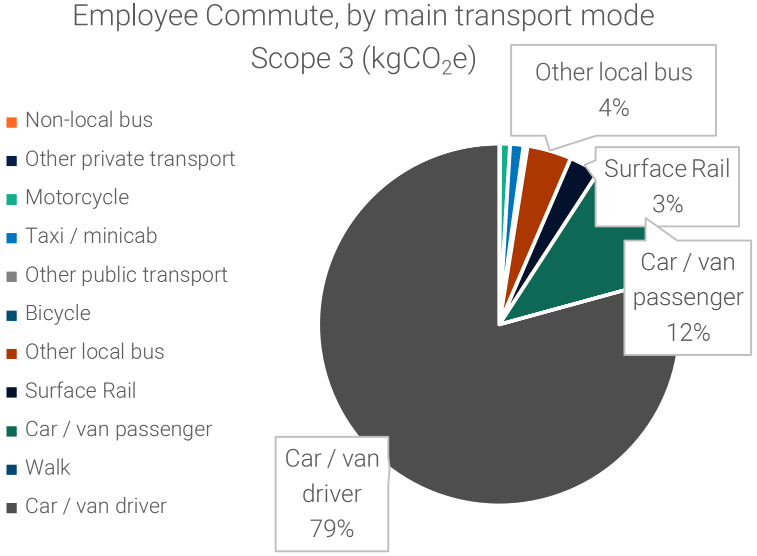






Note that, due to the unavailability of high-level data, a number of categories in procurement spend were unable to be mapped against emissions factors published by DEFRA. Similarly, sources of procurement spend were categorised as unclassified and omitted as they could not be assigned at a more granular level.

- The council's other emissions are largely comprised of input/output emissions associated with procurement spend, accounting for **80%** of total GHG emissions, and **92%** of Scope 3 GHG emissions.
- The top emission sources under procurement spend were categorised as social community care and construction spend.
- The Scope 3 emissions from employee commute were estimated using public datasets from the Department for Transport (DfT) National Travel Survey (NTS) including, average commuter trips by employment status and main mode. This was calculated based on organisational employee size/person(s), with car/van drivers on average making up the largest proportion (**79%**) of Scope 3 emissions from employee commute.



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5. Agriculture and Land Use

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5. Agriculture and Land Use

Summary

Key results

- **Gross emissions[1] from agriculture and land use are in excess of 340 ktCO_2e, approximately 8% of emissions from the CW&C energy system.**
- Emissions from livestock are the dominant source of emissions from land use and agriculture, responsible for approximately 92% of gross emissions. **Dairy cows are responsible for 55% of gross emissions and non-dairy cows are responsible for 33%.**
- The other 8% is the result of crop and grassland emissions, typically the result of nitrous oxide emissions from fertilisers. **The land also acts as a carbon sink**, removing approximately 1% of gross emissions from the atmosphere.
- Using Committee on Climate Change forecasts, **reducing consumption of beef, dairy and lamb could reduce gross emissions by as much as 37% per year** as compared to current gross emissions.
- **Doubling** the area of **planted forest** within the CW&C region could **reduce emissions** from livestock and land by approximately **25%** as compared to current gross emissions.

Estimates in numbers

Agri & Land emissions are equivalent to **8%** of the energy system

92% of Agri & Land emissions are from livestock

8% of Agri & Land emissions from fertilizer application

1% emissions sequestered back into biomass & soil

1- 'Gross emissions' are defined as emissions which have not been subjected to any offsetting against soil and biomass carbon.

5. Agriculture and Land Use

Summary

Co-benefits and considerations

Avoiding the worst impacts of climate change is complementary to many other objectives. In the context of land use in CW&C, there are many co-benefits of taking steps to cut emissions. When deciding where and how to make emissions reductions there are many other considerations, including but not limited to:

- Future land stewardship promotions by government;
- Flood management;
- Maintaining landscape character, particularly in the context protected land, nature reserves or Areas of Outstanding Natural Beauty (if applicable);
- Maintaining and enhancing biodiversity, including connected habitats;
- Improving animal welfare;
- Balancing food production with land-use management and land-use change;
- Opportunities to work together as a wider region to make the necessary carbon reductions in a way that maximises the co-benefits while minimising potential adverse impacts.

Comparison with BEIS data

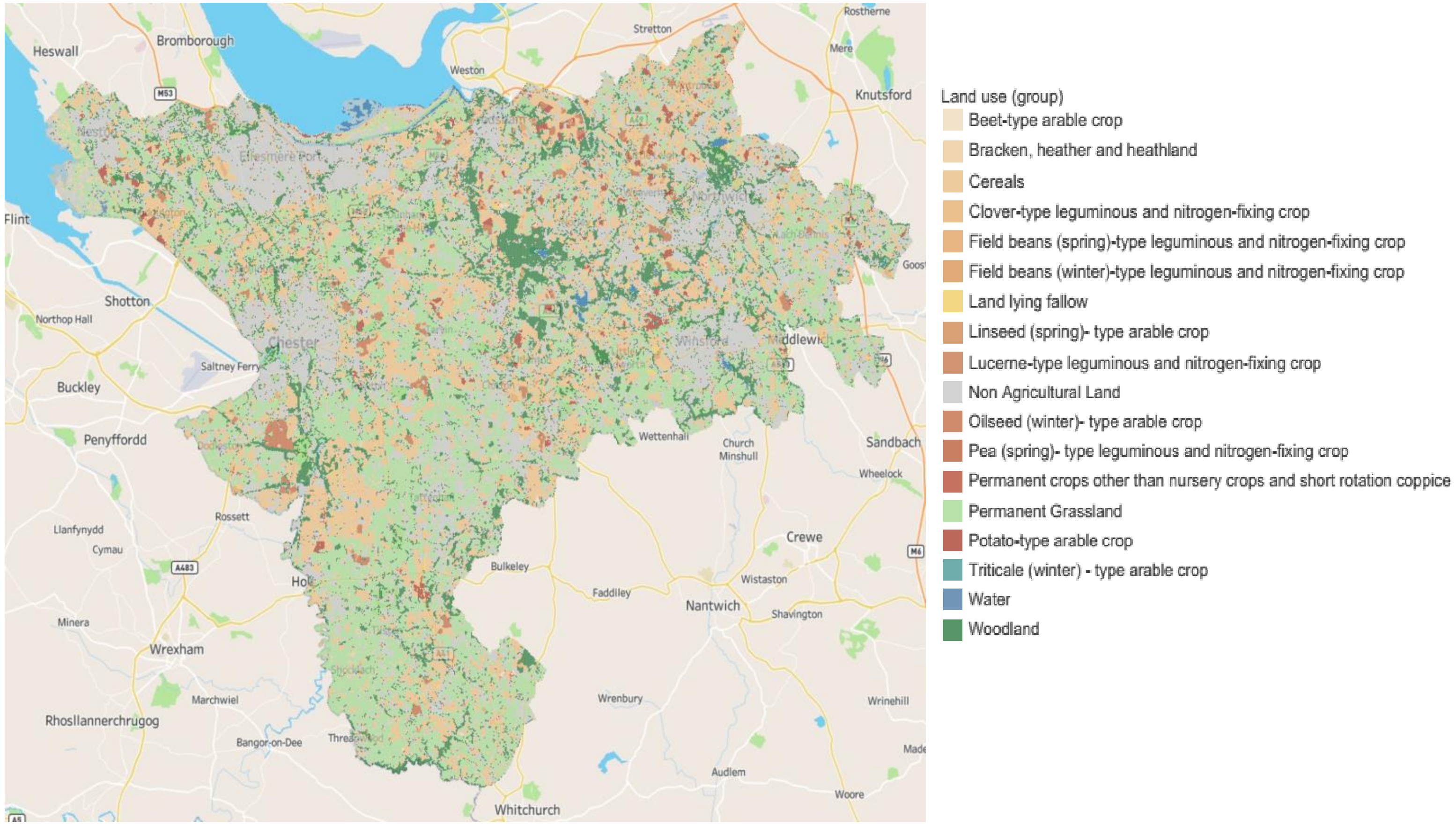
According to 2017 BEIS data, gross emissions from agriculture were 35.5 ktCO_2, offset by a figure of 3.6 ktCO_2 resulting from land use, land-use change and forestry (LULUCF).

The significant disparity in the emissions reported by BEIS and our analysis stems from the different greenhouse gases at work.

BEIS datasets considers only CO_2 emissions and neglects other greenhouse gases such as methane and nitrous oxide. These gases are emitted in significant volumes within the agriculture sector, through rearing of cattle livestock and fertilisers. Anthesis' analysis considers these gases and provides a figure for the equivalent weight of CO_2 after accounting for the more potent methane and nitrous oxide (see page 37).

5. Agriculture and Land Use

Land



Rural Payments Agency, 2019: [Crop Map of England (2017)]

The single largest land use is urban infrastructure (non-agricultural land), which forms about 30,600 hectares (33%) of the total. The next major land-type is permanent grassland of 25,200 hectares (27%) then Arable land (20%) and woodland / trees (including trees in hedgerows and fields) of 12,300 hectares (13%).

The map below is taken from the Crop Map of England, which mainly uses satellite data to identify land-uses and crop types; it is a snap-shot at a point in time (summer 2018) and should be considered indicative only.

The table below summarises land use:

Land Use	Hectares	%
Non-agricultural land	30,632	33%
Permanent Grassland	25,175	27%
Arable	18,871	20%
Woodland (including trees in fields and hedgerows)	12,323	13%
Fallow land	2,579	3%
Legumes / nitrogen fixing	2,080	2%
Heathland	2,044	2%
Water	418	0%
Total	94,121	100%

Table 9: Land-use in the region

5. Agriculture and Land Use

Emissions from Agriculture & Livestock

Emissions from agriculture come from two main sources:

- Livestock production produces 92% of gross emissions. The majority comes from enteric fermentation in dairy cattle.
- Fertiliser applications produce the remaining 8%. The main sources are nitrous oxide from grassland (which has low fertiliser applications but a large total area) and wheat production (which has a high average fertiliser application rate and large area). These will vary each year if crops are rotated.

Land-use, land-use change and forestry is currently acting as a net sink of CO_2, storing 1% of the gross emissions from livestock and land each year.

The table below describes the emissions from agriculture and land (see Appendix 11 for inclusions, exclusions and methodology):

Annual emissions	CO_2 equivalent, t	% of gross
Livestock[1]	315,269	92%
Crop and grassland (non-CO2)[2]	27,697	8%
Gross emissions	342,966	100%
Land (soil and biomass carbon)[3]	-2,519	-1%
Total	**340,447**	**99%**

Table 10: Emissions from agriculture and land. 1. Methane from enteric fermentation and manure management, plus nitrous oxide from direct manure management. 2. Nitrous oxide emissions from fertiliser (including manure) application to land. 3. Net carbon sequestration, taken from "UK local authority and regional carbon dioxide emissions national statistics." The statistics report does not provide any detail on what this is, but it may come from soil carbon returning to equilibrium following historic changes e.g. afforestation, deforestation / conversion to cropland or grassland.

A note on different greenhouse gases

The numbers in the tables are shown as CO_2 equivalents, using well-established conversion factors. Methane (87% of emissions above) is a very potent greenhouse gas which, in the short term (20 years), has 84 times the warming effect of carbon dioxide and, in the long term (100 years) has 28 times the effect. While carbon dioxide emissions are the primary cause of climate change, cuts to methane emissions have a much more immediate climate impact, helping to limit short- and long-term temperature increases. Nitrous oxide (13% of gross emissions) has 265 times the warming impact of carbon dioxide – reductions in this gas from reduced fertiliser use and manure management are also needed.

The table below shows emissions from livestock. These come predominantly from methane emissions by breeding dairy cattle, due to the large feed intake required for producing milk, and the large herd size.

Livestock type	Number	Total CO_2e, t	Per head CO_2e, t
Dairy Cattle	40,828	188,377	4.61
Non-dairy cattle	58,156	111,637	1.92
Sheep	42,444	5,575	0.13
Pigs	21,750	8,712	0.40
Poultry	508,024	966	0.00
Total	**671,202**	**315,269**	**0.47**

Table 11: Livestock emissions.

5. Agriculture and Land Use

Soil and Biomass Emissions

A detailed breakdown of the soil and biomass carbon number is not available for the CW&C borough as a whole, but it is available for Chester. The table below shows that grassland and forests act as **carbon sinks**, storing a total of about 30,900 tCO_2 per year in Chester. However, these sinks are more than outweighed by soil carbon losses arising from cropland and settlements. Such losses typically occur due to land conversions in earlier years but can also arise due to the way soils are managed. The wider region is a carbon sink of -2,519 tCO_2, likely due to the larger proportion of forestland and grassland outside of Chester, relative to settlements and cropland.

Land type	tCO_2e
Grassland	-17,925
Forestland	-12,959
Settlements	12,718
Cropland	18,918
Total	**752**

Table 12: Estimated soil and biomass gains and losses for Chester only. Source: BEIS / CEH / Ricardo.

Land use - forestry

Forestry in the UK as a whole is a net carbon sink, storing an average of 5.5 tCO_2 per hectare per year for existing woodland. Of this, about 1.3 tonnes are stored in the soil, 2.9 tonnes in trees, and 1.3 tonnes in dead wood and leaf litter. Applying this average to the total area of forestry in the CW&C area would give net storage of about 68,000 tCO_2 per year; this is plausible given the 12,959 t for Chester alone in the table below. Additional data on forest age and type would be needed to better estimate the actual contribution of current forestry to net emissions.

Carbon stocks by land use

Understanding existing carbon stocks can help prioritise areas for action – for conservation of existing stocks or for additions through land-use management or change. Carbon is stored in several "pools" – the key ones being soil and above-ground biomass (trees, crops and other plants). The balance of total carbon between these pools depends on the type of land – woodland stores relatively more carbon in above-ground biomass (trees) than cropland or grassland, for example.

Habitat	tC per ha				tCO_2 per ha
	Soils (15cm)	Vegetation	Soils (100 cm)	Vegetation & Soils (100 cm)	Vegetation & Soils (100 cm)
Dwarf shrub heath	88	2	218	220	799
Coniferous woodland	90	70	185	255	935
Broadleaf, mixed woodland	73	70	150	220	808
Neutral grassland	69	1	130	170	628
Improved grasslands	67	1	116	117	431
Arable and horticulture	47	1	95	96	351

Table 13: Carbon stocks by land-use type. Adapted from Natural England, 2012 and Open University 2018 . Carbon in soils to 100cm is extrapolated from 15cm using ratios calculated from Natural England 2012.

5. Agriculture and Land Use

Soil Carbon

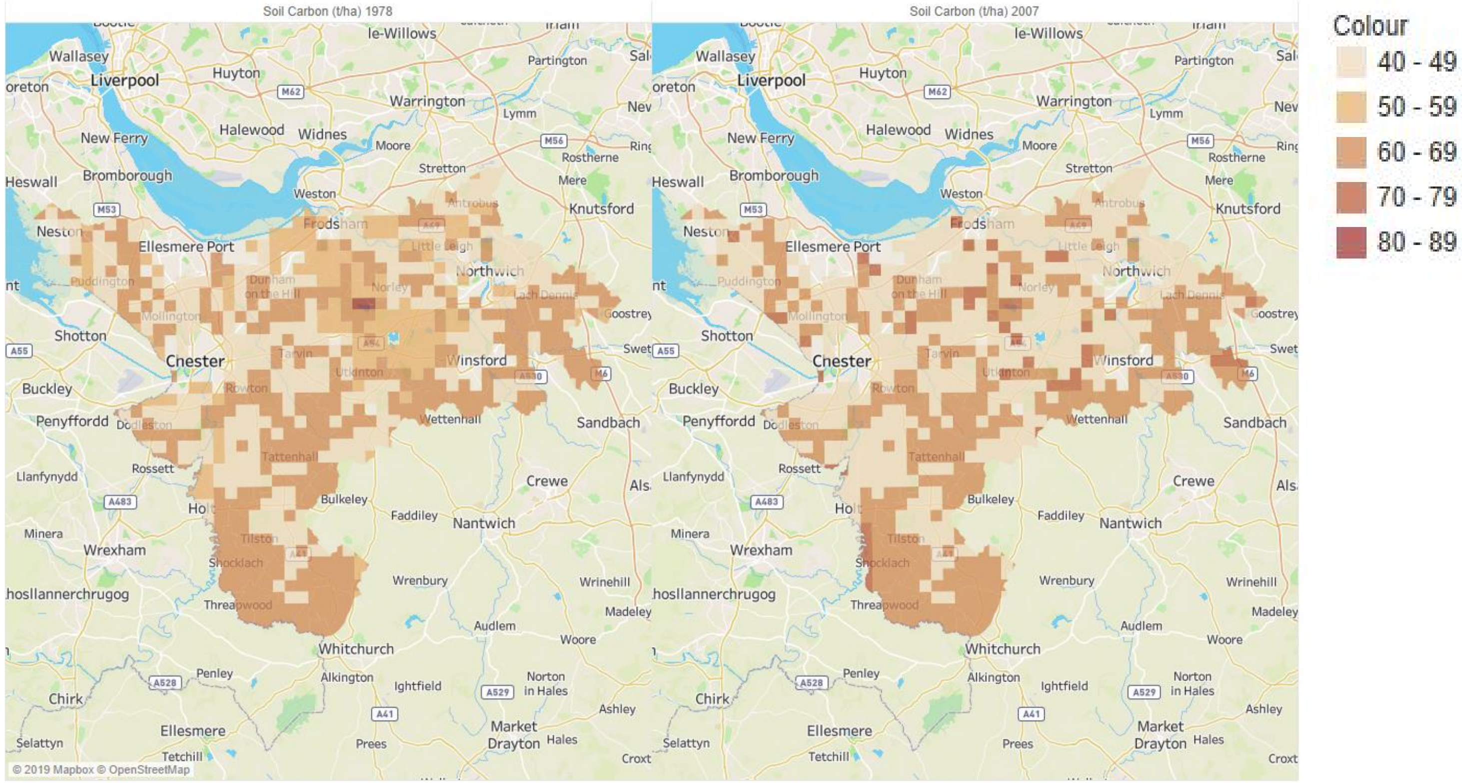


Figure 8: Estimated soil carbon stocks to 15cm based on land-cover type (land-use) and soil characteristics. Source: Countryside Surveys 2007 and 1978. The map is lower-resolution than the CROME and the underlying land-uses in this map don't always correspond to those in CROME.

The maps opposite show estimated soil carbon to 15cm in the area in 1978 and 2007. The numbers (tonnes of carbon per hectare) are broadly comparable to the first column of the table above. The areas with higher carbon stocks correspond largely with areas designated within the Countryside Surveys as improved grassland (as carbon stocks are estimated using this designation).

Total soil carbon in the top 15cm for the area, based on the above data, is estimated to be 4.6 million tonnes carbon, equivalent to 16.9 $MtCO_2$. Extrapolating this to a depth of 100 cm gives approximately 10 million tonnes carbon stored, equivalent to 35.6 $MtCO_2$.

Above-ground carbon

Using the values in Table 13 above and applying them to the broad land-types within the Crop Map of England gives an estimated 900,000 tonnes of carbon (3.4 $MtCO_2$) stored in vegetation. The majority is within woodland and trees, using an area of 12,300 hectares.

5. Agriculture and Land Use

Emissions Reductions Scenarios

The UK Committee on Climate Change (CCC) provides several scenarios for how changes in land-use and agriculture can contribute towards the UK's emissions reductions targets. These are set at low, medium and high ambitions. These represent business-as-usual, adoption of currently-available measures, and more radical and novel measures respectively. Only the medium and high ambition measures are considered here.

Dietary Change

This scenario includes a reduction in the national consumption of dairy, beef and lamb of 20% (medium) and 50% (high) by 2050. Some of this is replaced by increased consumption of pork and chicken. This is modelled here as a 20% or 50% reduction in cattle numbers, and the same reductions in grassland and associated fertiliser applications. Pig and chicken numbers increase by 20% under both ambition levels.

Grassland is reduced by about 5,000 and 13,000 hectares respectively in the medium and high scenarios. While more crops will be needed to replace some of the animal products, gains in productivity should mean little additional cropland is needed.

Afforestation

For this report, the equivalent area of grassland freed by dietary change is converted to forestland over the period to 2100. The forest management plan used by the CCC is followed – a mix of native broadleaved and conifer woodlands which are managed to provide some fuel and harvested wood products.

The grassland area is planted at a constant rate per year to the year 2100, equivalent to 60 hectares per year (medium) and 150 hectares per year (high). Grassland is assumed to be replaced by woodland to provide a simple scenario for the purposes of these calculations.[1] **Planting 12,600 ha of woodland would double the existing area of woodland within CW&C.**

Greenhouse gas emissions reductions

The table below shows average annual emissions reductions associated with these scenarios between now and 2100.

	CO2e, t net emissions reductions per year		% of current gross emissions[3]	
Scenario	Medium	High	Medium	High
Dietary change (grassland) - change to 2100	-388	-969	-0.1%	-0.3%
Dietary change (livestock) - change by 2050	-49,313	-125,710	-14%	-37%
Dietary change (subtotal)	**-49,701**	**-126,679**	**-14%**	**-37%**
Planting forests on saved land	-37,046	-84,356	-11%	-25%
Total	**-86,747**	**-211,036**	**-25%**	**-62%**

Table 14: emissions reductions from the two scenarios. 1. This is the average annual savings from the reductions in cattle and sheep and associated grassland use by 2050. 2. This is the average annual net carbon sequestration over the period to 2100 in biomass and soil. 3. Gross emissions are used here as the impact on current sequestration (and net emissions) is not known.

With medium ambition the measures can reduce gross emissions in this sector by about 25%. With high ambition, emissions can be reduced by 62%.

1 - The overall UK woodland mix is used here (using the published CCC numbers), which includes a much higher proportion of conifers than would normally be planted in England or Wales. This will likely overstate carbon storage as faster-growing conifers tend to store more carbon under the scenarios analysed. In practice, where and on what type of land woodland is planted depends on a variety of factors including the suitability of the land and the aim of providing connected habitats for biodiversity promotion.

Appendices

Anthesis

Appendix 1

Data Tables for SCATTER and BEIS Emissions Summaries

Sector	Scope 1 & 2 Emissions, $ktCO_2e$
Industry and Commercial Electricity	414.8
Industry and Commercial Gas	469.3
Large Industrial Installations	1,598.2
Industrial and Commercial Other Fuels	104.3
Agriculture	35.5
Domestic Electricity	143.5
Domestic Gas	338.3
Domestic 'Other Fuels'	52.5
Road Transport (A roads)	400.3
Road Transport (Motorways)	326.6
Road Transport (Minor roads)	162.8
Diesel Railways	11.3
Transport Other	46.1
LULUCF Net Emissions	-3.6
Grand Total	**4,099.9**

Notes:

- BEIS data (above) and SCATTER data (right) are compiled using different methodologies. The SCATTER model operates on 2016 data. BEIS data is from 2017.
- Within the SCATTER model, national figures for emissions within certain sectors are scaled down to a local authority level based upon a series of assumptions and factors.
- Given the unique nature of the CW&C industrial sector, assumptions based around national averages for energy consumption begin to break down and the result is a misappropriation of some emissions to the 'institutional buildings and facilities' sub-sector.

IE	= Included Elsewhere
NE	= Not Estimated
NO	= Not Occurring

Sub Sector	Direct, tCO_2e	Indirect, tCO_2e
Residential buildings	370,317.23	201,689.80
Commercial buildings & facilities	377,160.41	64,730.25
Institutional buildings & facilities	1,201,098.29	327,095.51
Industrial buildings & facilities	407,697.06	189,611.24
Agriculture	25,920.39	IE
Fugitive emissions	0	0
On-road	769,179.50	IE
Rail	9,945.95	IE
Waterborne navigation	23.69	NO
Aviation	0	IE
Off-road	0	0
Solid waste disposal	40,068.88	0
Biological treatment	0	0
Incineration and open burning	0	0
Wastewater	21,000.36	0
Industrial process	1.24	0
Product use	0.01	0
Livestock	19,823.99	0
Land use	-0.01	0
Other AFOLU	NE	0
Electricity-only generation	0	0
CHP generation	11739.87	0
Heat/cold generation	0	0
Local renewable generation	0	0
Sub-total	**3,242,236.99**	**783,126.80**
Grand total	4,025,363.79	

Appendix 2

Petroleum Refineries Within SCATTER

The estimate of in-boundary emissions made the following exclusions:

- Any products that were exported out of region either domestically or internationally
- Conversion losses that arise from conversion from crude to other petroleum products

The following processes were considered and assigned as in-boundary emissions given that they occur at the plant throughout the manufacturing processes. These *own-use requirements* are treated as **fixed**, meaning that they do not change over time and are the same now as in 2050.

Energy requirement	% of refined hydrocarbons
Electricity (delivered to end user)	0.58%
Liquid hydrocarbons	3.91%
Gaseous hydrocarbons	0.10%
Heat transport	0.31%

In order to achieve a quantitative figure, the SCATTER scaling factors were modified to acknowledge that a substantial oil refinery was within the region's boundary.

The total annual capacity of Stanlow was taken to be 12 million barrels of oil per annum, taken from Oil and Gas Environmental Report. The conversion into 5MtCO_2e was achieved using a conversion factor for a barrel of crude oil into a weight of CO_2e emissions found here.

The ambition level input to the SCATTER model reflects current government projections around the power output of petroleum refineries. These projections indicate that the amount of crude oil processed domestically and exported declines significantly between now and 2050.

	2025	2030	2050
% reduction in crude oil imports against 2015 levels	23%	40%	78%
% reduction in domestic processing of crude oil against 2015 levels	18%	36%	76%

The vast majority of the fuels produced at petroleum refineries are exported. Therefore, SCATTER does not apportion the emissions output of the resultant fuels to CW&C, since they are consumed out-of-boundary. Instead, SCATTER scales the total emissions arising from petroleum refineries to the local authority level by population and household figures as well as accounting for the in-boundary energy consumption of the refinery itself – which is approximately 5% of the total energy produced at the refinery.

This approach allows a more representative in-boundary figure to be calculated for the emissions **as a result of the refinery itself** as well as **a regionally-scaled proportion of the refinery's products.**

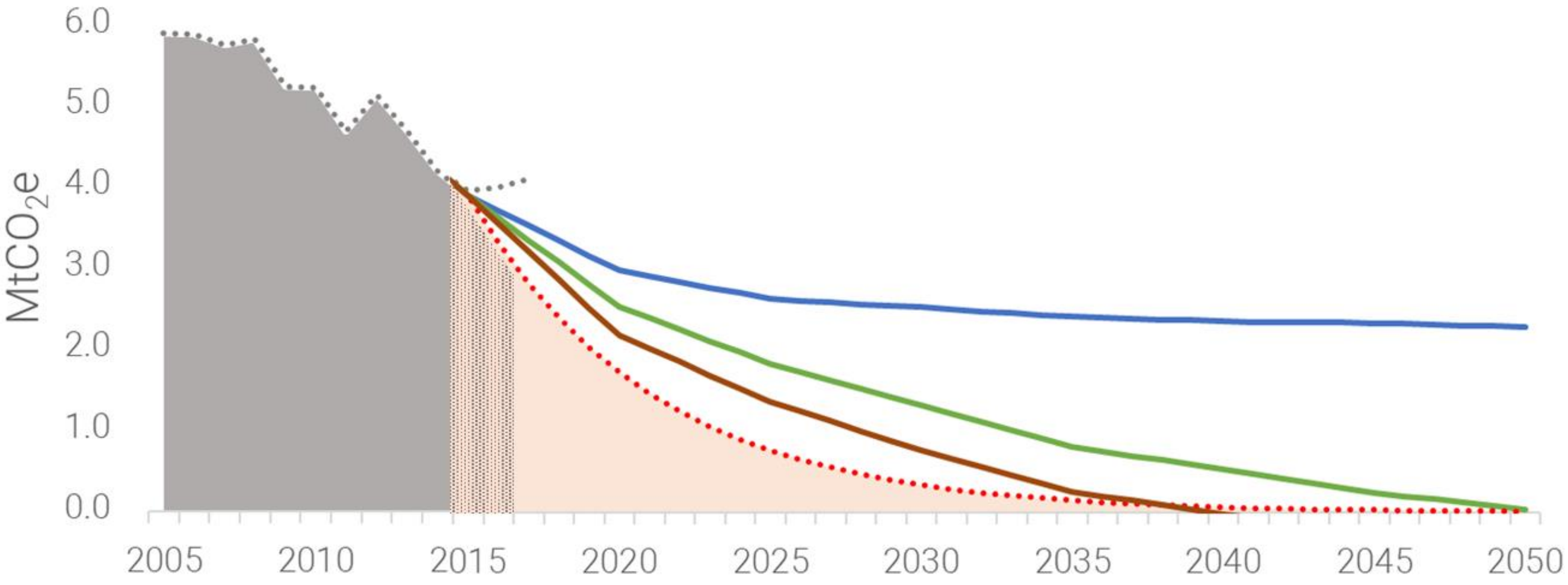
Appendix 3

Comparison with Another Local Authority

Given the unique challenges posed by the heavy industry in the CW&C region, we have investigated what a less industrial local authority's Level 4 trajectory would look like if starting out from the same point as CW&C. The result is shown below by the maroon line.

For this, we selected a local authority with a very similar GVA and population profile to CW&C – both are within 3% of CW&C. The grand total value of emissions from this local authority deviates from the mean value of all local authorities by approximately 10%, so it is also a useful insight into what an 'average' version of CW&C would look like in terms of emissions.

The emissions profile of this local authority has been scaled to that of CW&C (to allow the two plots to be superimposed on top of one another) and has been modelled to follow the same Level 4 pathway interventions as those which return the green line.



The key difference between the two local authorities is that the maroon trajectory corresponds to a more typical emissions profile with much less weighting towards heavy industry. This means that the barriers associated with reaching carbon neutrality are much less focused on commercial and industrial sectors which are associated with the most difficult-to-remove emissions (e.g. freight, industrial processes etc.).

The modelled 'average' local authority achieves carbon neutrality at some point in 2039 having followed the most ambitious SCATTER pathway.

Appendix 4
The Use of Scaling Factors Within SCATTER

Notes:

- The SCATTER inventories and the BEIS inventories do not directly overlap as a result of their slightly different scopes. SCATTER produces forecasts for emissions between 2015 and 2050. BEIS has since published figures for the early part of this range (2015-2017) which do not match the forecasted values from SCATTER.
- For visualisation purposes, a scaling factor is applied to the SCATTER data which allows the forecasted data to be represented as a continuation of historical BEIS data. This scaling factor is applied equally across all measures, interventions and sectors.
- The scaling factor is employed to allow the overlaying of SCATTER with BEIS data and serves as an acknowledgement of the differing scopes of the two emissions reporting methodologies. In both cases it shows the relative impact of a set of carbon reduction measures – the key variable being the base year.
- The table opposite shows both scaled and unscaled cumulative totals for CW&C to 2050.
- The Tyndall Centre cumulative budget is 24 $MtCO_2$ for the period of 2020 to 2100.

Cumulative totals of $MtCO_2$ (BEIS) and $MtCO_2e$ (SCATTER L1 & L4 Pathways) to 2050

Year	BEIS	L1 Pathway		L4 Pathway	
		Scaled	Unscaled	Scaled	Unscaled
2015	3.94	3.89	4.75	3.89	4.75
2017	12.04	11.12	13.59	10.85	13.26
2025	-	34.40	42.04	29.78	36.36
2030	-	47.20	57.67	37.37	45.64
2050	-	94.43	115.39	48.00	58.63

Appendix 5

Summary List of Interventions and Modification Summary

Measure	Updated from original Pathways Calculator?
Energy generation & storage	
Onshore wind	N
Biomass power stations	Y
Solar panels for electricity	N
Solar panels for hot water	N
Storage, demand shifting & interconnection	N
Geothermal	N
Hydro	N
CCS	N
Bioenergy sourcing	
Increase in land used to grow crops for bioenergy	Y
Reduction in quantity of waste	N
Increase the proportion of waste recycled	Y
Bioenergy imports	N
Transport	
Reducing distance travelled by individuals	N
Shift to zero emission transport	Y
Choice of fuel cell or battery powered zero emission vehicles	N
Freight: Shift to rail and water and low emission HGVs	N

Measure	Updated from original Pathways Calculator?
Domestic buildings	
Average temperature of homes	N
Home insulation	Y
Home heating electrification	Y
Home heating that isn't electric	N
Home lighting & appliances	N
Electrification of home cooking	N
Commercial buildings	
Commercial demand for heating and cooling	Y
Commercial heating electrification	Y
Commercial heating that isn't electric	N
Commercial lighting & appliances	N
Electrification of commercial cooking	N
Industrial processes	
Energy intensity of industry	Y

Notes:

- Updates flagged do not include scaling to local region – it is assumed that this happened for all measures. They relate to instances where the upper threshold of the ambition has been pushed further(i.e. at Level 4)
- Updates exclude alignment of Level 1 ambition to the National Grid FES (2017)
- Note that bioenergy source did not have material bearing on the model due to assumptions linked to bioenergy shortfalls (i.e. it is assumed that bioenergy would be sourced from outside of region, or another renewable source would be used). Waste assumptions may however drive more sustainable consumption behaviours.

Appendix 6

Domestic Retrofit Measures Assumed within SCATTER

Retrofit Measure	Number of households retrofitted per annum						
Year	2020	2025	2030	2035	2040	2045	2050
Solid wall insulation	1,135	1,087	1,034	996	1,314	12	12
Cavity wall insulation	2,268	206	203	181	238	-	-
Floor insulation	1,295	1,240	1,179	1,136	1,500	1,299	1,299
Superglazing	2,576	2,465	2,345	2,259	2,982	2,582	2,582
Lofts	2,743	2,630	2,500	2,413	3,320	-	-
Draughtproofing	9,050	553	546	487	666	13	13

Notes:

- This data is included within SCATTER but is not directly linked to the emissions calculation in the model (it was used to inform cost assumptions in the original legacy DECC 2050 Pathways calculator).
- The numbers shown are the minimum assumed measures for the L4 Pathway, as ambition was pushed further than the legacy DECC tool to which this table relates.
- 2050 household levels are predicted to be 154,851, derived from non-region specific growth assumptions in legacy DECC Pathways tool.
- Household is defined as per https://www.gov.uk/guidance/definitions-of-general-housing-terms#household
- The average heat loss per home includes new builds (at PassivHaus standard), which will contribute to lowering the average over time.
- For further detail, please refer to Section D of the DECC 2050 Pathways guidance:

Appendix 7

Energy Performance Certificates (EPCs)

Non-domestic EPC ratings for CW&C, 2008-19	
EPC rating	Number of lodgements
A	72
A+	5
B	429
C	1,532
D	1,717
E	867
F	329
G	402
Not Recorded	1
Total number of lodgements	5,354

Domestic EPC ratings for CW&C, 2008-19	
EPC Rating	Number of lodgements
A	43
B	2,426
C	27,076
D	42,346
E	17,536
F	4,947
G	1,580
Not Recorded	1
Total number of lodgements	95,955

Notes:

- Defining in terms of 'lodgements' allows direct comparison between domestic and non-domestic property.
- Only 66% of domestic properties carry a publicly available EPC rating.
- Live reporting on the EPC ratings of all properties (both domestic and non-domestic) can be found at: https://www.gov.uk/government/statistical-data-sets/live-tables-on-energy-performance-of-buildings-certificates#epcs-for-all-properties-non-domestic-and-domestic

Appendix 8

Domestic & Commercial Heating and Hot Water Systems Assumed Within SCATTER

Heating and hot water systems share, as a % of households				
Technology package	2020	2025	2030	2050
Gas boiler (old)	44%	37%	31%	6%
Gas boiler (new)	39%	34%	28%	6%
Resistive heating	7%	7%	7%	7%
Oil-fired boiler	6%	6%	5%	1%
Solid-fuel boiler	2%	2%	2%	0%
Stirling engine μCHP	-	-	-	-
Fuel-cell μCHP	-	-	-	-
Air-source heat pump	1%	9%	18%	52%
Ground-source heat pump	-	4%	9%	26%
Geothermal	-	-	-	-
Community scale gas CHP	1%	0%	0%	0%
Community scale solid-fuel CHP	-	-	-	-
District heating from power stations	-	0%	1%	3%

Heating and hot water systems share, as a % of total demand (TWh)				
Technology package	2020	2025	2030	2050
Gas boiler (old)	45%	37%	30%	0%
Gas boiler (new)	16%	13%	11%	0%
Resisitive heating	18%	16%	14%	7%
Oil-fired boiler	8%	7%	5%	0%
Solid-fuel boiler	-	-	-	-
Stirling engine μCHP	-	-	-	-
Fuel-cell μCHP	-	-	-	-
Air-source heat pump	9%	17%	26%	60%
Ground-source heat pump	4%	9%	13%	30%
Geothermal	-	-	-	-
Community scale gas CHP	-	-	-	-
Community scale solid-fuel CHP	-	-	-	-
District heating from power stations	-	1%	1%	3%

Notes:

- Matrix is unchanged from original DECC Pathways Calculator. It is acknowledged newer technologies or fuel sources such as Hydrogen are not reflected in this tool.

Appendix 9
Transport Assumptions

Projection of modal share of transport (units: % of passenger-km)			
Mode	2015	2050 L1	2050 L4
Walking	4%	4%	4%
Bicycles	1%	1%	5%
Cars, Vans, and Motorcycles	80%	80%	62%
Buses	5%	5%	19%
Railways	9%	9%	10%
Travel demand relative to 2015	100%	100%	75%

Ambition level (units: Pax* / vehicle-km) @ 2050			
Mode	2015	2050 L1	2050 L4
Cars, Vans, and Motorcycles	1.56	1.56	1.65
Buses	11.32	11.32	18.00
Railways	0.32	0.37	0.42

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*Pax ~ people/persons/occupants

Appendix 10

Waste & Industry Sector Focus

A large proportion of CW&C's emissions can be attributed to the various industries in the region. By using GVA data we can observe the dominant industries within the region and compare and contrast against national proportions. This can then offer an indicator for the heaviest-emitting industries. The table opposite shows the proportion of total GVA for selected SIC subsectors at both the national and regional level.

The CW&C economy is underpinned by the manufacture of petroleum, chemicals and other minerals as well as the manufacture of machinery and transport equipment. In both of these sectors the contribution to the region's total GVA is many times greater than the national average.

A note on GVA

GVA (*gross value added)* offers insight into the financial impact of a given industry on a region. Traditionally GVA is calculated by adding up the financial components of an industry; compensation of employees, rental income, gross trading profit, surplus and so on.

The regional GVA data analysed here is based upon a 'balanced approach' which incorporates aspects of the two mainstream approaches used to calculate regional (and national) GVA figures ('production' and 'income').

This balanced approach allows regional estimates of the GVA from SIC industry sectors.

SIC07 description	% GVA contribution	
	CW&C	UK
Manufacture of petroleum, chemicals and other minerals	13%	2%
Manufacture of machinery and transport equipment	6%	2%
Total manufacturing	22%	10%
Total services sector	70%	79%
Construction	5%	6%

Selected SIC industry sectors within CW&C which represent contributors to GVA that deviate most strongly from the national levels. ONS data source.

By contrast, industries within the services sector are less heavily relied upon as compared to the UK proportion. The services sector describes commercial industries such as food and beverage, retail and entertainment as well as public admin services and real estate.

Appendix 11

Land Use

The table opposite shows a full list of land-use by standard codes taken from the Crop Map of England.

LU Code	LU description	Hectares
NA01	Non-Agricultural Land	30,632
PG01	Permanent Grassland	25,175
WO12	Woodland	12,323
AC17	Maize-type arable crop	6,330
AC66	Wheat (winter) - type arable crop	4,186
FA01	Land lying fallow	2,579
AC01	Barley (spring)- type arable crop	2,068
HE02	Bracken, heather and heathland	2,044
AC44	Potato-type arable crop	1,606
AC19	Oats (spring)- type arable crop	1,573
AC63	Barley (winter)- type arable crop	1,158
LG20	Field beans (winter)-type leguminous and nitrogen-fixing crop	1,108
AC67	Oilseed (winter)- type arable crop	1,067
LG03	Field beans (spring)-type leguminous and nitrogen-fixing crop	878
WA01	Water	418
AC65	Oats (winter)- type arable crop	415
AC32	Wheat (spring) - type arable crop	259
AC03	Beet-type arable crop	103
AC68	Rye (winter)-type arable crop	80
LG11	Lucerne-type leguminous and nitrogen-fixing crop	48
LG07	Pea (spring)- type leguminous and nitrogen-fixing crop	29
TC01	Permanent crops other than nursery crops and short rotation coppice	18
LG14	Clover-type leguminous and nitrogen-fixing crop	17
AC16	Linseed (spring)- type arable crop	7
	Total	94,121

Appendix 11 (cont.)

Inclusions, Exclusions and Methodology Assumptions for Land-use Studies

Inclusions and Exclusions

Analysis in this section include the major sources of greenhouse gases (methane from livestock and nitrous oxide from manure and artificial fertilizers). It is assumed that livestock are managed according to the UK "average" e.g. dairy cattle are outside for about one-quarter of the year, and beef cattle for about one-half.

In practice, some areas will be under environmental stewardship schemes which promote better land management practices. These numbers could be refined using actual data in a more detailed study.

It is possible that land management practices such as additions of manure to grassland or cropland may add to soil carbon stocks. However, it would require scientific study of the area to ascertain whether this is the case and to quantify any gains (or losses).

Emissions from fossil fuel use (e.g. diesel used for machinery and crop drying) are excluded in this section.

Methodology

Datasets used to compile the maps are as follows:

- The crop map is from a 2018 survey
- The livestock numbers are from 2016
- The National Inventory data is from 2018
- The soil carbon maps are from 2007 data

The analyses are limited by the resolution of the underlying map data, meaning that values for areas are estimates and will differ from the 'actual' area as a result.

Emissions from agriculture and land-use are subject to very large error bands and should be taken to be high-level estimates only.

Cattle numbers are only available at the high level for local regions (i.e. total number of cattle) so these have been divided into 'dairy' and 'non-dairy' using averages for larger regions. Emissions from livestock are estimated using emissions factors based on national averages. It is also assumed that all manure from livestock is spread on land within the local region and none is imported / exported.

Actual emissions will vary considerably based on factors including the composition of livestock within categories, their diet, milk production, housing and manure management practices. More detailed information on livestock numbers and farming practices would help produce better estimates. Emissions from livestock include methane from enteric fermentation, methane from manure storage and direct nitrous oxide emissions from manure management when housed.

Nitrous oxide emissions from land-use are based on average fertiliser application rates and standard UK emissions factors. They only include direct emissions from fertiliser dropped by livestock on the land and artificial fertilisers used on the land. They do not include indirect emissions from volatilisation, which could be significant but require further research as to their applicability before inclusion. Similarly, estimates of carbon stocks in soil are subject to large error bands as they vary considerably according to soil type, soil depth, current and historic land-use and current management practices.

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