Oxford City Council

Climate Emergency Strategy Support

September 2019

OXFORD CITIZENS ASSEMBLY
ON CLIMATE CHANGE

Anthesis

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1. Introduction & Scope

Introduction

The 2018 Intergovernmental Panel on Climate Change (IPCC) report warned that the current global target of 80% cut in carbon emissions by 2050 is not enough to avert catastrophic temperature change. It said it's essential that global temperature change is limited to 1.5 degrees Celsius and that rapid, far-reaching and unprecedented changes in all aspects of society are required to ensure this.

In January 2019, Oxford City Council members unanimously declared a climate emergency and agreed to create a citizens assembly in Oxford to help consider new carbon targets and additional measures to reduce emissions. In April, Members set a vision to reduce the City Council's own emissions to net zero by 2030 at the latest.

The Oxford Citizens Assembly on Climate Change will involve a randomly-selected representative sample of 50 Oxford residents who will learn about climate change and explore different options to cut carbon emissions through a combination of presentations from experts and facilitated workshops. Oxford is the first city in the UK to deliver a citizens assembly on the topic of climate change.

Participants in the Assembly will consider measures to reduce Oxford's carbon emissions to net zero and, as part of this, measures that reduce Oxford City Council's own carbon footprint to net zero by 2030. The will be asked to provide a view to Councillors on where they think the Council should focus its activities.

Oxford City Council's influence is varied and complex across the different activities that occur within their own operations and also within the city. This report seeks to set out areas that the City Council has control or influence over in order to make a meaningful impact on carbon emissions. This report has thus provided the focus for the topics under discussion at the Citizens Assembly.

Scope of work

This current commission seeks to build on the two prior engagements and support the council in their preparation to host the Citizens Assembly in September 2019.

The areas of focus in this report are:
1. Current profile – Overlaying Oxford-specific context on the city's emissions inventory.
2. Future pathways – Providing further context in relation to the forward looking pathways generated by the SCATTER tool.
3. Council Influence – Understanding and documenting where areas of stronger potential influence may exist, and seeking to quantify this where possible.
4. Other mitigation options – exploration of offsetting, out of boundary renewable energy purchasing, land and agriculture sequestration.

1. Introduction & Scope

Process to date

The diagram (right) sets out some key activities that Oxford City Council has performed or is planning to perform.

2008
Oxford City Council Members launch their first Carbon Management Plan.

2010 -2013
Low Carbon Oxford partnership established: More than 50% of city's emissions represented (2010).
EU funded OxFutures programme established to leverage investment in community owned renewables (2012).
Second Carbon Management Plan launched. 25% carbon reduction achieved to date. (2013).

2018
Zero Emissions Zone (ZEZ) plans published, which sets a goal for zero transport emissions in Oxford by 2035.

January 2019
Oxford City Council Members unanimously declare a Climate Emergency.

June-August 2019
Senior officers in Oxford City Council convene to understand what it may mean to decarbonise the city, and influence they may have, in light of the most recent science[1]. Anthesis prepare briefing pack for Council leaders (this document).

September 2019
Oxford to host the first UK City's Citizens Assembly on Climate Change.

January 2020
Preparation of new sustainability strategy for Oxford begins following recommendations from the Citizens Assembly.

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

2. Current Emissions Profile

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2. Current Emissions Profile
Summary

The figures and charts presented below summarise the emissions relating to the area administered by Oxford City Council. 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 overleaf (see Appendix 1 for full data tables).

Chart 1: 2016 SCATTER Direct & Indirect Emissions – Summary, $ktCO_2e$

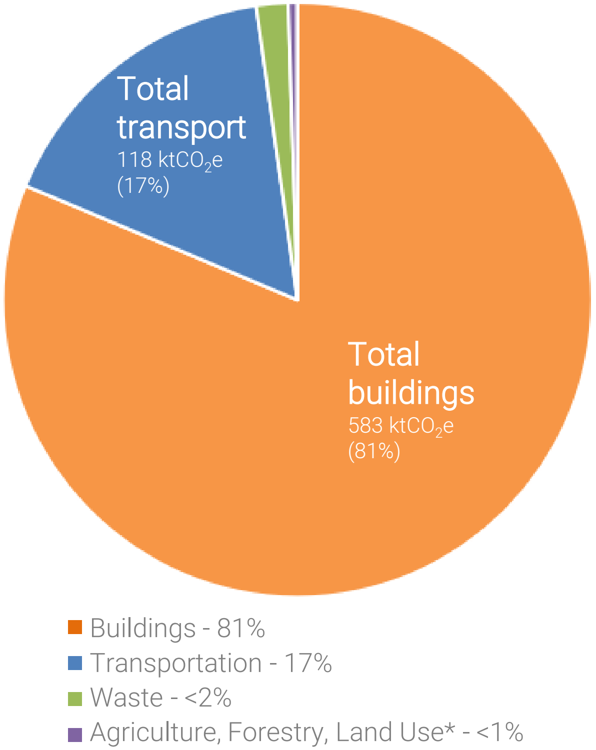


Chart 2: 2016 SCATTER Direct & Indirect Emissions – Sub-sectors, $ktCO_2e$

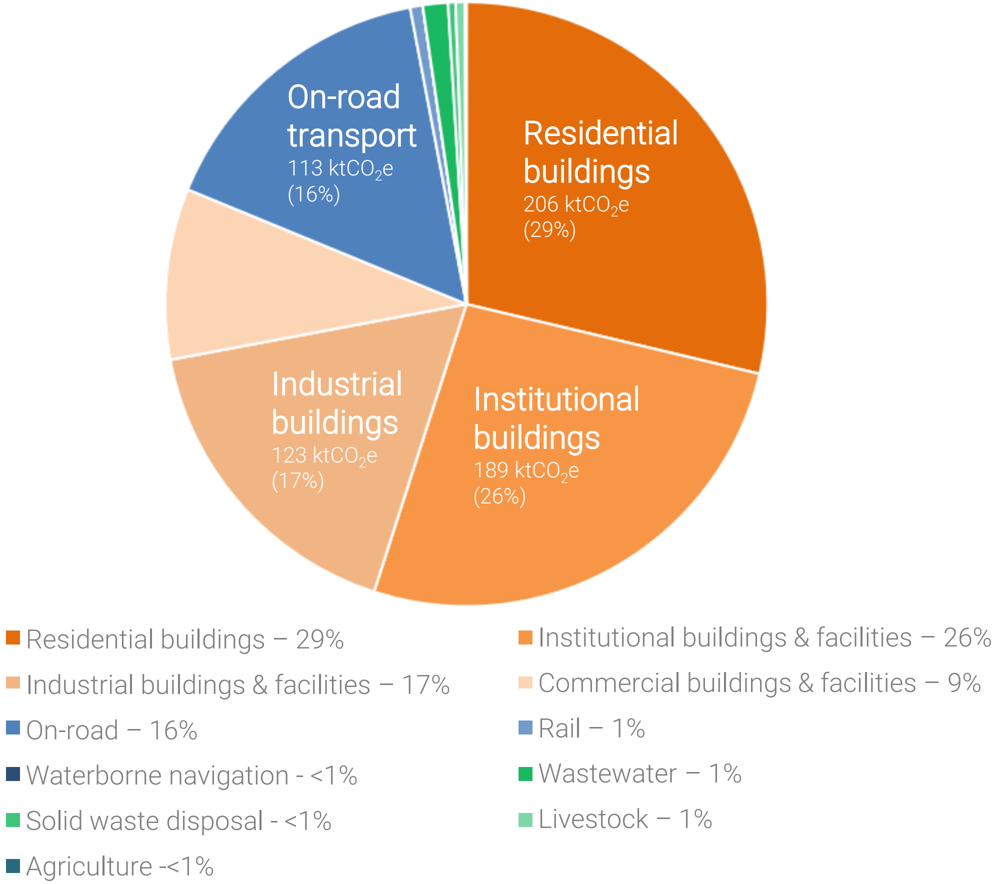
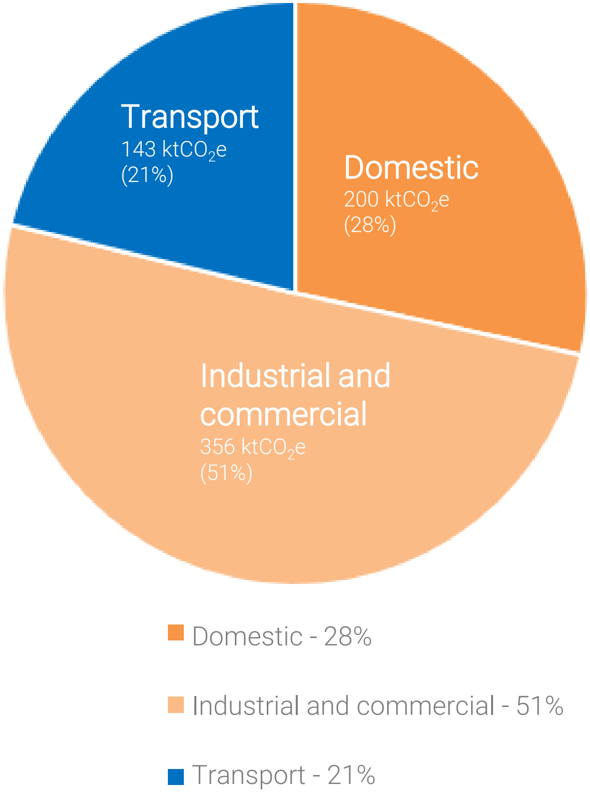


Chart 3: 2017 BEIS Direct & Indirect Emissions – Summary, $ktCO_2e$



2. 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 city boundary (also referred to as Scope 2).

Other = All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city 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. Other Scope 3 emissions are however explored within Sections 2 and 3.

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 City of Oxford region.
- The full methodology available on request at http://SCATTERcities.com.

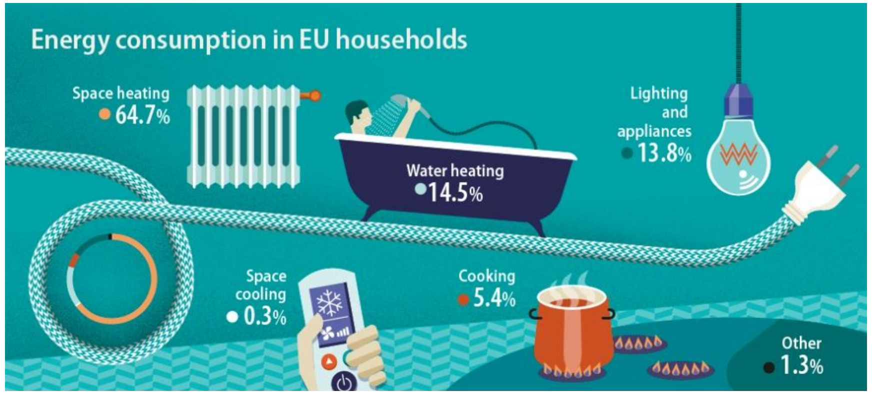
Why does the BEIS summary differ from the SCATTER summary?

- 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 3 of this report.

2. Current Emissions Profile

Residential Buildings

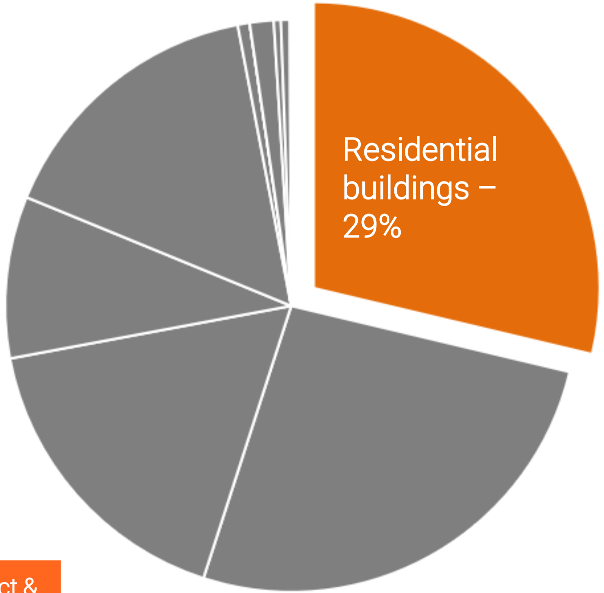
Emissions from energy and fuel use in residential buildings is the greatest single contributor to Oxford's carbon footprint - 29% in total.



Energy use in the home may follow this EU approximation: Heating is by far the greatest source of energy consumption (64.7%) in residential buildings. It is followed by water heating (14.5%), lighting and appliances (13.8%), and cooking (5.4%). [1]

Sub-sector (Buildings & Facilities only)	Direct (Scope 1) tCO_2e	Indirect (Scope 2) tCO_2e	Total Direct & Indirect	
Residential	131075	75067	206142	35%
Commercial	40816	24832	65647	11%
Institutional	63056	125480	188536	32%
Industrial	49995	72738	122734	21%
Total (Buildings & Facilities only)	284942	298117	583059	100%

Table 1: Breakdown of building emissions, tCO_2e. Residential emissions account for 35% of the total emissions by buildings. 2016 data as split by SCATTER



Barton in Oxford is ranked amongst the 15% most deprived neighbourhoods in England. Its basic, steel frame pre-fabricated houses don't retain heat and are very energy inefficient, leading to high fuel bills and impacts on health and wellbeing.

Image: Low Carbon Hub. Houses before (left) and after (right) deep retrofit measures. External wall insulation among one of many retrofit measures applied.

Oxford has around 60,000 homes, of which approximately 12,000 are socially rented (of which approximately 7,800[2] are owned by the council). Various housing providers exist across the entire city.

Residential type	Total Direct & Indirect tCO_2e	
Socially rented	43290	21%
Non-socially rented	162852	79%
Total	206142	100%

Table 2: Breakdown of emissions between socially and non-socially rented residential buildings, CO_2e. Source: 2011 UK Census. Note: 'non-socially rented' refers to private rental accommodation. Figures are based on Oxford's emissions (as presented on Chart 2) using ONS data to allocate emissions accordingly.

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1 – EC Eurostat: https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20190620-1
2 – Oxford City Council internal data source

2. Current Emissions Profile

Institutional Buildings & Facilities

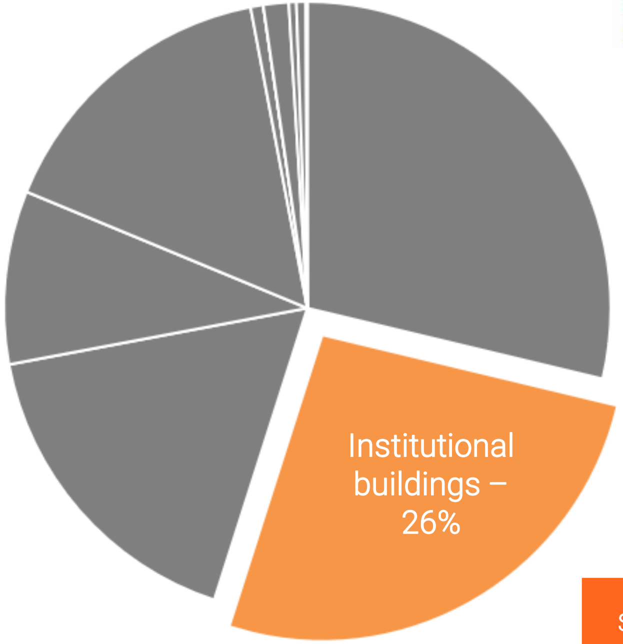
Among the buildings sector, the institutional buildings sub-sector is the second biggest contributor to direct carbon emissions in Oxford, responsible for over 25% of the city's total emissions.

The University of Oxford and Oxford Brookes University have substantial energy requirements associated with management of their buildings (e.g. libraries, events spaces, sports facilities, halls of residence, etc.). The University of Oxford is the single greatest contributing organisation to the city's carbon footprint.

Image: Sidharth Bhatia/ Unsplash

Institution	Total Direct & Indirect (2017/18) tCO_2e	
University of Oxford[1]	54,826	8%
Oxford University Hospitals	17,533	2%
Oxford Brookes University[1]	10,552	2%
Oxford City Council	8,145	1%
Sub-total	91,056	13%
Oxfordshire County Council[2]	TBD	TBD
Other	627,306	87%
Total	718,362	100%

Table 3. Large institutional emitters. The University figures were provided by Oxford University and do not include emissions relating to colleges. Council 17/18 emissions here and hospitals emissions estimated from here. Schools maintained locally by the Council will be included, however privately maintained schools will not.



The City Council has a substantial carbon footprint associated with the heating and electricity requirements of its operational buildings (e.g. office buildings, depots, leisure centres, car parks, sports pavilions, public conveniences and other miscellaneous sites).[3]

There are four hospitals within the Oxford University Hospitals NHS Foundation Trust (John Radcliffe, Churchill, Nuffield Orthopaedic Centre and Horton General). Annual spending on utilities in 2017/18 was over £10 m, with a scope 1 and 2 carbon impact of over 17,500 t CO_2e.

Table 4: Breakdown of building emissions, tCO_2e. Institutional emissions account for 32% of the total emissions by buildings. 2016 data as split by SCATTER

Sub-sectors (Buildings & Facilities only)	Direct (Scope 1) tCO_2e	Indirect (Scope 2) tCO_2e	Total Direct & Indirect, tCO_2e	
Residential	131075	75067	206142	35%
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Industrial	49995	72738	122734	21%
Total (Buildings & Facilities only)	284942	298117	583059	100%

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1 - University emissions are assumed to all occur within the city boundary. In reality, there may be some of the estate that sits outside of the City of Oxford boundary.
2 - It was not possible to identify the County Council emissions impacts that occur within the City of Oxford boundary based on publicly available information (at the time of writing).
3 - https://www.oxford.gov.uk/downloads/file/4909/greenhouse_gas_emission_report_2017-18

2. Current Emissions Profile
Industrial Buildings & Facilities

Industrial buildings and facilities are those involved in the manufacturing of products. This sub-sector is estimated to be responsible for 17% of Oxford's total carbon footprint.

There is a wide range of manufacturing businesses in Oxford, with a notable proportion of automotive and hi-tech engineering and pharmaceuticals companies.

Similarly to for commercial buildings (see following slide), it is difficult to access data on the carbon footprint of small to medium-sized companies within this sub-sector.

Image: Crystal Kwok/ Unsplash

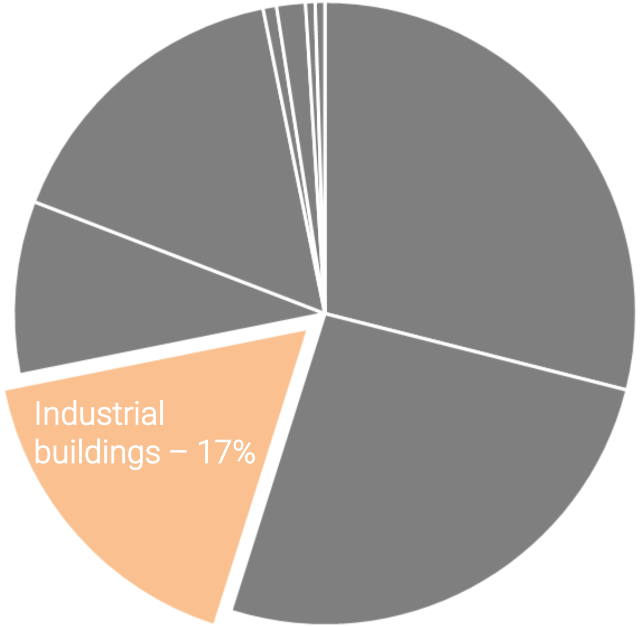

Image: Jon Lewis/ oxfordmail.co.uk

BMW MINI Plant Oxford accounts for nearly half of citywide industrial space. BMW are one of the largest employers in the region and were one of the founding members of Low Carbon Oxford. The Oxford facility is home to the largest Solar PV array in the city.

Since production of the new MINI started in 2001, more than 2.5 million cars have been made at Plant Oxford. BMW, have invested over £1.5 billion in the car plant in Oxford over the past ten years.

Table 5: Breakdown of building emissions, tCO_2e. Industrial emissions account for 21% of the total emissions by buildings. 2016 data as split by SCATTER

Sub-sectors (Buildings & Facilities only)	Direct (Scope 1) tCO_2e	Indirect (Scope 2) tCO_2e	Total Direct & Indirect, tCO_2e	
Residential	131075	75067	206142	35%
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2. Current Emissions Profile

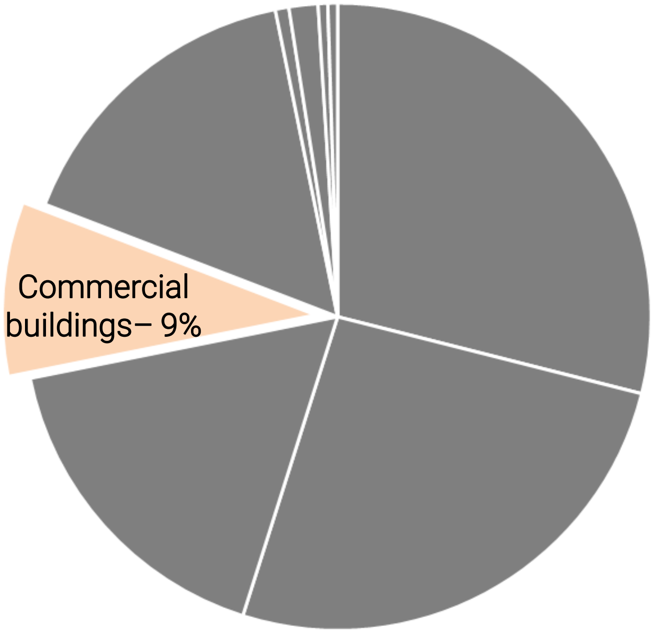
Commercial Buildings & Facilities

Just under 10% of Oxford's carbon footprint is attributable to commercial buildings and facilities.

The City of Oxford is home to around 5,300 businesses, collectively employing approximately 133,000 people. 62% of these businesses employ fewer than 5 people, with 12% employing over 20.[1]

While a large number of people in the city are employed in universities and the public sector, there are also significant jobs in other sectors including publishing, tourism, customer services, hospitality and a growing hi-tech sector.

The city is home to diverse international enterprises including Oxford University Press, Unipart, Centrica, Amey, Nielsen and TripAdvisor among numerous others.



While large companies often report on their overall carbon impact, there is no centralised system for collecting and communicating their impact at a city level. Smaller and medium sized companies are often not mandated by law to disclose information on their carbon emissions and may not have the necessary resources to commit to measurement and reporting.

There are therefore significant challenges around understanding the proportion of Oxford's carbon footprint attributable to commercial buildings & facilities.

Table 6: Breakdown of building emissions, tCO_2e. Commercial emissions account for 11% of the total emissions by buildings. 2016 data as split by SCATTER

Sub-sector (Buildings & Faciliteis only)	Direct (Scope 1) tCO_2e	Indirect (Scope 2) tCO_2e	Total Direct & Indirect, tCO_2e	
Residential	131075	75067	206142	35%
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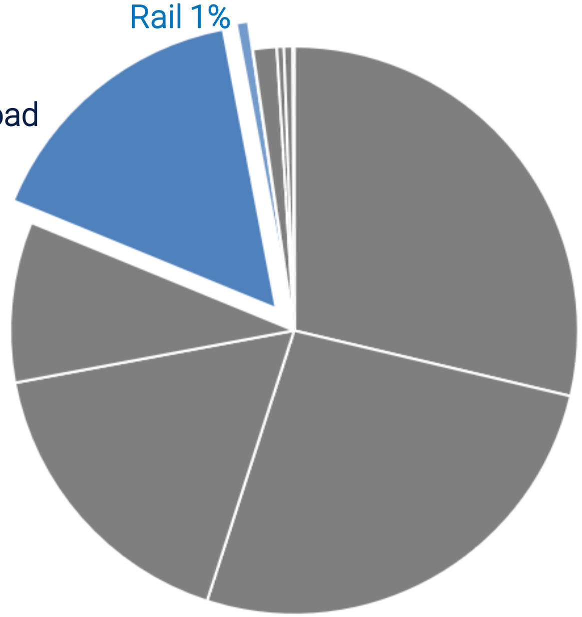
1 - https://www.oxford.gov.uk/downloads/file/3795/oxford_economic_profile_january_2018

2. Current Emissions Profile

Transport

Transport accounts for 17% of Oxford's total emissions. This is broken into two sub categories, on-road and rail emissions. Oxfordshire County Council is the local Transport Authority.



Commuters

In 2011 there were over 100,000 average daily commuter trips, as reported in the Oxford Transport Strategy, with subcategories published by the Office for National Statistics.

Commuting Method	2011 Inflow	2011 Outflow
Car or van	30,592	9,882
Train	2,420	1,446
Bus	6,992	2,063
All methods	45,852	16,013

Table 7: Number of people entering (inflow) or leaving (oxford) for work (daily). 2011.

Sector	Direct (Scope 1) tCO_2e	Indirect (Scope 2) tCO_2e	Total Direct & Indirect, tCO_2e	
Buildings	285,493	298,121	583,614	81%
Transportation	**118,337**	**0**	**118,337**	**17%**
Waste	12,540	0	12,540	<2%
Agriculture, Forestry, Land Use	3,591	0	3,591	<1%
Industrial Processes	0	0	0	0%
Total	419,961	298,121	718,082	100%

Table 8: Breakdown of transport emissions, tCO_2e. On-road and rail emissions account for 17% of the total emissions in Oxford. 2016 data as split by SCATTER

Oxford Buses

Upwards of 190 buses and coaches enter the city per hour at peak times. The main bus companies in Oxford are :

National Bus Provider	No. of Oxford Services
Thames Travel	16
Stagecoach	53
Oxford Bus Company	18

Table 9: Number of Oxfordshire bus services within or that pass through and stop in the City of Oxford. Taken from Oxford Transport Strategy.

Oxford Railway Station

Emissions from rail are significantly lower, yet In 2017/18 there were a total of ~8 million annual rail passengers through Oxford Railway Station.
There are presently three main train providers at Oxford Railway Station.

National Rail Provider	No. of Oxford Services
Chiltern Railways	2
CrossCountry	2
Great Western Railway	2

Table 10: Number of train services by provider. 2019.

Furthermore ~26% of total Oxford train movements were freight (this percentage is likely to have increased) since 2010.

Mitigation

The Oxford Low Emission Zone aims to reduce the most harmful emissions in the city centre, with a zero emission zone being considered for the city by 2035. Subsequently, electric buses are being trialled and rail electrification works may take place (but is currently not going ahead).

2. Current Emissions Profile

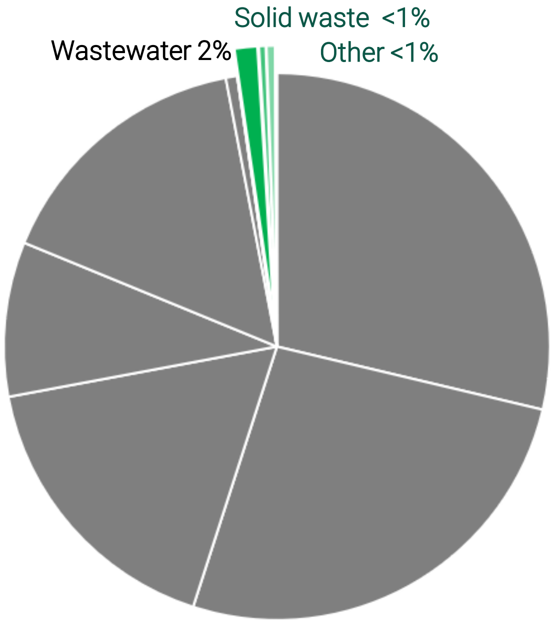
Waste

Oxford's waste treatment accounts for under 2% of Oxford's footprint. The city's solid waste treatment has three main components – energy recovery, landfill and recycling.
It is important to note that there are other emissions associated with waste, including; transport emissions from waste collection and embodied carbon within the goods consumed then disposed of.

Energy Recovery

Most non-recyclable rubbish (green bin and lilac sack) goes to Ardley Energy Recovery Facility (ERF), which diverts at least 95% of non-recyclable rubbish from landfill. This generates 24MWe of electricity enough to power ~59,616-homes, reducing GHG emissions by ~56,800t of CO_2e per annum.[1]

Food waste is used to generate power in an Anaerobic Digester just outside of the City boundary in West Oxfordshire, as the Cassington AD facility.



Sector	Direct (Scope 1) tCO_2e	Indirect (Scope 2) tCO_2e	Total Direct & Indirect, tCO_2e	
Buildings	285,493	298,121	583,614	81%
Transportation	118,337	0	118,337	17%
Waste	**12,540**	**0**	**12,540**	**<2%**
Agriculture, Forestry, Land Use	3,591	0	3,591	<1%
Industrial Processes	0	0	0	0%
Total	419,961	298,121	718,082	100%

Table 11: Breakdown of waste emissions, tCO_2e. Waste accounts for under 2% of the total emissions by buildings. 2016 data as split by SCATTER

Non-recyclable

Oxford produces approximately 80,800t of non-recyclable waste per year[2]. The majority of which will be incinerated at Ardley ERF.

Recycling

The City of Oxford's recycling rate is ~50%.[3]
Other organizations working to decrease waste include:

Oxford Wood Recycling is owned by its members, who are its workers and regular volunteers, helping to further reductions, reuse and recycling.

Oxford Food Surplus Cafe reduces food waste and helps to help redress the imbalance in our food system by reclaiming surplus food and transforming it into healthy meals accessible to all

Commercial Waste

In 2012/13 the City Council collected 63t of food waste for re-processing from business. City Council has a corporate target to reduce carbon emissions from its activities by a 5% per year until 2016/17.

1 - https://www.viridor.co.uk/energy/energy-recovery-facilities/ardley-erf/
2 - https://www.gov.uk/government/statistical-data-sets/env18-local-authority-collected-waste-annual-results-tables
3 - https://www.oxfordmail.co.uk/news/17653751.recycling-rates-for-oxfordshire-every-council-ranked/

3. Future Pathways

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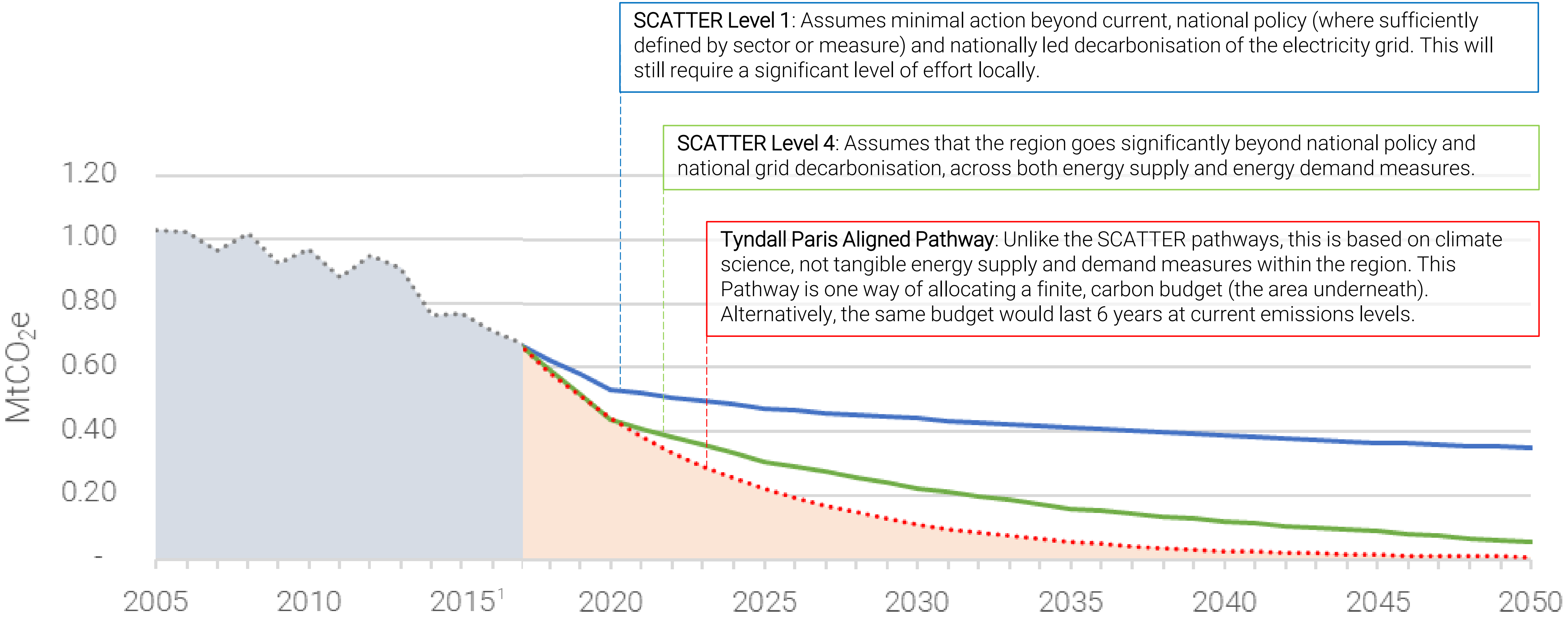
3. Future Pathways
Summary

Oxford City Carbon Budget and Pathways for the City-Wide Energy System, Annotated.

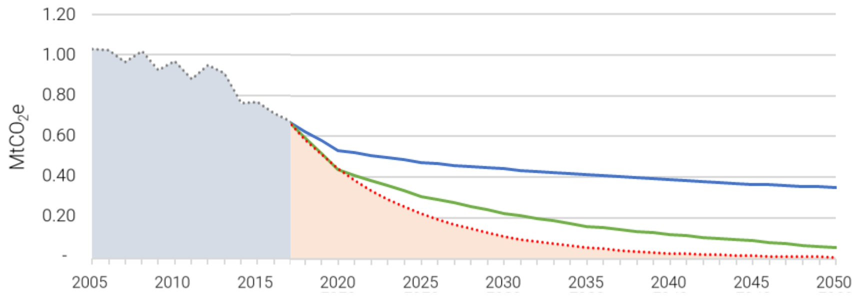


1- Local Authority emissions & energy consumption data is published 2 years in arrears. SCATTER Tool operates from 2015 Base year, with adjustments made using 2016 & 2017 BEIS Local Authority Emissions data Tyndall budget assumes 6 years at current levels from 2020.

3. Future Pathways

Summary

Oxford City Carbon Budget and Pathways for the City-Wide Energy System, Not Annotated.



SCATTER "Level 1' Pathway – Assumes the selected region doesn't take much action beyond current, national policy (where sufficiently defined by sector or measure) 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 2 for further details.

Tyndall Paris Aligned Budget – The finite, cumulative amount that the region should emit between 2020 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 City of Oxford. The pathways do not represent reductions outside of the City of Oxford 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).

The City of Oxford 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'.

1 – The BAU carbon intensity of electricity tracks the National Grid Future Energy Scenario (FES) "2 Degrees", 2017), on the basis that this was aligned with the legislated targets at the time the SCATTER tool was developed (December 2017).
2 – This is based on information not yet publicly available, however the method is broadly comparable with work performed for Sheffield City Council, 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, 2017 published data is represented on the graph as the SCATTER Pathways tool had not been updated at the time of writing. % Reduction figures presented do reflect the 2018 published BEIS data

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3. Future Pathways

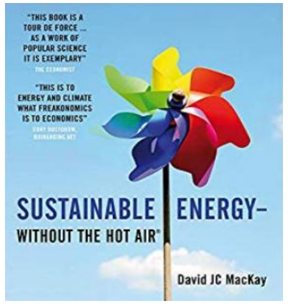
About the SCATTER model

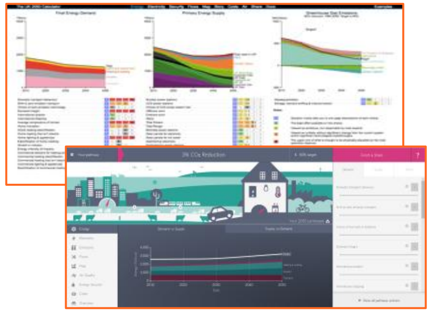
SCATTER is intended to serve as one of many information sources to help users inform their priorities for emissions reduction. Specifically with reference to the forward looking pathways modelling element, it is intended to focus on the 'what' rather than the 'how'. It is important to note that SCATTER 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 principals

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.

3. Future 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 target (the *Two Degrees* FES), electricity demand still increases. SCATTER’s ‘Level 4’ 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 city level. For example, energy bills can reduce and at a city 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 12: Comparison of changes in future electricity demand assumptions

Source	Change in current[1] demand	
	2030	2050
FES Two Degrees (2019)	▲ 5%	▲ 48%
SCATTER “Level 4" Pathway	▼-2%	▼-11%

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 global emissions targets[2].

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

3. Future Pathways

Domestic Buildings

The following tables provide proxies for the nature and extent of Oxford specific measures. These are all assumed in order to track the green SCATTER Level 4 (L4) Pathway, as presented on the graph on page 15.

Measure	Current City of Oxford Context	SCATTER L4 Pathway		
		2025	2030	2050
Improved insulation	2,687 Energy Company Obligation (ECO) measures installed (<5% of households) to date[1] 11.7% of households are fuel poor[2] 8,000 new homes by 2026[3] 59% of homes are EPC rated D or below[4] 233 Watts/°C average heat loss per house	51,420 homes have had 'some form'[5] of retrofit (80%) C.2,781 New build since 2019 to PassivHaus Standard Retrofit rate of c.1,800 homes per year[6] 183 Watts/°C average heat loss per house	51,779 have had 'some form'[5] of retrofit (77%) C.6,054 New build since2019 to PassivHaus Standard Retrofit rate of c.1,800 homes per year[6] 158 Watts/°C average heat loss per house	54,793 have had 'some form'[5] of retrofit (76%) C.12,125 New build since 2019 to PassivHaus standard Retrofit rate of c1,800 homes per year[6] 58 Watts/°C average heat loss per house
Reduction of average temperature	17.3°C is the current average, across the year and all rooms in the house[7]	16.8°C[8]	16.7°C[8]	16.0°C[8]

1 - https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/795930/Detailed_HEE_tables_18_Apr_2019_FINAL.xlsx
2 - https://www.gov.uk/government/statistics/sub-regional-fuel-poverty-data-2019
3 - https://www.oxford.gov.uk/downloads/file/1450/oxford_core_strategy
4 - https://www.gov.uk/government/statistical-data-sets/live-tables-on-energy-performance-of-buildings-certificates#epcs-for-existing-domestic-properties
5 – Refer to Appendix 4
6 – Based on 2050 number of 54,793 over the 30 year period (i.e. starting in 2020).
7 - ECUK (2017) Table 3.16: Internal and external temperatures 1970 to 2012.
8 - Reductions may be achieved through better heating controls (i.e. 'Smart thermostats') that zone the heat, as opposed to reducing comfort or posing increased risk to the vulnerable.

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3. Future Pathways

Domestic Buildings

Measure	Current City of Oxford Context	SCATTER L4 Pathway		
		2025	2030	2050
Electrification of heat	c.50,600 gas meters in Oxford, average 2017 consumption 13,740 kWh.[1] This may imply over 80% of households use gas for heating.[2] 30 domestic Renewable Heat Incentive (RHI) installations from April 2014 to May 2019[3] Project LEO (Local Energy Oxfordshire) will encompass around 90 local low carbon energy projects which could become part of the distribution network during this time. Priority projects will include a community hydro project, an electric vehicle transport hub and heat network proposals. Refer to Appendix 5 for further detail on the type of heating technologies assumed in SCATTER.	26% of heating systems replaced in existing stock 66% Gas/oil/solid fuel fired boiler	40% of heating systems replaced in existing stock 53% Gas and oil-fired boiler	92% of heating systems replaced in existing stock 0% Gas and oil-fired boiler
Appliance & lighting efficiency	Consumption by domestic lighting and appliances in the UK has reduced by 7% (2015 compared to 2018)[4]	15% Energy reduction (from 2015 levels)	23% Energy reduction (from 2015 levels)	65% Energy reduction (from 2015 levels)
Electrification of cooking	47% Electric (2015)[5]	69% Electric	76% Electric	100% Electric

1 - https://www.gov.uk/government/statistical-data-sets/gas-sales-and-numbers-of-customers-by-region-and-local-authority
2 - Assuming 1 meter per household. 55,400 households in Oxford City area (2011 census data)
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 - 47% based on legacy SCATTER assumptions

3. Future Pathways

Non-Domestic Buildings

Measure	Current City of Oxford Context	SCATTER L4 Pathway		
		2025	2030	2050
Commercial space heating & cooling	Over 57% of Non-Domestic 'lodgments' [1] are EPC rated D and below. [2]	12% Heating & Cooling reduction	17% Heating & Cooling reduction	40% Heating & Cooling reduction
Electrification of heat	89% Gas and oil-fired boiler (2015)[3] .Refer also to Appendix 5 for further detail on the type of heating technologies assumed. Project LEO is likely to impact non-domestic buildings (see page 19).	58% Gas and oil-fired boiler	46% Gas and oil-fired boiler	0% Gas and oil fired boiler
Appliances & lighting	Consumption by non-domestic lighting and appliances in the UK has reduced by 2% (2015 compared to 2018)[4]	7% Reduction on 2015 demand	11% Reduction on 2015 demand	25% Reduction on 2015 demand
Energy used for cooking	24% Electric (2015)[3]	46% Electric	57% Electric	100% Electric

1 - A lodgement is taken to represent the non-domestic equivalent as the 'household' unit used for domestic buildings. This allows a standardised measure for comparison between domestic and non-domestic property.
2 – See Appendix 3 and https://www.gov.uk/government/statistical-data-sets/live-tables-on-energy-performance-of-buildings-certificates#epcs-for-non-domestic-properties
3 - BEIS Total sub-national final energy consumption, 2015, Total Domestic Fuel - Allocated according to ECUK proportions
4 - https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/820753/2019_Electrical_Products_Tables.xlsx

3. Future Pathways

Transport

Measure	Current City of Oxford Context	SCATTER L4 Pathway		
		2025	2030	2050
Distance reduction	Travel by car remains the dominant form of transport to all destinations other than the city centre. Since 2001, the number of journeys made by car have increased from 27,700 to 30,600.[1]	17% reduction in passenger-km per person per year	25% reduction in passenger-km per person per year	25% reduction in passenger-km per person per year
Significant modal shifts	Chiltern Railways Cowley Branch increased passenger rail services to Oxford Science Park and Oxford Business Park, saving 675 t CO_2 in avoided road traffic emissions per annum.	5% switch away from car travel mode	8% switch away from car as travel mode	18% switch away from car travel mode
Modal shift of freight and increase in efficiency	71% of Freight emissions in the UK are from road (2015).[2] Oxford aims for world's first zero emissions zone with petrol car ban. The council plans to start phasing out polluting vehicles including taxis, cars and buses from city centre area in 2020.[3]	75% of freight rail travel is diesel 25% of freight rail travel is electric 100% of freight road travel is diesel[4]	63% of freight rail travel is diesel 37% off freight rail travel is electric 100% of freight road travel is diesel[4]	100%of freight rail travel is electric 95% of freight road travel is diesel, 5% is electric[4]

Refer to Appendix 6 for further information on assumptions on other modes of transport.

1 – https://www.oxford.gov.uk/download/downloads/id/2637/54_transport.pdf
2 - Department for Transport Statistics - Table TRA3105 Heavy goods vehicle traffic by axle configuration and road category in Great Britain, 2015.
3 - https://www.oxford.gov.uk/zez
4 – SCATTER assumptions in this area do not include hydrogen as freight fuel and are left unmodified from the legacy DECC 2050 Pathways calculator

3. Future Pathways

Transport

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

Measure	Current City of Oxford Context	SCATTER L4 Pathway		
		2025	2030	2050
Shift to zero carbon cars	Eight EV charging point sites presently in Council operated car parks. 7 require membership to use. Oxford City Council increased their zero-emission fleet to 16% of their total fleet with acquisition of eight Nissan Leaf vehicles. Council in talks to phase in Zero Emission Zones between 2020-35 within the city centre. Project LEO is likely to impact transport (see page 19).	51% EV, 13% PHEV, 36% Petrol / Diesel	76% EV, 14% PHEV, 10% Petrol / Diesel	100% EV
Shift to zero carbon buses	Low Emission Zone within city centre prohibits buses not compliant with Euro V emissions standard. Council in talks to phase in Zero Emission Zones between 2020-35 within the city centre.	51% EV, 31% HEV, 18% Diesel	76% EV, 24% HEV	100% EV
Rail electrification	Corridor between Oxford and Didcot has previously had plans for electrification, however currently work in not going ahead.	100% Electrification	100% Electrification	100% Electrification

Note:
- Percentages relate to % of passenger km travelled
- Resources required for EV replacement may be placed under strain if every region (and country)were to make this transition. City impacts and influence over such resource pressure is beyond the scope of this study, however important to acknowledge. For further information, please see: https://www.nhm.ac.uk/discover/news/2019/june/we-need-more-metals-and-elements-reach-uks-greenhouse-goals.html

3. Future Pathways

Waste & Industry

Measure	Current City of Oxford Context	SCATTER L4 Pathway		
		2025	2030	2050
Waste reduction[1]	Ardley ERF treats over 320,000 tonnes of non-recyclable waste each year, diverting 95% of that waste away from landfill.	8% decrease in household waste	11% decrease in household waste	20% decrease in household waste
Increased recycling[2]	Seven recycling centres in the Oxfordshire county (no breakdown available for the city) area, open seven days a week.	55% Household Recycling rate	61% Household Recycling rate	85% Household Recycling rate – exceeding the EU waste directive of 70% by 2035

1 - Volume % relate to household waste only. Other categories within SCATTER include Commercial and Industrial waste, Construction & Demolition waste, Sewage Sludge and Landfill Gas.
2 - 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. Future Pathways

Waste & Industry

Measure	Current City of Oxford Context	SCATTER L4 Pathway		
		2025	2030	2050
Industry efficiency	Deployment of renewable solutions in energy consuming sectors, particularly industry, is still well below the levels needed, and progress in energy efficiency is lagging.(2019)[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 processes are electric	44% of industrial processes are electric	66% of industrial processes are electric
Carbon Capture and Storage (CCS) on industry	UK government is investing £20m in supporting the construction of carbon capture, use and storage technologies at industrial sites across the UK[3]	2% of industrial process CO_2 is captured[4]	4% of industrial process CO_2 is captured	42% of industrial process CO_2 is captured

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.businessgreen.com/bg/news-analysis/3067118/the-time-is-now-government-unveils-plans-for-uks-first-carbon-capture-and-usage-project
4 - Note that in the interest of prudence and geographic constraints (CCS opportunities are limited in the City of Oxford area) and have not been applied to the modelling, but are presented for information purposes. Carbon savings do not include CCS in industry.

3. Future Pathways

Renewable Energy Supply

- SCATTER scales national levels of renewables (as defined by both the National Grid Future Energy Scenario 'Two Degrees' (2017), and the legacy DECC 2050 Pathways Calculator), to local authority regions. This serves as a indicator for the nature and extent of renewable supply required to future demand.
- Naturally, certain cities and regions will be more suited to some types of renewables than others based on its geographic profile. Consideration of the local feasibly is beyond the scope of SCATTER and would require a further study specific to Oxford, to understand if SCATTER ambition levels are technically feasible, and if not, what the maximum potential is (and why), per measure.

Measure	Current City of Oxford Context	SCATTER Level 4 Pathway		
		2025	2030	2050
Solar PV	1,120 homes (2% of all homes in Oxford) have Solar PV Installed totalling 8MW Installed Capacity (2017)[1] This is equivalent to 0.06km^2 (11 football pitches)[2] 0.006 TWh total Generated per year (2017)[1]	40% of homes + 0.46km^2 (85 football pitches)[2] on commercial roof space and ground mounted sites 119 MW Installed Capacity 0.09TWh Generated per year	50% of homes + 0.75km^2 (140 football pitches)[2] on commercial roof space and ground mounted sites 166 MW Installed Capacity 0.13TWh Generated per year	50% of homes + 2.26km^2 (423 football pitches)[2] on commercial roof space and ground mounted sites 374 MW Installed Capacity 0.28TWh Generated per year
Onshore wind	2 Turbines installed (2017) 0.0011MW Installed Capacity (5.5kW per turbine) (2017) [1] 0.024 GWh Generated per year (2017) [1]	16 Turbines installed 40 MW Installed Capacity (2.5 MW per turbine) 8.3 GWh Generated per year	24 Turbines installed 59 MW Installed Capacity (2.5 MW per turbine) 8.8 GWh Generated per year	60 Turbines installed 150 MW Installed Capacity (2.5MW per turbine) 9.8 GWh Generated per year

1 - https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/743822/Renewable_electricity_by_Local_Authority__2014-2017.xlsx
2 - Method for converting and allocating the SCATTER generated installed capacity (MW) to homes assumes the average installation per domestic installation in the city is 2.2kW and will be suitable for up to 50% of households by 2050. This is a judgmental hypothesis which needs further testing. The residual area assumes that a 2.2kW installation has an area of 16m^2 as per the Energy Savings Trust Guidance:

3. Future Pathways

Renewable Energy Supply

Measure	Current City of Oxford Context	SCATTER Level 4 Pathway		
		2025	2030	2050
Bioenergy supply (heat & electricity)	0 Anaerobic Digestion Facilities (2017)[1] Food waste collections are sent to an AD plant just outside of the city boundary in West Oxfordshire. 0 MW Installed Capacity	23.2 Installed Capacity	23.5 MW Installed Capacity	38.6 MW Installed Capacity
Hydro power	2 hydro sites 0.1 MW Installed Capacity (2017). One is Osney Lock Hydro Generating clean renewable energy for the community of West Oxford (and raise finance for further community energy projects). Annually the project will generate enough to power around 60 homes. 296 MWh Generated per year (2017)[1]	4.82 MW Installed Capacity 16 GWh Generated per year	6.19 MW Installed Capacity 20 GWh Generated per year	7.22 MW Installed Capacity 16 GWh Generated per year
Storage	redT to supply 72 energy storage units to world-first energy project in Oxford (50MW Capacity). The batteries look like shipping containers, each with a capacity of 0.7MW). [2]	12 MW Peak Power Storage	18 MW Peak Power Storage	36 MW Peak Power Storage

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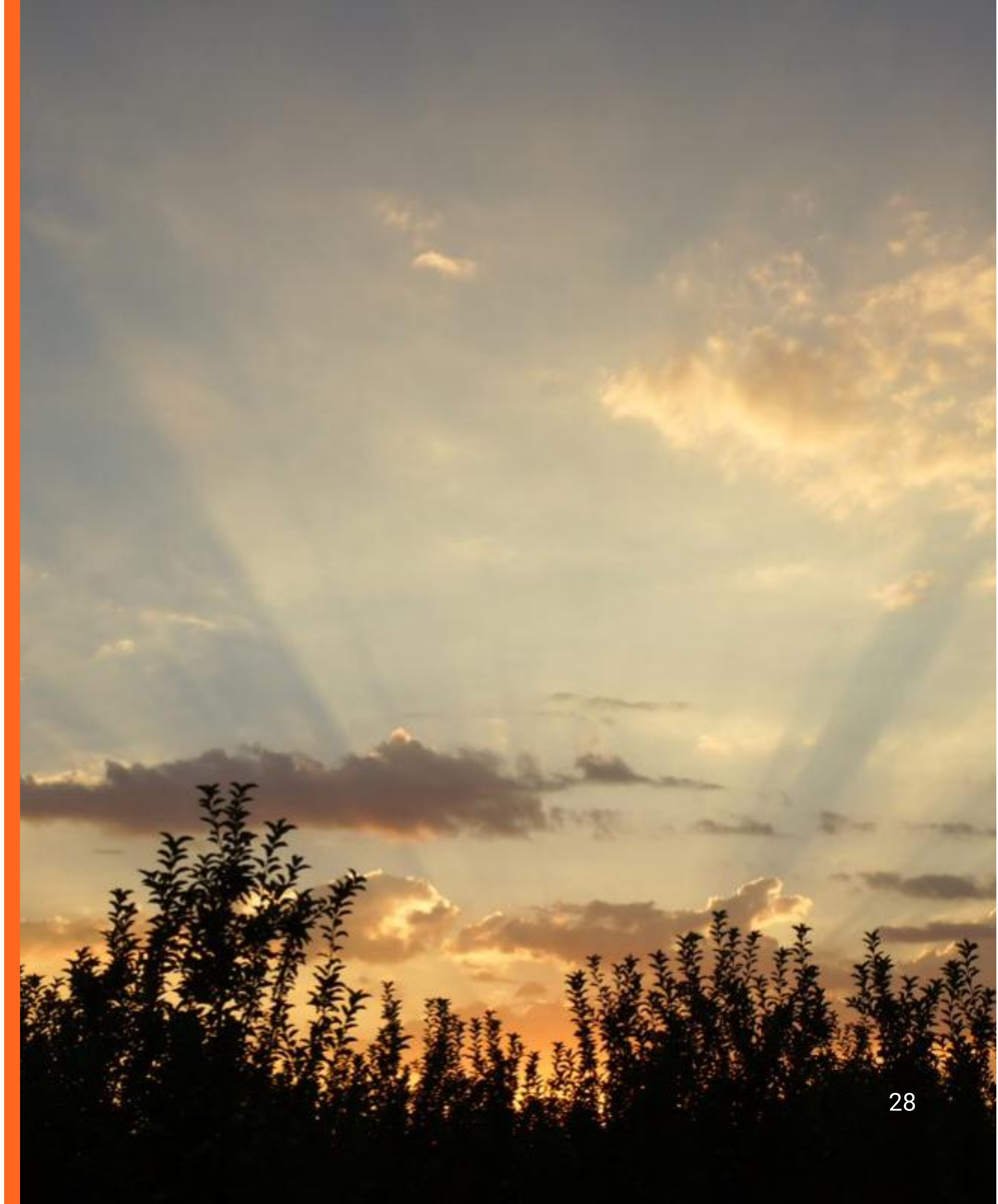
1 - https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/743822/Renewable_electricity_by_Local_Authority__2014-2017.xlsx
2 -https://governmentbusiness.co.uk/news/10042019/%C2%A341m-project-trial-hybrid-energy-storage-system-oxford

4. Oxford City Council Influence



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[Chart is illustrative only and not to scale]

4. Oxford City Council Influence

Overview

Our approach

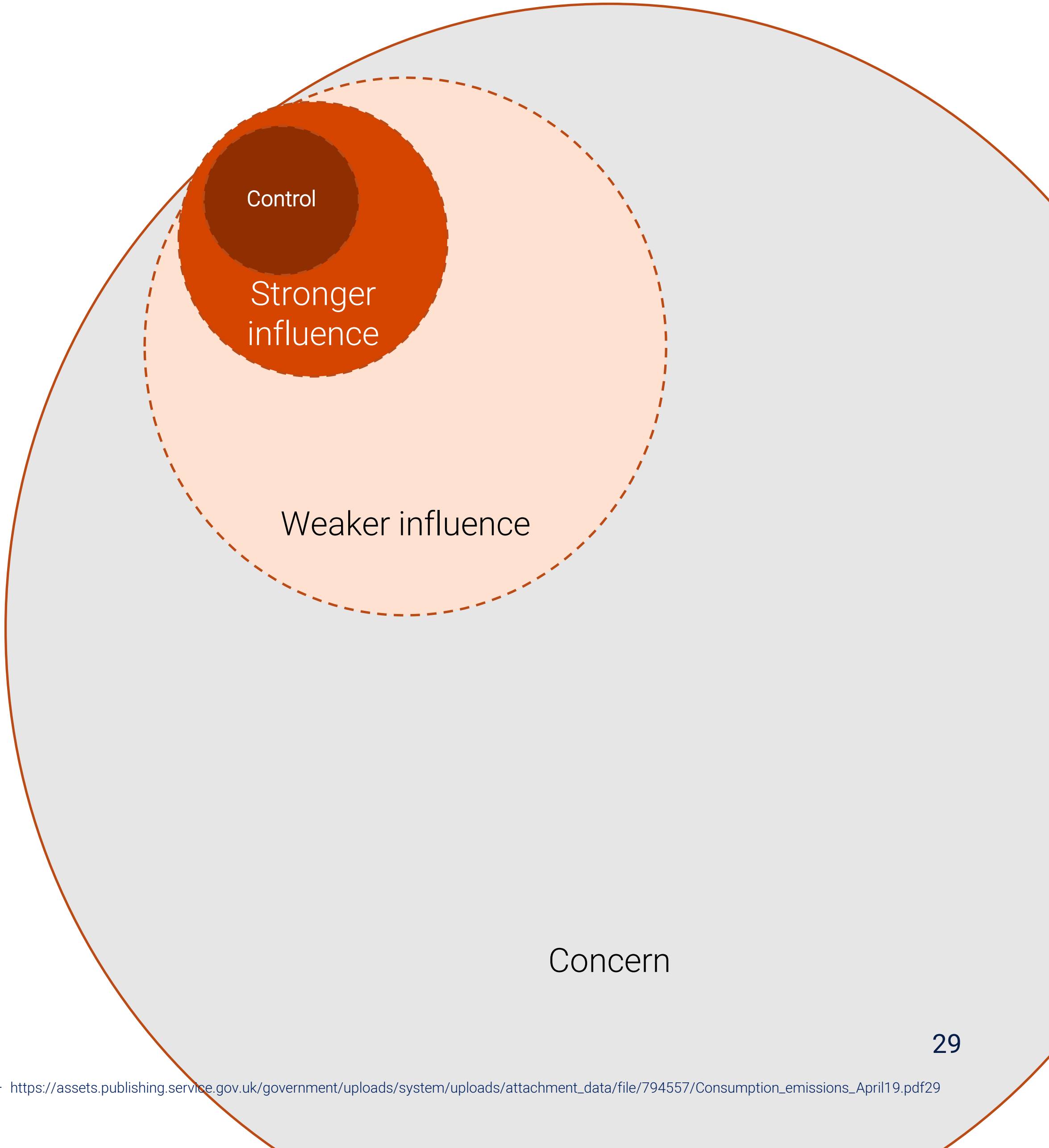
This chart illustrates that Oxford City's influence is varied and complex across the different activities that occur within their own operations and also within the City.

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 Oxford City Council to apply their influence in areas or ways previously not fully explored (e.g. by using 'convening power' and/or policy).

Influence also extends beyond the city boundary, whereby Oxford's demand (and supply) of goods and services will be driving emissions in supply chains around the world. Such emissions are often referred to as consumption based emissions. Research suggests that imports from abroad could represent a further 45% of GHG emissions (relative to the UK produced emissions totals).[1]

Influence	Description
Control	Emissions sources are directly owned or operationally controlled by the Council.
Stronger	Owners and operators of emissions sources are clearly defined but are not directly owned or operated by the Council. Emissions relate to council 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 city.
Concern	Owners and operators of emissions sources are not clearly defined, but still within the Councils' concern. Influence limited to lobbying central government or associations.

Table 13: Influence definitions



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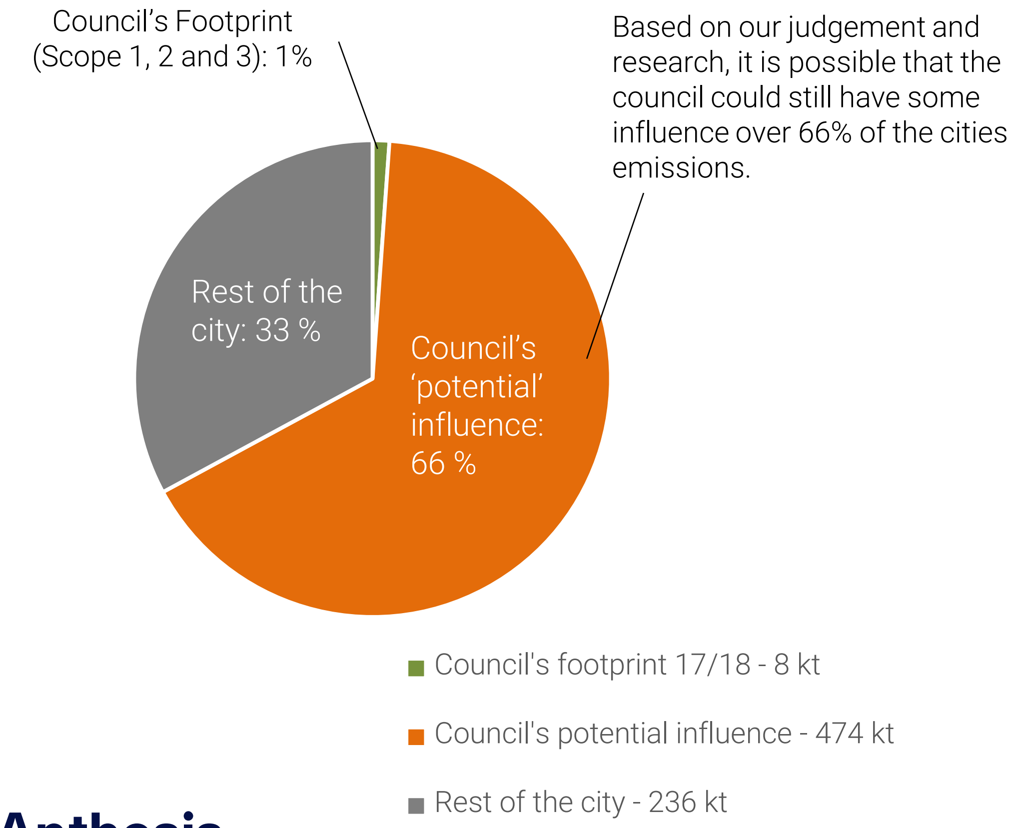
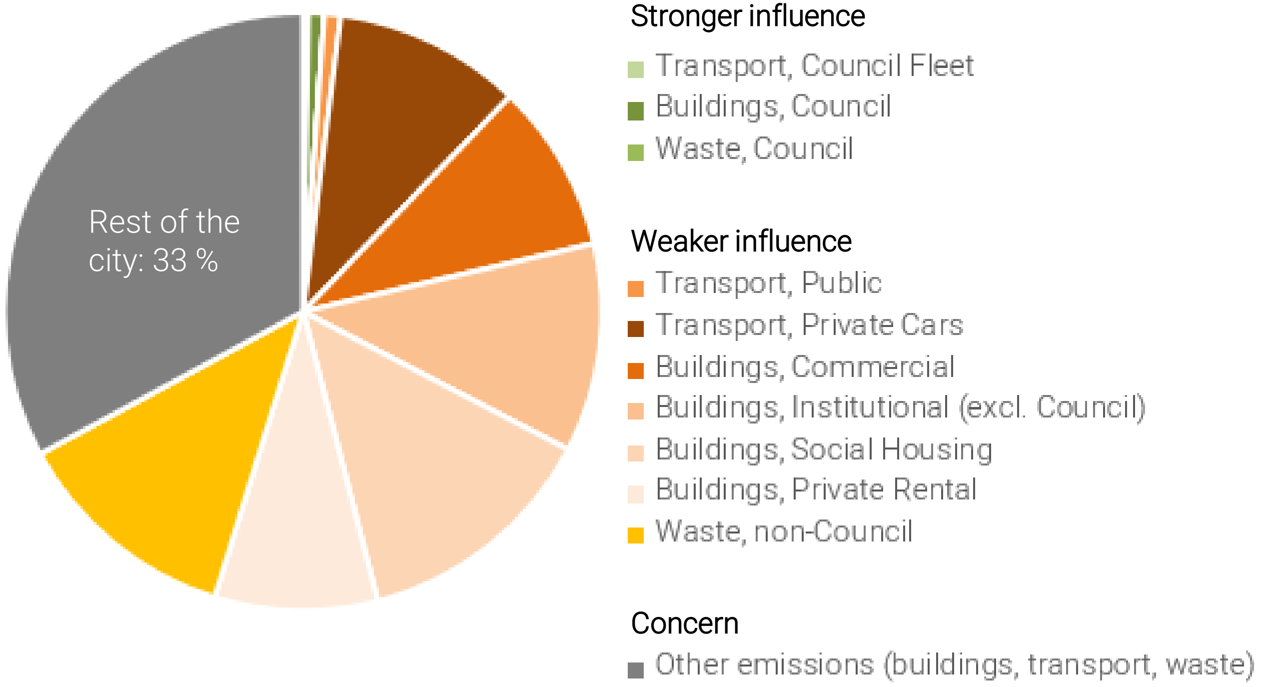
1 - https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/794557/Consumption_emissions_April19.pdf29

4. Oxford City Council Influence
Current influence

Only a tiny fraction (1%) of the city's in-boundary GHG emissions are under some influence or concern of the City Council.



This 'potential' influence also includes forms of influence outside of direct control (i.e. convening power, local policy changes). A large number of sectors make up the city's footprint that is within the sphere of 'moderate influence' of the City Council. Weaker/limited forms of influence were not possible to estimate. For a full list of assumptions, please refer to Appendix 7.



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4. Oxford City Council Influence
Potential Council impact - snapshot

Some examples, from our research, of the types of activity already planned in sectors across the city. what levels of emissions may look like in 2030 based on these sub-sectors. In all cases – to realise these emissions impacts and build on existing/proposed activities, additional resource and investment will be needed.

Transport, Private Cars: The City is a member of the consortium delivering Energy Superhub Oxford (ESO), a £41m project, which aims to substantially improve the city's EV charging infrastructure.

Buildings, Commercial: The City Council are exploring a number of initiatives aimed at reducing commercial building carbon impact. For example, the potential for a low carbon heat network to provide low carbon heating for business in the city centre is being explored.

Buildings, Institutional: The council are exploring plans to enhance and enforce standards around building envelope performance (i.e. insulation and draughtiness), appliance energy efficiency, and a deliveries policy that will encourage emissions reduction in institutional buildings including hospitals and universities.

Buildings, Social Housing: Plans for ground source heat pump installation targeting social housing under Energy Superhub Oxford will see around 300 homes reduce their carbon footprint from heating by 50% and reduce operating costs by 25%. The innovative heat pumps will be better controlled via smart thermostats/ with smart phone interface.

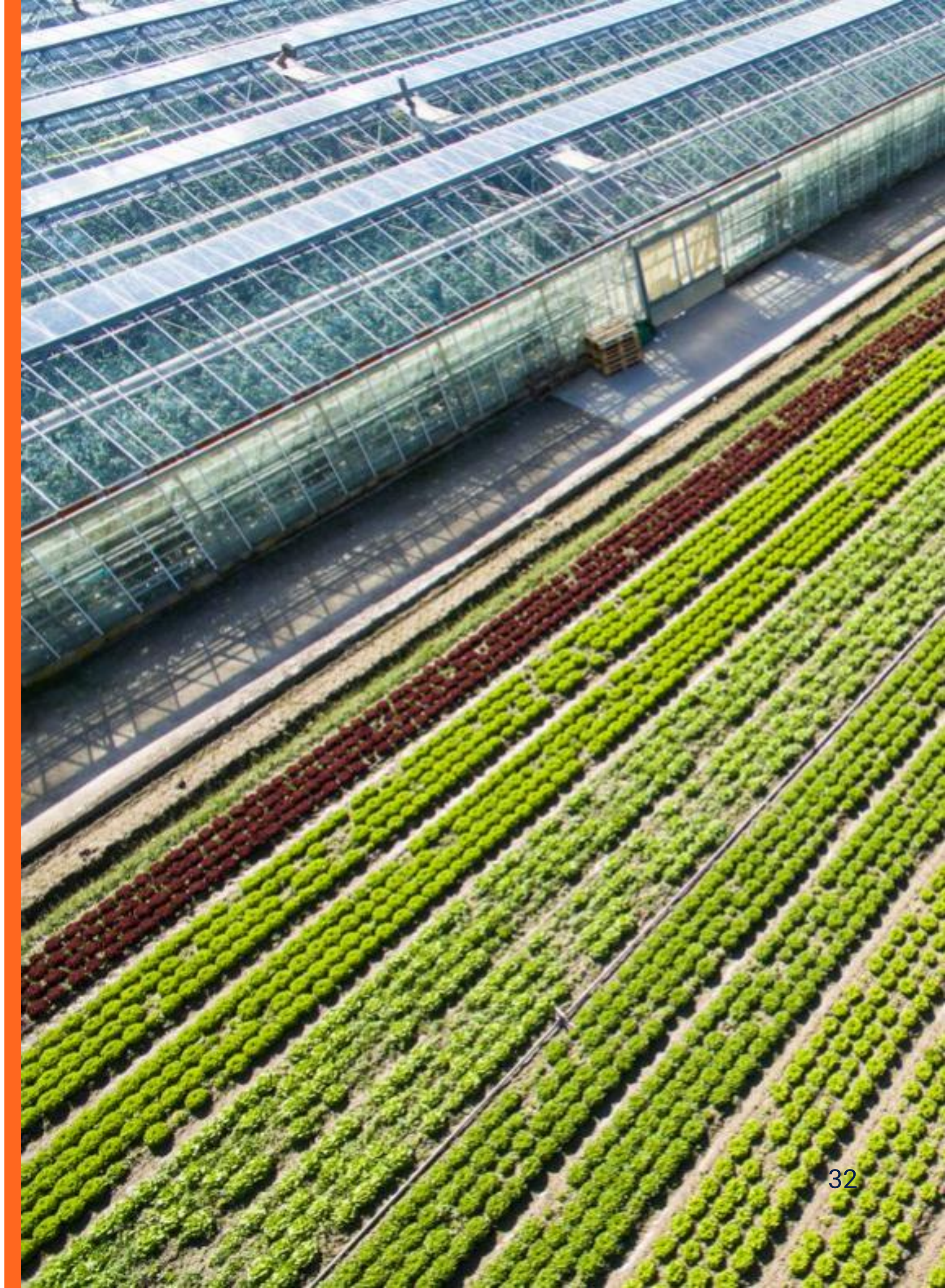
Buildings, Private Rental: The City Council is developing plans to strengthen its ability to enforce energy efficiency standards in private rented accommodation and also to increase those standards. Details of such plans are yet to be published, however may look to build on current planning policy, and the Minimum Energy Efficiency Standard (MEES) already enforced in the private rental sector (BEIS Funded).

Waste, Non-council: Emissions can be reduced through measures around reducing/ reusing/ recycling, such as changing refuse collection policy to encourage recycling. The council can also engage with Viridor and County Council over carbon capture and storage (CCS) in relation to energy recovery.

New build: Similarly, influencing powers should be considered with regards to the construction of new buildings (both commercial and domestic) in the city. There may be scope to influence (and reduce) the associated embodied and operational emissions in this area.

Other emissions: The City Council can lobby national government for changes in policy concerning these emissions, for example, decarbonisation of grid electricity and product energy efficiency standards. The potential for policy interventions at this level is massive, however in reality the City Council has only very limited influence to affect such policy.

5. Offsetting & Out of Boundary Initiatives



5. Offsetting & Out of Boundary Initiatives

Context

Some emissions are really hard to remove - Getting the city anywhere near carbon neutral is going to be incredibly challenging. Even if all the measures presented in SCATTER were applied to the maximum ambition level, current assumptions indicate that there are some sources of emissions are likely to remain in the energy system at 2050. These are predominantly from freight and industry, where, despite significant energy reductions from efficiency improvements and electrification, some residual emissions still exist.

Technology and policy may not move quick enough - Technology developments (e.g. synthetic fuel development or more widespread application of Carbon Capture and Storage on industry) and/or policy developments (e.g. banning of all fossil fuels by a certain year) may help to close this gap at some point in the future. However, given there is such future uncertainty over our ability to deploy both the known and more nascent technologies at scale, we have explored the role of offsetting and out of boundary measures.

Carefully consider the role offsets play - We do however, advise strong caution in exploring such measures, as these are not intended to displace or compensate for any 'lower ambition' roll out, where users may interpret this as such. On the contrary, it is likely that such measures may be required 'in addition to' everything else. They may however, present Oxford some wider socio-economic opportunities as the city seeks to mobilise and implement the full extent of measures directly 'in-boundary', as a first priority.

5. Offsetting & Out of Boundary Initiatives

Offsetting

Carbon Offsetting

The Tyndall Centre for Climate Change Research describe carbon offsetting as follows: "Carbon offsetting refers to the purchase of a tradeable unit, representing emissions rights or emissions reductions, to balance the climate impact of an organisation, activity or individual. Although they can be stored and traded like a commodity, they are not material things; offset credits are not literally "tonnes of carbon" but stand in for them and are better regarded as intangible assets or financial instruments. To act as an offset, units must be cancelled to represent a reduction and prevent further trading."[1]

For the City of Oxford, the term 'offset' may either refer to:

a) Outside the city boundary: The purchase and cancellation of tradeable units representing emissions reductions or sequestration outside the boundary of the city (i.e. in other areas of Oxfordshire, the UK, or abroad) to compensate for 'residual' carbon emissions (such as freight or industry).

b) Inside the city boundary: While not in keeping with the Tyndall Centre's definition, we have commonly encountered use of the term when referencing in-boundary sequestration measures that 'net off' or 'offset' emissions from the energy system. These are assumed to be non-tradeable units, for example, tree planting or negative emissions technologies (NETs). For clarity, we will refer to this type of offsetting as 'netting off' if referring to in-boundary intervention; however it is important to appreciate the distinction.

Risks

All outside of boundary offset arrangements may be open to criticism and subject to some risks. These may include:

- Lack of substance - 'Carbon neutrality' achieved this way is an accounting procedure rather than a physical status.
- Undermined through change - The procedures and the context under which the offset operates is liable to change through time, for better or worse.
- Diversion of finance - Money and investment is potentially being diverted outside of the city, with no financial return on investment.
- Diversion of other benefits -Wider social, economic and environmental benefits may be diverted outside of the city, such as benefits to health of residents from clean air or warmer homes.
- Distraction from priorities -The offsets may distract or reduce the urgency with which more effective measures are deployed as the public perceive the offsets as the city 'playing its part'.
- Quality & fraud risk - The level of 'additionality' of saving that the offset provides maybe negligible if the quality of the offset is poor and/or fraudulent, whereby the saving is traded twice, or would have occurred irrespective of whether the city invested.

If the city did identify financial resources and the necessity to pursue out of boundary offsets, then it should:

i) Only consider high quality, regulated systems and purchases
ii) Revisit the available tradeable units at the time of purchase to consider which are the most robust and reliable
iii) Recognise that this will be a controversial approach potentially drawing criticism, and public and professional cynicism.[1]

1 - https://www.research.manchester.ac.uk/portal/files/83000155/Tyndall_Quantifying_Paris_for_Manchester_Report_FINAL_PUBLISHED_rev1.pdf

5. Offsetting & Out of Boundary Initiatives

Renewable Energy Purchasing

Renewable Energy Purchases

Offsets and purchased renewable energy via 'green tariffs' or certificates ("RECs") are often used interchangeably, and are very often assumed to mean the same thing. These do in fact represent very different things, but both linked to achieving the same broader purpose of decarbonisation.

RECs, represent one megawatt hour (MWh) of energy generated from a clean, renewable source, such as wind, solar, hydro, or certain types of renewable biomass. Since these renewable energy resources generate little to no carbon as they produce energy, they represent an indirect emission reduction, whereby a "clean" energy source can indirectly displace the demand for "dirty" fossil-fueled energy.[1]

RECs are not typically held to as rigorous 'additionality' standards as offsets (depending on the quality), where, for example, surplus electricity generated and sold as RECs, may have still have been generated anyway and supplied to the national grid.

In the UK, RECs are formally recognised under the Renewable Energy Guarantee of Origin scheme (REGO)[2], whereby the origin of generation can anywhere in the EU (if specific criteria are met).

Oxford is currently a member of the UK100, a network of highly ambitious local government leaders, who have pledged to secure the future for their communities by shifting to 100% clean energy by 2050.

Accounting principles

In the context of city-wide emissions accounting, Cities are currently able to report any renewable purchased energy (i.e. electricity or heat), and disclose an additional emissions total for Scope 2 'in-direct' emissions. This is known as a Market Based metric, and, similar to organisations, the city as a whole would need to ensure that renewables they consume can be supported and meet the relevant accounting criteria[2]. The this can come from either in-boundary or out-of-boundary; the accounting standard does not specify.

At present, only Location-Based figures are reported for Scope 2 'in-direct' emissions, which applies a grid carbon intensity factor based on the UK national average. There is currently no robust and efficient method for estimating a city or district wide renewables consumption in the UK. Conversely, in the absence of clear measurement, renewables generated in-boundary (for which published data is available at Local Authority Level)[3], may be being sold to other cities or regions, so there is no guarantee that this is actually consumed in the same region that generation occurs (without better transparency).

Impact and priorities

Relative to fossil fuels, purchasing renewable energy is a significantly more ethically responsible action and, as a minimum, may serve as a stimulus for greater investment and more ambitious policy.

However, the majority of emissions (60%) still come from direct combustion of fossil fuels, predominantly used to heat buildings and operate vehicles. So unless this 'demand side' consumption is shifted to electrified alternatives, then renewable energy alone may not make any impact on this share of emissions.[5]

1 – https://www.greenbiz.com/blog/2009/03/12/rec-vs-carbon-offset-do-you-know-difference
2 – https://www.ofgem.gov.uk/environmental-programmes/rego
3 - GHG Protocol Scope 2
4 – BEIS LA data
5 – With the exception of biofuel for transport and Biomass CHP & Solar Thermal for heat

5. Offsetting & Out of Boundary Initiatives

Renewable Energy Purchasing

Priorities should therefore still remain focused on demand reduction which is commonly the quickest and financially economical way to reduce emissions. Demand side electrification would then follow, which would enable renewable electricity generated or purchased to be more widely used.

Additionality

Purchasers of renewable energy should look to maximise additionality to ensure they are directly contributing to or stimulating generation that would have otherwise not have happened. RECs that are purchased 'bundled' together in relation to one specific project or source are regarded as offering a greater level of additionality, in-contrast to 'un-bundled' RECS, where it can be harder to attribute to an individual project or are much for small individual amounts across a higher volume of sources.

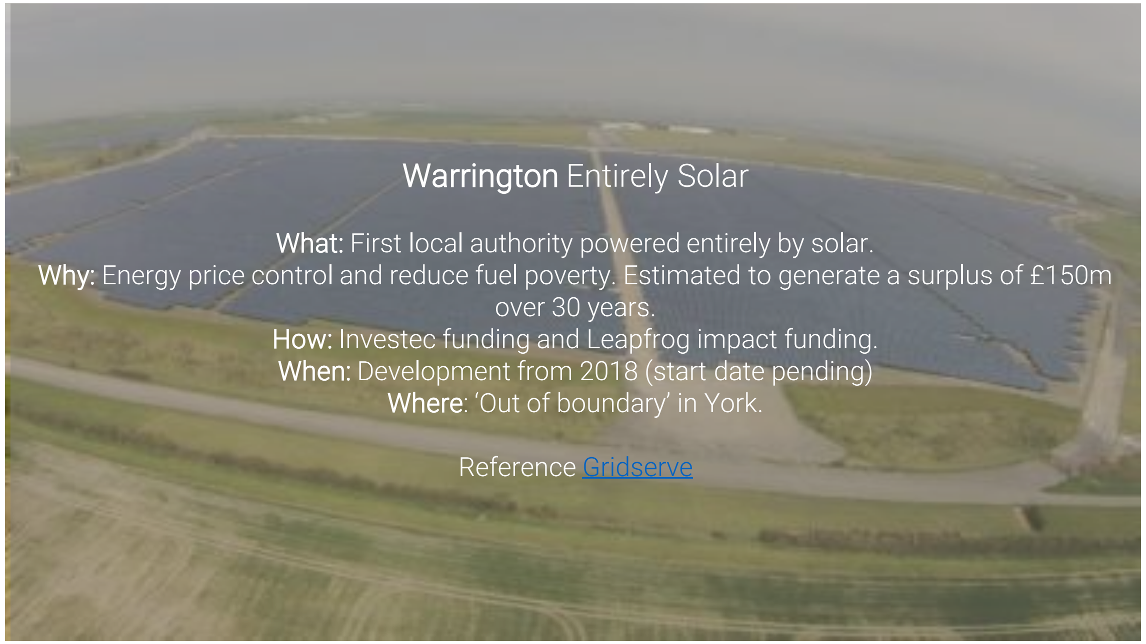
Finally, and importantly, city and regional renewable energy purchases are more commonly being observed as originating from jointly owned or jointly controlled assets under Power Purchase Agreements (PPAs), when the energy is then often sold and administered through a Local Authority led energy company. While there are many diverse and complex versions of such ventures, ultimately, they can help cities and authorities to generate new revenue stream(s) to re-invest in other carbon neutral workstreams.

Risks

In summary, key risks may include:

- Lack of additionality - As with offsets, if additionality is not sufficiently considered, there is a risk that the emissions impact may be trivial..
- Demand side complacency – Zero carbon supply is not even half the battle - demand side intervention should still be the priority.
- Diversion of socio-economic benefits – If purchased out of boundary, it may divert job opportunities and future income streams from the city.

Case study



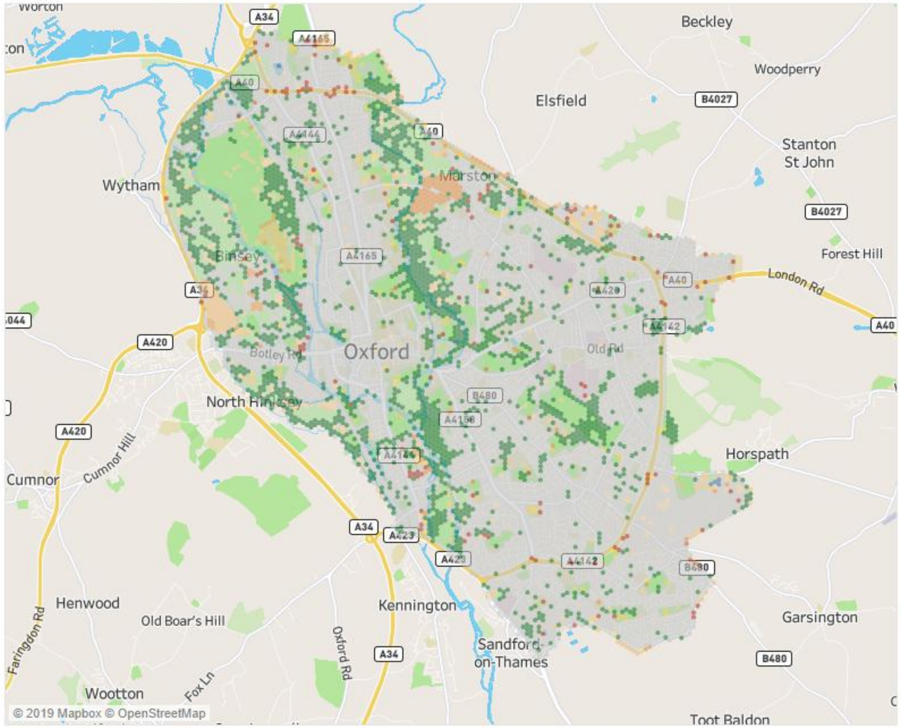
5. Offsetting & Out of Boundary Initiatives

Emissions associated with land use

Introduction

This section assesses the potential for in-boundary sequestration that could potentially 'net-off' against the emissions from the energy system. Additionally, it considers other sources of emissions that are not fully accounted for in the energy system emissions, such as livestock, fertilizers, and carbon stored in the soil.

Land Usage Profile – Oxford



- Bracken, heather and heathland
- Cereals
- Clover-type leguminous and nitrogen-fixing crop
- Field beans (spring)-type leguminous and nitrogen-fixing crop
- Field beans (winter)-type leguminous and nitrogen-fixing crop
- Land lying fallow
- Lucerne-type leguminous and nitrogen-fixing crop
- Non Agricultural Land
- Oilseed (winter)- type arable crop
- Permanent Grassland
- Potato-type arable crop
- Short rotation coppice
- Water
- Woodland

The City of Oxford is dominated by urban infrastructure (non-agricultural land), which forms about 3,000 hectares (66%) of the total. The next major land-type is woodland / trees (including trees in hedgerows and fields) of 750 hectares (16%) then permanent grassland of 450 hectares (10%). There is only one distinctly arable area within the city region, which is the orange area just west of Marston and south of the A40.

The maps shown are 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. Refer to Appendix 8 for further assumptions on land use per hectare.

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

Emissions associated with land use

Forestry

Forestry in the UK as a whole is a net carbon sink, storing an average of 5.5 tonnes CO_2 per hectare per year for existing woodland. Of this, about 1.3 tonnes are stored in the soil, 2.9 tonnes in living biomass (trees), and 1.3 tonnes in dead wood and leaf litter. Applying this average to the total area of forestry in the Oxfordshire area would give net storage of 247,500 tonnes per year; this is considerably larger than the estimate from the UK national accounts of 93,000 tonnes (see Table 6 opposite, which also includes storage in grassland and emissions from cropland). 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.

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	C, tonnes per ha				CO_2, t per ha
Habitat	Soils (15cm)	Vegetatio n	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 14: 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.

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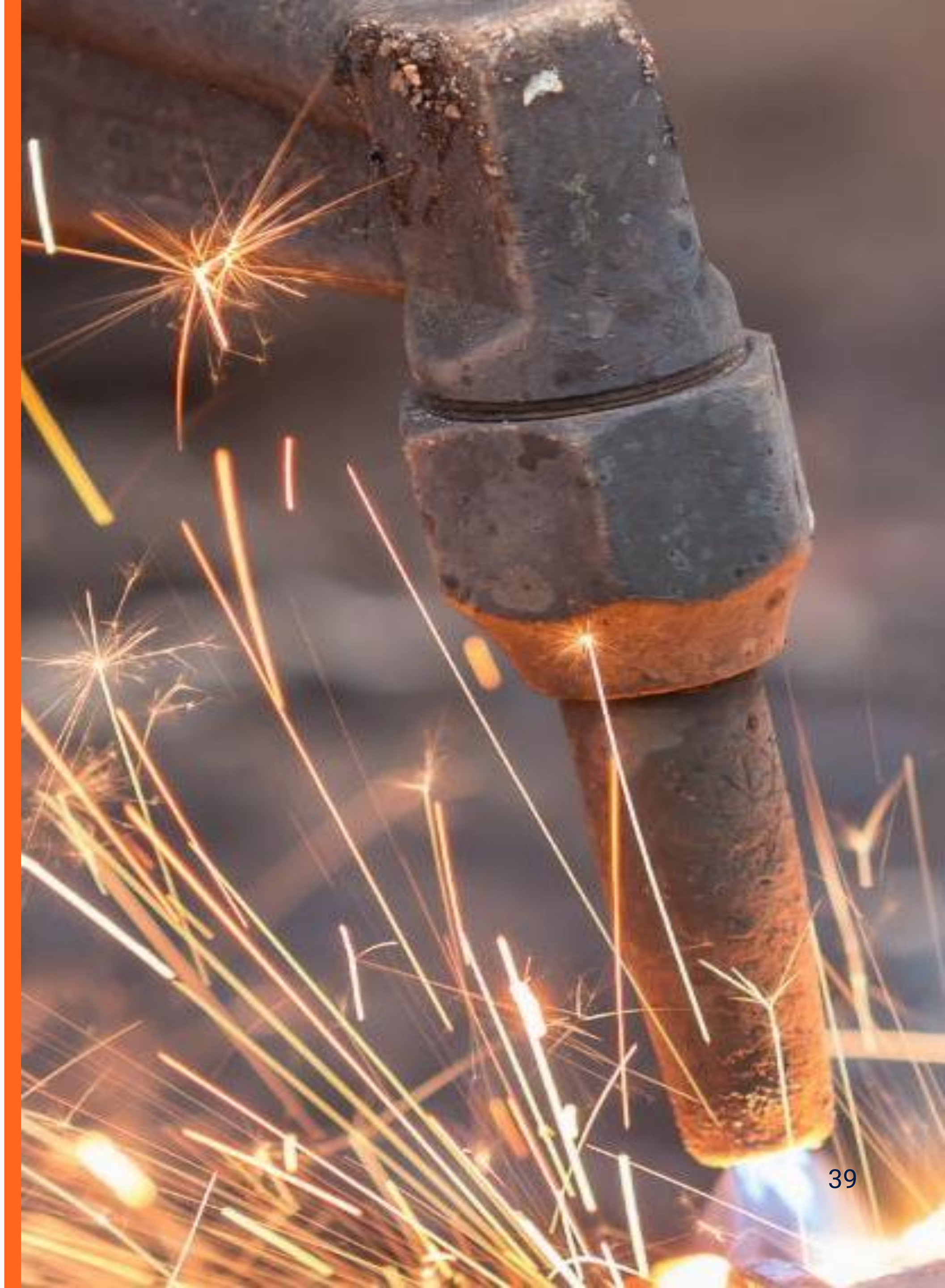
Source: UK submission to UNFCCC 2019, Table 4.A. Total forest remaining forest = 3,036kha. Total CO_2 removals = 18,009kt.

Appendices



Appendix 1

Data Tables for SCATTER and BEIS Emissions Summaries

Sub-sector	Direct (Scope 1)	Indirect (Scope 2)
	CO_2e (t)	
Residential buildings	131075	75067
Institutional buildings & facilities	63056	125480
Industrial buildings & facilities	49995	72738
Commercial buildings & facilities	40816	24832
On-road	113491	IE
Rail	4843	IE
Waterborne navigation	2	NO
Wastewater	9683	0
Solid waste disposal	2857	0
Livestock	3591	0
Agriculture	551	4
CHP generation	280	0
Industrial process	0	0
Local renewable generation	0	NE
Industrial product use	0	0
Fugitive emissions	0	0
Aviation	0	IE
Off-road	0	IE
Biological treatment	0	0
Incineration and open burning	0	0
Electricity-only generation	0	0
Heat/cold generation	0	0
Land use	0	0
Sub total	420241	298121
Total	718362	

Sector Name	CO_2 (kt)
Industry & Commercial Electricity	183
Industry & Commercial Gas	147
Large Industrial Installations	5
Industrial & Commercial Other Fuels	20
Agricultural Combustion	1
Domestic Electricity	62
Domestic Gas	133
Domestic Other Fuels	5
Road Transport (A roads)	73
Road Transport (Motorways)	0
Road Transport (Minor roads)	58
Diesel Railways	5
Transport Other	7
LULUCF Net Emissions	-2
Total for all sectors	696

Notes:

- BEIS data (right-hand table) and SCATTER data are compiled using different methodologies. The SCATTER model operates on 2016 data. BEIS data is from 2017. See page 7 for further notes on why the data differs between SCATTER & BEIS.

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

Appendix 2

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	N
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 3

Domestic & Non-Domestic Energy Performance Certificates (EPCs)

Domestic (all dwellings)		
EPC Rating	Number of Lodgments	
A	63	-
B	4,287	9%
C	16,265	33%
D	18,438	37%
E	8,381	17%
F	1,817	4%
G	445	1%
Not Recorded	2	-
Total	49,698	100%

Non-domestic		
EPC Rating	Number of Lodgments	
A	128	5%
A+	3	-
B	314	11%
C	721	26%
D	794	29%
E	417	15%
F	146	5%
G	211	8%
Not Recorded	1	-
Total	2,735	100%

Notes:

- Live reporting on the EPC ratings of all property (both domestic and non-domestic) can be found at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/821898/EPB_Cert_Statistics_Release_Q2_2019.pdf
- Further raw datasets can be downloaded from: https://www.gov.uk/government/statistical-data-sets/live-tables-on-energy-performance-of-buildings-certificates#epcs-for-all-domestic-properties-existing-and-new-dwellings, Table EB1.

Appendix 4

Domestic retrofit measures assumed within SCATTER

Retrofit measure	2015	2020	2025	2030	2035	2040	2045	2050	% of available households (at 2050 levels)
Solid wall insulation	3,966	6,460	8,927	11,481	14,036	17,394	17,422	17,450	24%
Cavity wall insulation	13,602	18,747	18,710	18,831	18,910	19,884	19,884	19,884	28%
Floor insulation	4,525	7,371	10,186	13,100	16,015	19,846	22,854	25,861	36%
Superglazing	8,998	14,655	20,252	26,045	31,841	39,459	45,438	51,417	72%
Lofts	15,129	21,312	27,407	33,759	40,103	48,689	48,689	48,689	68%
Draughtproofing	31,614	51,492	51,420	51,779	52,026	54,734	54,763	54,793	76%
Total houses	58,615	61,621	64,094	67,046	69,667	71,717	71,717	71,717	100%

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 number of measures 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.
- Total household numbers (including new build and demolition) are derived from non-region specific growth assumptions in Legacy DECC Pathways tool. We acknowledge that this may vary from city specific targets/rates.

Appendix 5
Domestic heating and hot water systems assumed within SCATTER

Technology penetration						% of households
Heating and hot water systems share, as a % of households						
Code	Technology package	2015	2020	2025	2030	2050
1	Gas boiler (old)	44%	37%	31%	25%	0%
2	Gas boiler (new)	39%	34%	28%	23%	0%
3	Resistive heating	7%	7%	7%	7%	7%
4	Oil-fired boiler	6%	6%	5%	4%	0%
5	Solid-fuel boiler	2%	2%	2%	1%	0%
6	Stirling engine μCHP	-	-	-	-	0%
7	Fuel-cell μCHP	-	-	-	-	0%
8	Air-source heat pump	1%	9%	18%	26%	60%
9	Ground-source heat pump	-	4%	9%	13%	30%
10	Geothermal	-	-	-	-	0%
11	Community scale gas CHP	1%	0%	0%	0%	0%
12	Community scale solid-fuel CHP	-	-	-	-	0%
13	District heating from power stations	-	0%	1%	1%	3%
	Total	100%	100%	100%	100%	100%

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 6
Transport assumptions

(i) 2050 mode shares			Pathway (units: % of passenger-km)	
Code	Mode	2015	2050 L1	2050 L4
WALK	Walking	4%	4.4%	4.4%
BIKE	Pedal cycles	1%	0.8%	4.7%
CAR	Cars, Vans, and Motorcycles	80%	80.3%	62.4%
BUS	Buses	5%	5.3%	18.7%
RAIL	Railways	9%	9.1%	9.8%
	Total	100%	100%	100%
	% change - cars		-	22.35%

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

*Pax ~ people/persons/occupants

Appendix 7

Assumptions around council influence

Degree of Influence	Sector	Emissions footprint (t CO_2)	Assumptions	Links
Stronger	Institutional Buildings	Counted elsewhere	Oxford City Council Emissions Report 2017/18 used as a baseline.	Oxford City Council Emissions Report is available to download at: https://www.oxford.gov.uk/downloads/file/4909/greenhouse_gas_emission_report_2017-18
	Transport	1,986	We assume that the CO_2e intensity of the fleet can be reduced by 80% whilst assuming that the fleet size does not increase, using Oxford City Council Emissions Report 2017/18 as a baseline.	
	Institutional Buildings	6158	Used Oxford City Council Emissions Report 2017/18 and data from the Oxford City Council Housing Energy Strategy 2016-2020 as baselines.	The Oxford City Council Housing Energy Strategy is available here: http://mycouncil.oxford.gov.uk/documents/s32233/FINAL%20Housing%20Energy%20Strategy%20-%202015.pdf
	Waste	21	Assumed maximum recycling rate of commercial and industrial waste of 100%; that all council staff work in council-operated buildings, and used BEIS conversion factors for emissions savings due to recycling.	BEIS conversion factors available for download at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019
Moderate	Transport	6,339	ONS averages for number of travellers and average distance travelled per traveller per annum. BEIS conversion factors used to derive emissions values from these assumptions.	
	Transport	73,112	Assumed successful implementation of council plans for ultra-low emissions zones. ONS averages for number of travellers and average distance travelled per traveller per annum.	
	Commercial Buildings	65,648	Current footprint value for scope 1 and 2 emissions from commercial buildings taken from SCATTER.	
	Institutional buildings	81,164	Institutional buildings in Oxford excluding the City Council (University of Oxford, Oxford Brookes University, and Oxford University Hospitals)	
	Residential buildings	95,823	Oxford City Council published values for socially rented housing used alongside average household carbon footprint assumed from the Committee on Climate Change.	
	Residential buildings	63,302	Oxford City Council figures used for numbers of private rented housing alongside average household carbon footprint assumed from the Committee on Climate Change.	Committee on Climate Change 2016 data available at: https://www.theccc.org.uk/2016/07/20/fifth-carbon-budget-infographic/
	Residential buildings	-	Assuming c. 6,000 new build properties adhering to the median zero carbon homes standard under Code for Sustainable Homes regulations.	Code for Sustainable Homes 2010 available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/5976/code_for_sustainable_homes_techguide.pdf
	Waste	88,517	Emissions from waste management published in Oxford City Council Arisings Data using BEIS conversion factors. Assuming successful implementation of reduction, reusing and recycling policies as well as directing waste to incineration.	

Appendix 7

Assumptions around council influence

Degree of Influence	Sector	Emissions footprint (t CO_2)	Assumptions	Notes
Weaker	Residential buildings	104814	Oxford City Council figures used for numbers of privately owned housing alongside average household carbon footprint assumed from the Committee on Climate Change.	
	Commercial buildings	Counted elsewhere	Current footprint value for scope 1 and 2 emissions from commercial buildings taken from SCATTER.	
	Institutional buildings	Counted elsewhere	Current footprint value for scope 1 and 2 emissions from institutional buildings taken from SCATTER.	
	Waste	88517	Oxfordshire Minerals and Waste Core Strategy forecasts from were assumed correct.	Oxfordshire Adopted Minerals and Waste Core Strategy 2017 available at: https://www2.oxfordshire.gov.uk/cms/sites/default/files/folders/documents/environmentandplanning/planning/mineralsandwaste/September2017/AdoptedMineralsWasteCoreStrategySept2017.pdf
Limited influence over emissions that are not modelled by SCATTER and lie outside of the scope of estimation. Lobbying National Government is a potential measure for minimising these emissions.				

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Appendix 8
Agriculture and land use

Notes:
Land-use by standard codes, taken from the Crop Map of England (unscaled to the City of Oxford area).

LU Code	LU description	Tableau Ha
PG01	Permanent Grassland	53,028
WO12	Woodland[1]	47,848
NA01	Non-Agricultural Land	45,273
AC66	Wheat (winter) - type arable crop	37,705
AC67	Oilseed (winter)- type arable crop	20,893
AC01	Barley (spring)- type arable crop	18,839
FA01	Land lying fallow	11,644
AC63	Barley (winter)- type arable crop	10,604
LG20	Field beans (winter)-type leguminous and nitrogen-fixing crop	6,572
AC17	Maize-type arable crop	5,855
LG03	Field beans (spring)-type leguminous and nitrogen-fixing crop	4,863
HE02	Bracken, heather and heathland	4,569
AC19	Oats (spring)- type arable crop	3,473
AC44	Potato-type arable crop	2,001
AC32	Wheat (spring) - type arable crop	1,078
AC65	Oats (winter)- type arable crop	1,016
WA01	Water	594
AC68	Rye (winter)-type arable crop	416
LG07	Pea (spring)- type leguminous and nitrogen-fixing crop	325
LG11	Lucerne-type leguminous and nitrogen-fixing crop	144
TC01	Permanent crops other than nursery crops and short rotation coppice	128
AC16	Linseed (spring)- type arable crop	105
AC03	Beet-type arable crop	52
LG14	Clover-type leguminous and nitrogen-fixing crop	47
AC36	Oilseed (spring)- type arable crop	11
SR01	Short rotation coppice	1
AC07	Carrot-type arable crop	0
	Total	277,086

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