Oxfordshire Net Zero Route Map & Action Plan

Final Report

CITY SCIENCE
delivering decarbonisation

Date issued: 05/12/2022
Document status: Final
Version number: 1.2

Prepared by:

Katie Sharp BSc MSc	Graduate Transport & Sustainability Consultant
Aoife Dudley BA MTPS	Transport Consultant
Jade Baker-Edwards BEng BSc	Senior Energy & Sustainability Consultant
Joe McQuillen MEng	Principal Energy Consultant
Heather Watkinson BA	Associate Director – Net Zero Transport

Approved by:

Laurence Oakes-Ash BSc FCMA CGMA MCIHT	Director

Contents

Abbreviations

Abbreviation	Definition
BAU	Business As Usual
BECCS	Bio Energy with Carbon Capture and Storage
BEES	Building Energy Efficient Survey
CO_2	Carbon Dioxide
DAC	Direct Air Capture
DNO	District Network Operator
FiT	Feed-in-Tariff
FOP	Future Oxfordshire Partnership
FES	Future Energy Scenarios
GGRs	Greenhouse Gas Removals
GHGs	Greenhouse Gases
HGVs	Heavy Goods Vehicle
LAEP	Local Area Energy Plan
LGVs	Light Goods Vehicle
LTCP	Local Transport and Connectivity Plan
OxIS	Oxfordshire Infrastructure Strategy
OxLEP	Oxfordshire Local Enterprise Partnership
OxonCC	Oxfordshire County Council
PaZCO	Pathways to a Net Zero Carbon Oxfordshire
PV	Photovoltaic
SATN	Strategic Active Travel Network
ZCOP	Zero Carbon Oxford Partnership
ZEVs	Zero Emission Vehicles

Key Report Definitions

- **Action Plan**: Converts the broader targets presented in the Route Map, into a specific set of actions that need to be adopted to meet these interim milestones. They can contain short-, medium- or long-term actions, but crucially they provide direction on how the targets can be broken down into tangible, deliverable steps.
- **Carbon Neutral**: Refers to the use of offsets (not specifically greenhouse gas removals) to balance out residual emissions.
- **Net Zero Pathway Modelling**: The approach that this report adopted to calculate the overarching and sectoral (road transport, energy supply, domestic, and industrial & commercial) carbon reductions needed by certain dates to reach net zero targets.
- **Net Zero**: Generally interpreted as reducing emissions as close to zero as possible, with any residual being removed from the atmosphere with greenhouse gas removals.
- **Route Map**: High-level visual tools that deconstruct, the often distant, 2050 net zero target into clear and tangible intermediate goals aligned to milestones at 2025, 2030, 2040 and 2050.
- **Scope 1 Emissions**: The emissions from the combustion of fuel from owned or controlled sources of an organisation, they are considered a direct source of emissions.

- Scope 2 Emissions: The emissions from the purchase of electricity, they are considered an indirect emission source as the emissions are a consequence of activities of the reporting organisation but occur at a source owned by another.
- Scope 3 Emissions: Scope 3 emissions are the result of activities from assets not owned or controlled by the reporting organisation. However, the activities of an organisation will indirectly impact value chains outside of its direct control. Therefore, they are the indirect emissions upstream/downstream of the organisation's activities.

Executive Summary

Overview

Tackling climate change is an international priority – for governments, businesses, and citizens. There is widespread consensus to reduce carbon emissions at the international, national and local scale. The UK Government has committed to reach net zero by 2050, and in Oxfordshire, all districts and sectors have adopted targets that strive to achieve this sooner. Oxfordshire's local authorities have committed to varying net zero target dates ranging from 2030 to 2050.

To support the objective of a net zero Oxfordshire, this project (commissioned by the Future Oxfordshire Partnership (FOP)) develops a Route Map and Action Plan the county that is intended to identify areas for joint actions that the Oxfordshire local authorities can take together to provide a catalyst for positive action across the region. Building on existing work, such as Pathways to a Net Zero Carbon Oxfordshire (PaZCO) and the Zero Carbon Oxford Partnership (ZCOP), this study updates relevant evidence and sets out collaboratively developed actions, that are ambitious, locally owned and aligned to existing initiatives. The study is owned by FOP and intended to support Oxfordshire's local authorities and other key partners to develop an evidence-led approach to delivering a net zero Oxfordshire. A key component of delivery is the joint priority actions set out in the Action Plan.

Net Zero Pathway Modelling

The study sets out a Net Zero Route Map which represents a viable, recommended pathway to net zero in the context of the current policy and technological landscape. The Route Map provides a sense of the scale, timing and types of measures that need to be adopted to put Oxfordshire on a path to net zero by 2050 – or sooner (the county wide target, a number of the local authorities have earlier dates). Reducing Scope 1 and 2 emissions are the key focus of this report and the key priority for Oxfordshire over the next decade, and so are included within the modelling scope. Whilst outside of the scope of this work, we acknowledge that there is considerable interest across Oxfordshire in Scope 3 emissions, and that over time we expect increased focus on this area.

Modelling has been carried out on a sector-based approach to form sector-specific Route Maps and Actions, with a focus on the sectors below.


ROAD TRANSPORT


ENERGY SUPPLY


DOMESTIC


INDUSTRIAL & COMMERICAL

The Pathway Modelling has demonstrated that dramatic changes are required in each sector to reach a sufficient level of decarbonisation and achieve net zero with some of the key points highlighted below:

- **Energy Supply**: By 2030, Oxfordshire will need to quadruple its installed photovoltaic (PV) capacity to reach PaZCO's ambitious target (achieving 6% of the national solar PV installed capacity by 2050). Cumulatively, the capacity of PV will need to increase 13 times against the 2020 base year, requiring a significant increase in PV installations on existing buildings (both commercial and domestic) and ground mounted arrays.

- **Transport**: In the 2020 base year, just under 4,000 Zero Emissions Vehicles (ZEVs) form part of the existing vehicle stock. By 2040, the pathway models that 100% of vehicles are switched to ZEVs (including Light Goods Vehicles (LGVs) and Heavy Goods Vehicles (HGVs)). This is equivalent to a 105-fold increase in the total number of ZEVs in Oxfordshire.
- **Domestic:** The domestic sector has two main challenges: addressing the energy efficiency and heating of both new builds and existing dwellings (so called "retrofit"). To contextualise the scale of the challenge, a total of 27,000 heat pumps were installed in the UK in 2019, however under the pathway, between 2041 and 2045, this rate of annual heat pump deployment will be required in Oxfordshire alone.
- **Industrial & Commercial:** The energy demand for 2050 in this sector is expected to be similar to that in 2020, as the growth of the sector offsets the reduction from energy efficiency measures. To achieve a 78% reduction in CO_2 emission by 2050 in industrial buildings, high carbon intensity fuels will need to eradicated, the electricity grid decarbonised and buildings self-supplied by solar PV electricity. For commercial buildings to achieve a reduction of 87% in CO_2 emissions, electricity needs to constitute 82% of the sector's energy demand with over half of this met by on-site solar PV.

Route Map

Five high-level Route Maps have been produced to deconstruct the often-distant 2050 net zero target into clear and tangible intermediate goals aligned to milestones at 2025, 2030, 2040 and 2050. These include four sectoral Route Maps (based on the highest emitting sectors explored within the net zero pathway modelling) and one overarching decarbonisation Route Map which provides an overview of Oxfordshire's interim targets.

The emission reduction targets for each sector (the Route Maps) have been determined by five-yearly carbon budgets that start from 2021 and end in 2050. The carbon budgets are the maximum quantity of cumulative emissions which can be emitted within those five-year periods that will not exceed the projected pathway. They act as a useful tool to assess risk, set goals and continually monitor progress.

Joint Actions

The Route Maps articulate the overarching strategic vision. The Action Plan provides direction and specific steps on how key interim emission milestones can be achieved, thereby maintaining progress towards the wider net zero goal. Informed by an extensive stakeholder engagement process, the Action Plan consists of a portfolio of 14 actions, ranging from actions that will deliver measurable results over the short-term to empower and demonstrate success, and others that will span across multi-year programmes. These actions build on existing activities to support the significant scale up of measures required to meet Oxfordshire's ambitious net zero commitments. Whilst ambitious these short-term actions are embedded in realism to support successful delivery.

Recommended approach

It is recommended that each action is assigned a convening lead to guide delivery, with delivery of the programme underpinned by 'Sprint Groups', which consist of relevant individuals and organisations that share a particular subject specialism to maximise efficiency in delivering solutions to specified decarbonisation problems, particularly through collaborative action. This approach mirrors that of ZCOP, thereby supporting consistency across the county. Key impact-based performance indicators should be embedded into the actions to continually track and monitor progress. Providing a clear progress monitoring framework will facilitate the sprint groups to manage their time effectively, remain focused, stay motivated and maximise the chances of success.

Conclusions & Next Steps

Oxfordshire has championed noteworthy decarbonisation efforts over the last decade. However, even with this strong track record, the size of the challenge remains significant and will require a considerable step change in activity. The two key priorities will be supporting collaboration across local authorities and drawing upon Oxfordshire's broader network of stakeholders, and expanding activities to sufficient scale.

The key focus of the Joint Action Plan is to support accelerated measures towards decarbonisation, with a specific focus on the priorities for the next three to five years. However, it is recognised that the Action Plan should be a living document. Throughout this study, barriers and uncertainties have been identified, suggesting that progress is unlikely to be uniform across all actions. Strong governance and regular monitoring of actions is therefore critical, with regular updates to the Action Plan, taking account of both programme successes and changes in the operating environment. We especially recommend frequent monitoring of actions through the mobilisation phase, to support the allocation of sufficient resources and capacity required for delivery.

1 Introduction

Chapter at a Glance
This Chapter provides an overarching introduction to the Route Map and Action Plan including how this work builds upon current and previous climate action within Oxfordshire and outlining the report structure.

1.1.1 Tackling climate change is an international priority – for governments, businesses, and citizens. The UK Government has passed legislation which commits the UK to a target of net zero by 2050. This is essential to meet the Paris Agreement goal of limiting global temperature rise to well below 2°C (and preferably to 1.5°C) compared to pre-industrial levels. The UK Government's approach is underpinned by the Net Zero Strategy (2021) alongside sector-specific strategies (e.g. Heat & Buildings Strategy (2021)). Furthermore, the BEIS Secretary of State has commissioned the Net Zero Review, which is an independent review of the government's approach to delivering its net zero target, to ensure that it is pro-business and pro-growth. Despite recent progress, there remains key gaps and inconsistencies, presenting significant challenges for local authorities, including in Oxfordshire, such as:

- National known policy gaps with the government being required to update the Net Zero Strategy following a recent judicial review.
- Managing carbon impacts from strategic allocations (70,000 new homes in Adopted Local Plans to 2036).
- Addressing cross-boundary emission and scope ambiguities (e.g. M40).
- Accelerating net zero before 2050 in the context of national policy levers (e.g. building standards).
- Funding significant measures (e.g. domestic building retrofitting).

1.1.2 Local Government is responding to the climate emergency. At the time of writing, over 90% of local authorities across the UK have declared a climate emergency. Oxfordshire prides itself on leading the way, delivering pioneering decarbonisation projects. For instance, Oxford City Council launched the UK's first Zero Emission Zone. Oxfordshire has established a clear consensus on the need for climate action. All of Oxfordshire's local authorities have declared climate emergencies and have committed to delivering net zero by 2050 – or sooner. Details of their climate action plans and locality-wide targets are shown in Table 1-1. We acknowledge that each council also has an estate net zero target.

LA	Net Zero Target	Action Plan	LALogo
Oxfordshire County Council (OxonCC)	2050	2020 Climate Action Framework For A Thriving Oxfordshire (2020)	
Cherwell District Council (North Oxfordshire)	2030	Cherwell Climate Action Framework (2020)	
Oxford City Council	2040	Oxford 2040 Net Zero Action Plan (2021)	
South Oxfordshire District Council	2030	Climate Action Plan 2022-2024	
Vale of White Horse District Council	2045	Climate Action Plan 2022-2024	
West Oxfordshire District Council	2050	Climate Change Strategy for West Oxfordshire 2021 – 2025 (2021)	

Table 1-1: Summary of Decarbonisation Plans for Oxfordshire Local Authorities

1.1.3 The county has mobilised this consensus for change into tangible progress, drawing from an extensive low carbon ecosystem of resources to create innovative net zero solutions which alongside grid decarbonisation and other measures has resulted in CO_2 levels being reduced by 27% by 2018, compared to 2008 levels[1]. This acts as a prime example of what can be accomplished at a local level with the right determination and provides optimal foundations for Oxfordshire to continue accelerating decarbonisation and deliver net zero before 2050.

1.2 Pathways to a Zero Carbon Oxfordshire

1.2.1 The PaZCO report published in 2021 was created by the University of Oxford's Environmental Change Institute alongside the sustainability organisation Bioregional and commissioned by the Oxfordshire Local Enterprise Partnership (OxLEP). It details how this momentum over the last decade could be sustained to achieve net zero emissions by 2050. Three potential pathways were presented and compared to a business as usual (BAU) scenario ("Steady Progression") which were:

- **Societal Transformation:** Led from the bottom up, with households adopting new technologies and practices and community groups corralling action.
- **Technological Transformation:** Relies on systemic change driven at the national level, including the deployment of hydrogen for heating and other technical solutions which require the least change to individual behaviour.

[1] 2008 base year for county wide emission reduction targets included to align with the Oxfordshire Energy Strategy and Pathways to a Net Zero Oxfordshire Report

- **Oxfordshire Leading the Way**: Mirrors the widespread cultural and behavioural changes seen in Societal Transformation, and combines this with high deployment of new local electricity generation using solar photovoltaics.

1.2.2 Oxfordshire local authorities are committed to delivering net zero ahead of 2050. To enable this and address the key priorities set out in the PaZCO report, the Future Oxfordshire Partnership Environmental Advisory Group, consisting of OxonCC, the county's four District Councils and Oxford City Council, commissioned the development of a Net Zero Route Map and Action Plan based on the evidence in the Oxfordshire Leading the Way scenario. However, this recognises there are factors outside of local authority control, and, as this report will demonstrate, businesses, policy makers and residents in Oxfordshire have a crucial role in supporting, developing and delivering the changes necessary to enable net zero.

1.2.3 The work supports FOP's Vision of achieving carbon neutrality and the guiding principles to embrace technological changes, support a prosperous and inclusive economy, and maximise the benefits of strong collaboration.

1.2.4 This report develops a Net Zero Route Map and Action Plan for the county, which runs alongside the work of Oxford City Council who commissioned a road map and action plan for Oxford City, that was published by the Zero Carbon Oxford Partnership (ZCOP) in July 2021. This work follows a similar structure to the ZCOP report, by identifying and modelling a pathway to county wide decarbonisation, and outlining priority actions required to deliver the net zero ambition. The key focus of both reports is collaborative action and a joint approach to accelerate decarbonisation and support delivery of a Net Zero Oxfordshire.

1.2.5 OxonCC and key stakeholders commit to working collaboratively with ZCOP to avoid duplication and to ensure the ZCOP's findings are applied to the pan-County Route Map and Action Plan. An important distinction between ZCOP's work and the countywide work is the extension to decarbonising rural communities – a community which requires a different approach to their urban counterparts, and which is often considered more difficult to decarbonise. For instance, there are fewer alternatives to the private car as the main transport mode. Furthermore, rural areas use of higher carbon forms of heating (such as oil and solid fuels) which have additional emission impacts. Through delivery of the countywide Action Plan it will support collaboration and efficiencies by the authorities working together to deliver the 14 unifying actions. A countywide approach will reduce the risk of conflicting messages, whilst also presenting opportunities to expand reach and impact, for instance through pooling resources and via joint funding bids.

1.2.6 The objective of the countywide work is to provide a springboard for action and a shared reference point for all Oxfordshire stakeholders, building on the existing detailed evidence developed by partners including through the PaZCO report. For consistency and clarity, we will use the following terms and classifications throughout this report:

- **Route Map**: High-level maps that articulate the overarching strategic vision to achieve a goal by a certain deadline, breaking it down into interim targets to reach by key milestones (2025, 2030, 2040 and 2050). In the context of decarbonisation, it outlines the trajectory of where emissions need to be at certain dates to achieve a wider net zero target.
- **Joint Actions Plan**: Converts the broader targets presented in the Route Map, into a specific set of actions that need to be adopted to meet these interim milestones. They can contain

short-, medium- or long-term actions, but crucially they provide direction on how the targets can be broken down into tangible, deliverable steps.

1.3 Report Structure

1.3.1 Chapter 2 sets out a net zero pathway for Oxfordshire (aligned to the original PaZCO and updated for the most recent strategies), which demonstrates the scale of measures required to achieve net zero. The modelling was developed for four key areas: road transport (hereby referred to as 'transport’, housing, industrial &commercial and energy supply. Energy supply is then linked to the individual sectors based on their demand profiles. The base year emissions for each sector are analysed and projections for emissions under the net zero pathway are detailed.

1.3.2 In Chapter 3, Decarbonisation Route Maps outline the overarching net zero strategic vision to 2050. Informed by the net zero modelling process and stakeholder engagement, the strategic and four sector-specific decarbonisation Route Maps break down the process into 5-yearly emission milestones, visualising these targets across the years 2025, 2030, 2040, 2050 to clearly communicate the pace of activity and necessary technical steps needed to meet wider decarbonisation targets.

1.3.3 The Action Plan is set out in Chapter 4. The Action Plan prioritises 14 tangible, short-term actions necessary to accelerate the transition to net zero in Oxfordshire. The action development process was informed by extensive stakeholder engagement to ensure the actions compliment and build on current progress being made across the region and to ensure local ownership of the process.

1.3.4 Chapter 0 brings together the Route Map and Action Plan, highlighting key findings from their developmental process, risks and dependencies related to action execution, outlining recommended governance within Oxfordshire, and key asks for national government that will support wider decarbonisation delivery. Insight is additionally offered into how further actions can be layered in future years to ensure maximum impact to 2030 and beyond.

1.4 Next Steps

1.4.1 This Route Map and Action Plan has been developed and tailored specially for Oxfordshire local authorities to own and execute. The Action Plan sets out 14 priority actions for Oxfordshire to focus on, aiming to mobilise and drive decarbonisation efforts over the course of the next three years to five years. Establishing the relevant ‘sprint groups’ that will work collaboratively to address the highlighted actions is a logical next step to transform Oxfordshire’s net zero ambitions into reality.

2 Net Zero Pathway Modelling

Chapter at a Glance
This Chapter details the baseline emissions and consumption by sector. It then introduces some of the key assumptions that have been made regarding energy supply in the pathway modelling, and finally delivers an analysis of the pathway implications for each sector in Oxfordshire.

2.1 Modelling Aims & Scope

2.1.1 The pathway modelling in this work provides a sense of the scale, timing and type of measures that need to be adopted to put Oxfordshire on a path to net zero by 2050 – or sooner. There are numerous routes to decarbonisation and, as a result, there are several potential pathways to consider. In addition, future technological innovations and policy changes are an area of great uncertainty, adding further complexity to the range of possible pathway scenarios. In this chapter, we explore one net zero route which represents what we consider is the most viable and recommended pathway in the context of the current policy and technological landscapes (the 'Oxfordshire leading the way' scenario).

2.1.2 We have applied the following definitions to this report.

- **Net Zero:** Generally interpreted as reducing emissions as close to zero as possible, with any residual being removed from the atmosphere with Greenhouse Gas Removals (GGRs). Net zero can refer both to all greenhouse gases (GHGs) or carbon dioxide (CO_2) alone.
- **Carbon-neutral:** Refers to the use of offsets (not specifically GGRs) to balance out residual emissions.

2.1.3 In this work, the pathway modelling has considered CO_2 only. We define this pathway as net zero as it attempts to eradicate emissions as far as is reasonably possible, with any residual emissions being balanced out with GGRs.

Carbon Offsetting & Greenhouse Gas Removals
Carbon offsets and Greenhouse Gas Removals (GGRs) are methods to balance out residual emissions made elsewhere. For clarity, we use the term removals in reference to methods that physically extract emissions from the atmosphere. The term offsets may also be used for schemes that avoid the production of future emissions.

- **Avoided natural depletion**: prevention of the future destruction of natural systems that act to maintain atmospheric levels of greenhouse gases (e.g. avoided deforestation).
- **Avoided emissions**: reducing future emissions by replacement with a lower carbon alternative (e.g. replacing fossil fuel power generation with renewables)
- **Nature-based GGRs:** conserving or managing ecosystems to remove emissions from the atmosphere (e.g. afforestation).
- **Engineered GGRs:** activities that extract emissions from the atmosphere, can be via technological means (e.g. Direct Air Capture (DAC)).

Avoidance methods are less favourable because the emissions avoided are much harder to quantify compared to those which have been extracted from the atmosphere by removals. In addition, avoidance inherently refers to emissions that have not yet happened, further increasing the uncertainty on their effectiveness. As a result, it is generally accepted that net zero can only be achieved using GGRs to balance out any residual emissions.

GGRs pose a range of challenges. Technological solutions which physically extract emissions from the atmosphere are still in their infancy, they are expensive, and there is uncertainty as to their scalability. There are also significant uncertainties in nature-based solutions (e.g. tree planting) in terms of their additionality, performance over time and potential timelines for deployment (though some methods can provide additional sustainability benefits such as the biodiversity gain from afforestation).
The use of GGRs should therefore also be minimised as much as possible in any net zero pathway.

2.1.4 It is widely accepted that some emission sources will not be reduced to zero. There are several hard-to-decarbonise activities for which there are currently no clear technological alternatives. Such activities include the process emissions arising from the manufacture of cement and the use of fossil fuels in industry. Oxfordshire County has little direct contribution from these hard-to-decarbonise activities, however the county still plays a role in the demand for these activities. Oxfordshire's local authorities will continue to leverage innovation potential via stakeholder engagement and their innovation services such as iHub and the Sustainable Innovation Team, to drive innovation and maximise emission reductions in the hard-to-decarbonise sectors. However, whilst Oxfordshire can play a role in reducing demand, emissions from these areas are not expected to reach zero over the forecast period. In recognition of the difficulty in completely displacing all Scope 1 and 2 emissions in the county, the Pathway Modelling therefore focuses on reducing emissions to as close to zero as possible while appreciating that some negative emissions will be required to balance out residual emissions.

2.1.5 This study considers emissions from Scope 1 and Scope 2. Scope 1 emissions are the direct emissions from the combustion of fuel from owner or controlled sources. Scope 2 emissions are indirect emissions from purchased electricity.

2.1.6 Reducing Scope 1 and 2 emissions are the key focus of this report and the key priority for Oxfordshire over the next decade. Whilst outside of the scope of this work, we acknowledge that there is interest across Oxfordshire in Scope 3 emissions, and that over-time we expect an increased focus on this area. For instance, as transport and energy emissions in the county reduce over time, Scope 3 emission sources such as embodied carbon in materials, will likely form an ever-growing proportion of the county's total emissions. The sustainability of supply chains across the county will also become increasingly important in climate related decision making. Therefore, while emissions from Scope 3 (see below) have not been explicitly modelled, they have been considered within some of the action planning activities.

Scope 3 Emissions & Embodied Carbon

Scope 3 emissions are the result of activities from assets not owned or controlled by the reporting organisation. However, the activities of an organisation will indirectly impact value chains outside of its direct control. Scope 3 emissions sources are therefore the indirect emissions upstream and downstream of the organisation's activities. Examples include purchased goods and services, business travel and disposal of end-of-life products.

Embodied carbon refers to the GHG emissions associated with the manufacturing, transportation, use and disposal of building materials used in construction. Embodied carbon is therefore an upstream emissions consideration and is categorised as Scope 3.

2.1.7 The modelling has been carried out on a sector-based approach to form sector-specific Route Maps and Actions. The sectors modelled are listed below:

- Energy Supply
- Transport (Road)
- Domestic
- Industrial & Commercial

2.1.8 The institutional sector (public buildings) has been included in the analysis of base year emissions for completeness, but is not provided with a dedicated Route Map. Due to its similarity with the commercial sector, the institutional sectors pathway to decarbonisation and the actions required is covered by the Industrial and Commercial Route Map. It is also noted that Oxfordshire local authorities are already carrying out detailed analysis of their own estates and assets, including investment grade audits to support plans in this area.

2.1.9 Emissions from agriculture are included in the industrial category.

2.2 Development Process

2.2.1 The pathway modelling was developed via the following process:

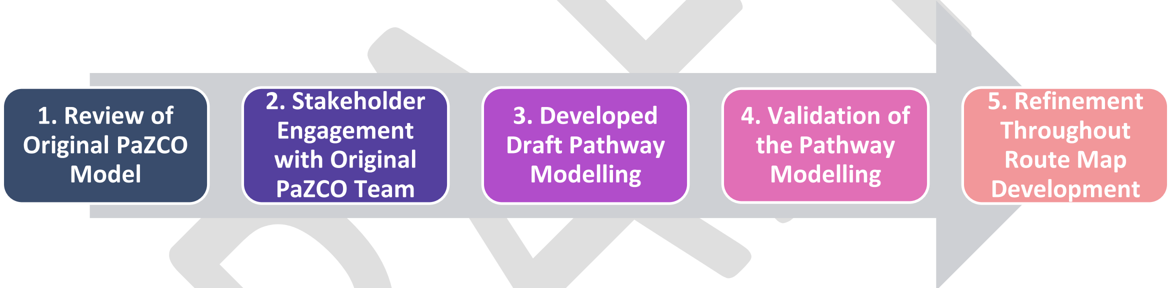


Figure 2-1: Pathway Modelling Development Process

Development Stage	Activities
Review of Original PaZCO Model	The spreadsheet model from the original PaZCO was provided by OxonCC and reviewed by City Science.
Stakeholder Engagement with Original PaZCO Team	Meetings were held with the original PaZCO team to understand the background model in addition to opportunities and gaps for development.
Developed Draft Pathway Modelling	A modelling approach was developed for each of the four sectors (energy supply, transport, housing, industrial & commercial) and assumptions were made on energy supply (solar PV uptake, electricity grid decarbonisation, gas grid decarbonisation). For the full list of modelling assumptions, please refer to Appendix A.
Validation via Two Baseline Consultation Sessions	The Pathway Modelling including underlying assumptions and data were shared with the key stakeholders below) via Baseline Consultation Sessions. • University of Oxford • Oxford City Council (Carbon Reduction Team) • OxonCC's Transport Team • OxonCC's Innovation Hub (EV Integration Team)

	A baseline report was also produced and provided to OxonCC's Climate and Transport teams for feedback.
Refinement Throughout Route Map Development	The Pathway Modelling was refined throughout the development of the Route Maps. Further details on this process can be found in Section 4.2.

Table 2-1: Summary of Pathway Modelling Development Process Activities

2.3 Baseline Emissions

2.3.1 The latest available data for use in the pathway modelling was 2020. However, 2020 experienced severe disruption caused by the COVID-19 pandemic, resulting in dramatic changes in transport and energy demands. For this reason, the 2020 baseline utilises 2019 (the most recent year unaffected by the pandemic) data to model the 2020 baseline:

- **Baseline Emissions Data Sources:** 2019 data obtained from the UK Local Authority and Regional Greenhouse Gas Emissions National Statistics (BEIS, 2021)
- **Baseline Energy Consumption Data:** 2019 data obtained from the Sub-national Electricity, Gas, Road Transport and Residual Fuels Consumption Statistics (BEIS, 2020), (BEIS, 2020), (BEIS, 2020), (BEIS, 2020).

2.3.2 A summary of the baseline that underpins the modelling is shown in Figure 2-2.

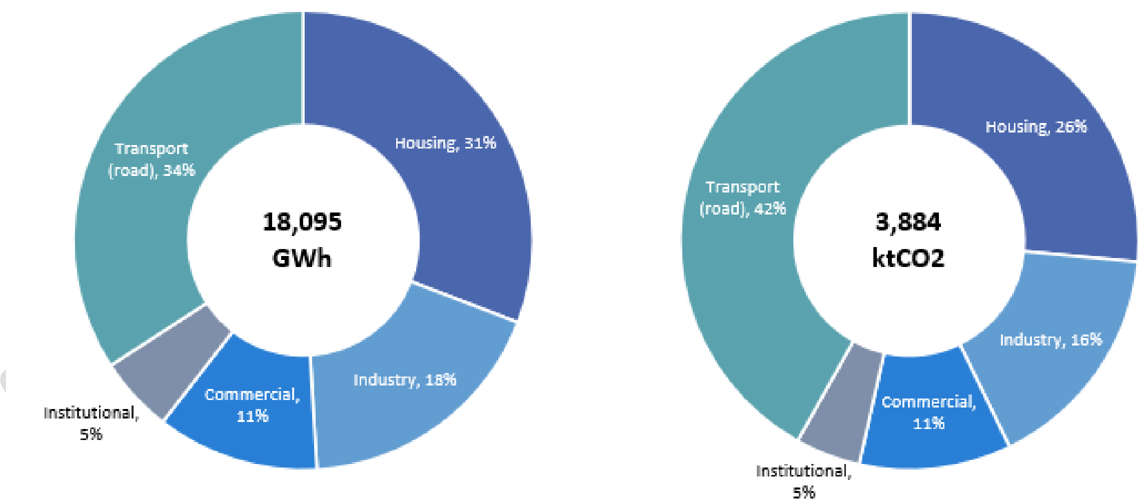


Figure 2-2: 2020 Baseline Energy Consumption (Left) and Emissions by Sector (Right)

2.3.3 Transport and domestic housing are the largest energy consuming sectors in Oxfordshire, each constituting about a third of the county's energy demand. The institutional sector is the smallest, accounting for just 5% of the county's energy demand. The proportional breakdown of emissions from each sector follows a similar pattern to the energy demands, however, the share of transport emissions is greater than its energy consumption proportion. This is due to its use of petroleum and diesel fuels which have a greater carbon intensity than natural gas and electricity.

2.3.4 Figure 2-3 shows the breakdown of energy consumption and carbon emissions in the base year by fuel type. Natural gas (which is delivered by the gas grid) is the fuel type with the highest consumption and is primarily used for space heating and hot water requirements in buildings. The transport fuels (diesel and petroleum) are the fuel types with the next largest consumption, with a combined share of 34% of the county's total energy demand.

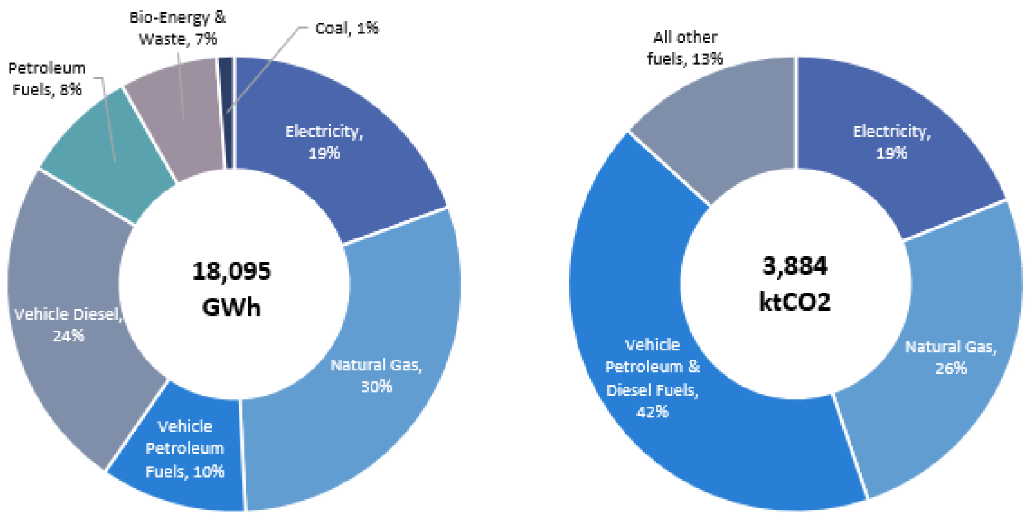


Figure 2-3: 2020 Baseline Energy Consumption (Left) and Emissions by Fuel Type (Right)

2.4 Energy Supply

2.4.1 This section outlines some of the key assumptions made on energy supply in the Pathway Modelling. The assumptions made on the development of energy supply influence the decisions made on the pathway towards decarbonisation in other sectors. For instance, the decision on whether hydrogen is the key decarbonisation solution for space heating is dependent whether the gas grid is expected to be repurposed for 100% conversion to hydrogen. Energy supply has therefore been outlined first, as the decisions made here set the basis for the net zero pathway in the other sectors. For the full list of modelling assumptions, please refer to Appendix A.

2.4.2 The overarching strategy towards decarbonisation in this pathway is to firstly reduce energy demand with energy efficiency measures, electrify heat and transport, and then to self-supply electricity with solar PV. Energy supply modelling mirrors the original PaZCO and explores different scenarios for the intensity of Oxfordshire's power grid that align to national forecasts. The energy supply modelling uses scenarios from the treasury's Green Book and a tailored "Oxfordshire Leading the Way" scenario based on the National Grid's Future Energy Scenarios to show the effect of different energy supply assumptions on the Route Map.

Hydrogen

2.4.3 In the pathway there is no assumption that the gas grid will be fully decarbonised with a 100% switch to hydrogen; therefore, hydrogen is not considered as a key enabler in decarbonising heating and transport. Instead, it has been assumed that the gas grid will reach 20% hydrogen by 2030, but there will be no further increase beyond this concentration level. The Clean Hydrogen Innovation Programme aims to speed up the deployment of clean hydrogen and could be an enabler for achieving 20% by 2030. Going beyond a 20% hydrogen concentration, domestic boilers and cooking hobs would have to be adapted, thereby enforcing significant disruption and cost to gas consumers (Energy Networks Association, 2022).

Electricity Grid Decarbonisation

2.4.4 The national electricity grid has undergone rapid decarbonisation over the past decade, and this is expected to continue. This work has used the Government's 2021 Green Book carbon intensity projections (BEIS, 2021) which show a carbon intensity of 0.159 kg CO_2e/kWh in the base year, which then reduces rapidly to just 0.052 kg CO_2e/kWh by 2030. The use of other carbon intensity projections was explored, particularly those from the National Grid's Future Energy Scenarios (FES), however, three out of the four scenarios under the FES, reach negative carbon intensity by 2050 due to the proliferation of Bioenergy with Carbon Capture and Storage (BECCS). This was deemed too optimistic; hence the Green Book projections were used instead. The FES carbon intensities were explored as a sensitivity and are discussed more in paragraph 2.5.10. The Green Book projection of the electricity grid decarbonisation is shown in Figure 2-4.

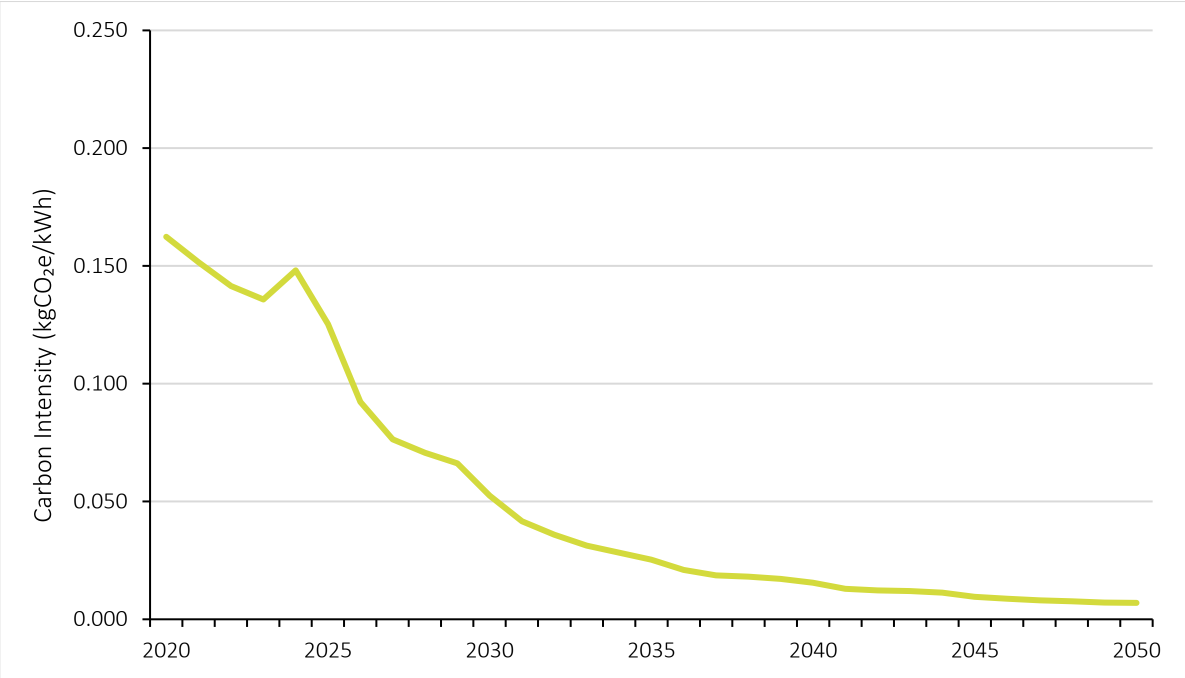


Figure 2-4: Green Book Electricity Grid Carbon Intensity Projection

Solar Photovoltaic Capacity

2.4.5 In line with the previous PaZCO work, under the "Oxfordshire Leading the Way" scenario, it has been assumed that Oxfordshire's share of the UK's solar PV capacity reaches 6% by 2050. The Pathway Modelling used National Grid's FES 2021 projection of national solar PV uptake under their Leading the Way scenario. Oxfordshire's proportion of this projection starts at 3% in the base year, rising linearly to 6% by 2050, which is equal to 5,314 MW of installed capacity. The modelling assumes that all PV has a capacity factor of 11.2%, resulting in a generation of 5,214 GWh in 2050.

2.4.6 It has been assumed that 50% of the PV capacity would be installed onsite within the domestic, industrial, commercial, and institutional sectors, and that all the onsite generation would be self-consumed (i.e. none exported to the grid). The remaining 50% capacity is assumed to be installed exclusively for delivering energy to the grid.

2.4.7 The amount of solar PV deployed on new build rooftops in the housing sector was driven by the Passivhaus energy efficiency standard applied to new builds (see more in paragraph 2.6.16), which stipulates a minimum amount of onsite renewable generation for each household. It was assumed that 25% of existing households would be retrofitted with solar PV by 2050. The capacity of PV installed across each of the industrial, commercial and institutional sectors was determined by the county's overall 6% target (minus the household capacity) but then proportioned across the other sectors by their base year electricity consumption. The amount of PV capacity modelled for each of the sectors is detailed in Table 2-2.

Year	2020	2025	2030	2035	2040	2045	2050
Installed Solar PV Capacity (MWp)							
Housing	0	56	101	255	462	770	1,078
Industrial & Commercial	0	306	596	883	1,052	1,240	1,337
Institutional	0	55	108	160	190	224	242
Solar PV Generation (GWh)[2]							
Housing	0	55	100	251	454	756	1,058
Industrial & Commercial	0	301	584	867	1,033	1,217	1,312
Institutional	0	54	106	157	187	220	237

Table 2-2: Pathway Onsite Solar PV Capacity and Generation

2.5 Countywide Pathway Analysis

2.5.1 Figure 2-5 and Figure 2-6 show the combined energy demand and carbon emissions projections under the pathway out to 2050 for all sectors modelled.

2.5.2 Due to the adoption of energy saving measures and the increasing efficiencies of electrification, the total energy demand of the four sectors is reduced from 17,000 GWh in the base year, to 11,000 GWh by 2050 (a reduction of 33%, see Figure 2-5). The reduction in carbon emissions is more pronounced, starting at 3,700 kt CO_2 in the baseline, then reducing by 92% to 300 kt CO_2 by 2050.

2.5.3 For each sector, growth has been modelled to follow the trajectory of the expected growth in the housing sector. Hence, whilst aggressive energy efficiency measures have been put in place for the industrial and commercial sectors, only modest energy reductions are achieved in 2050 against the baseline (reductions of 8% and 2% respectively) as the growth of the sector offsets the reduction from energy efficiency measures. Within the transport sector, there is a growth of energy demand from 2040 onwards, driven by growing demands of the sector. More detail on the growth projections for each sector can be found the sectoral pathway sections below and in Appendix A Technical Assumptions.

2.5.4 Large energy reductions in the housing and transport sectors are achieved by 2050, which is driven by the efficiency gains from the electrification of heating via air source heat pumps, and through the decarbonisation of transport via battery powered vehicles and zero carbon technologies.

[2] A capacity factor of 11.2% was used to estimate solar PV generation given the installed capacity.

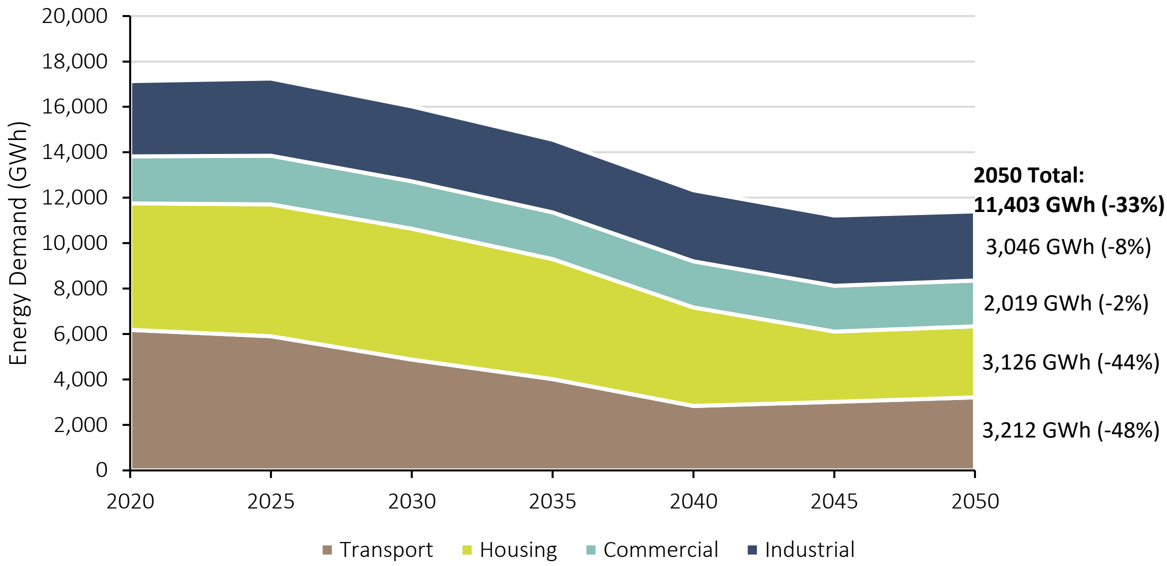


Figure 2-5: Pathway Energy Demands by Sector Projection

2.5.5 The combined carbon emissions of the four sectors are reduced significantly from 3,700 kt CO_2 in the base year to 300 kt CO_2 in 2050 (a reduction of 92%, see Figure 2-6). A small quantity of emissions remain in each sector in 2050 when Green Book assumptions are used for grid electricity (which has a small carbon intensity in 2050), and due to buildings still connected to the gas grid (it has been assumed that natural gas is still the dominant fuel delivered by the gas grid in 2050).

2.5.6 The transport sector has been modelled to achieve the largest emissions reduction (99% against the base year), driven by reductions in demand, modal shift, and a 100% switch to electric and other ZEVs to decarbonise residual emissions. The remaining sectors also achieve deep reductions in emissions through a mixture of energy saving measures and fuel switching to electricity or low-carbon fuels.

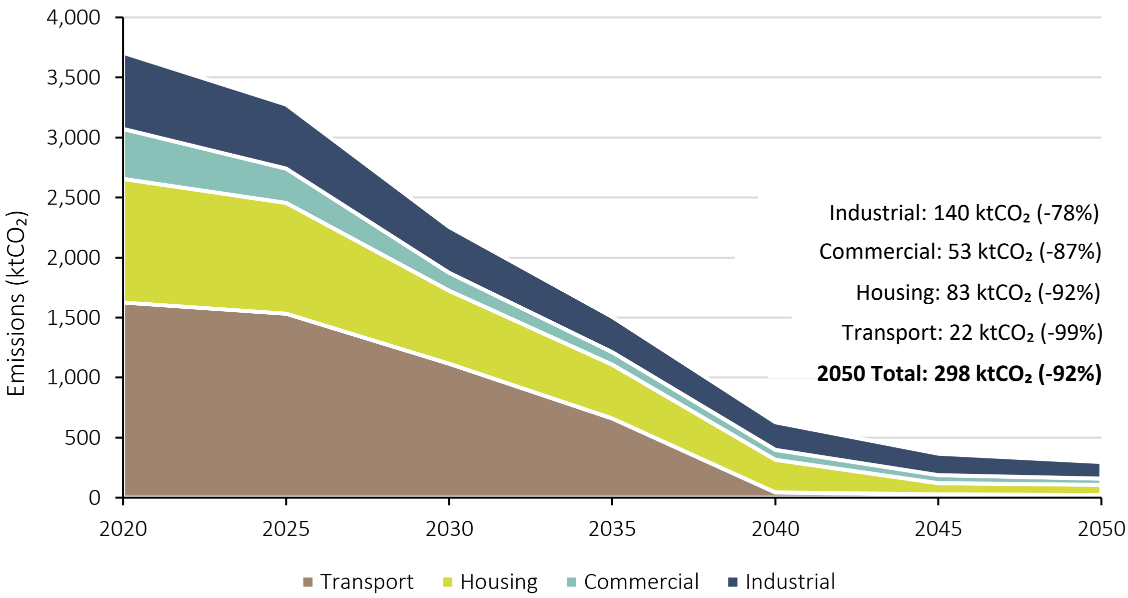


Figure 2-6: Projection of Pathway Carbon Emissions by Sector

2.5.7 Figure 2-7 breaks down the emissions reduction modelled by each sector by decade to 2050.

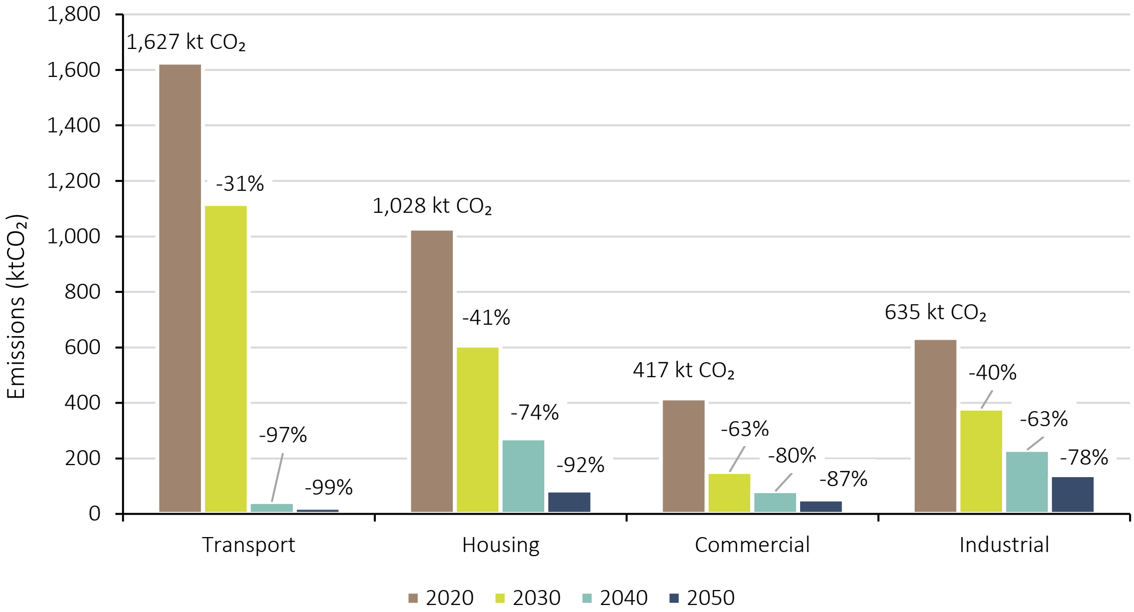


Figure 2-7: Pathway Carbon Emissions Reductions by Sector

Carbon Budgets

2.5.8 Given the combined projected emissions of all the four sectors, five-yearly carbon budgets have been determined starting from 2021 and ending in 2050. The carbon budgets are the maximum quantity of cumulative emissions which can be emitted within the five-year period that will not exceed the projected pathway. The carbon budgets have been displayed graphically in Figure 2-8.

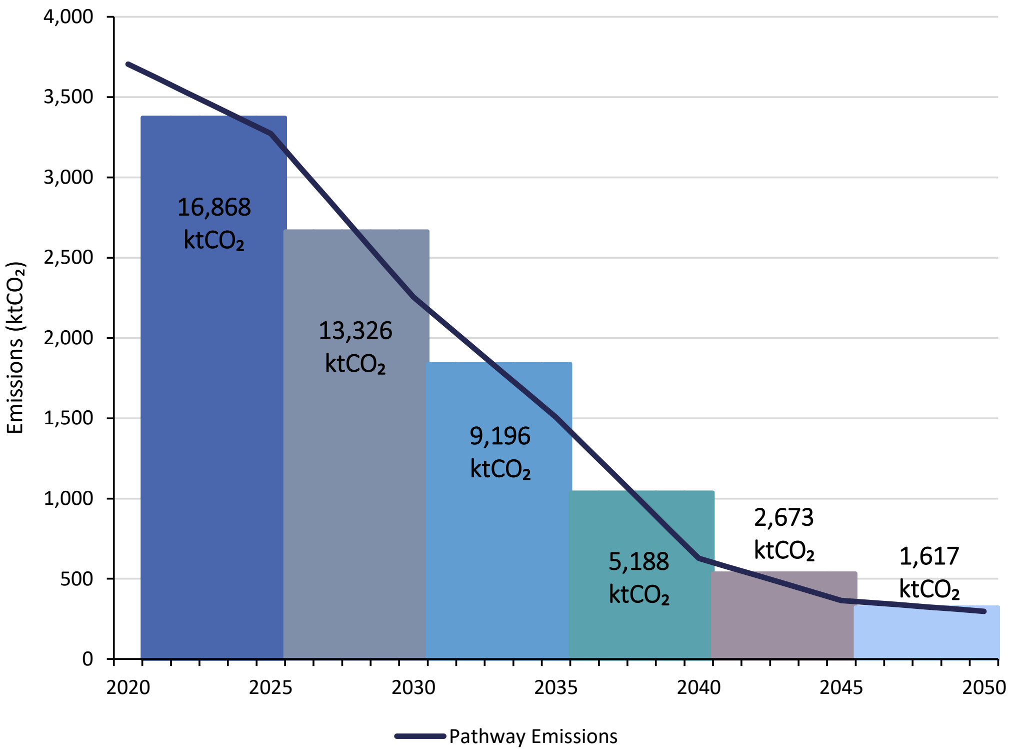


Figure 2-8: Pathway Five-Yearly Carbon Budgets

2.5.9 The five-yearly cumulative budgets and the average annual emissions allowable under each five-year period have been provided in Table 2-3. In the first five-year window, on average the annual emissions need to be reduced by 9% against the base year. To achieve the final budget between 2046 and 2050, the average annual emissions need to be reduced by 91%.

Budget Period	Five-Yearly Cumulative Budget	Budget Period	Five-Yearly Cumulative Budget
2021 - 2025[3]	16,868	3,374	9%
2026 - 2030	13,326	2,665	28%
2031 - 2035	9,196	1,839	50%
2036 - 2040	5,188	1,038	72%
2041 – 2045	2,673	535	86%
2046 - 2050	1,617	323	91%

Table 2-3: Five-Yearly Carbon Budgets

2.5.10 The pathway does not achieve full decarbonisation, instead 300 kt CO_2 of residual emissions remain in 2050. To achieve net zero, the use of GGRs to achieve negative emissions of this magnitude will be required. As discussed in paragraph 2.4.4 above, the use of alternative electricity grid emission projections was explored. Three out of four of the latest National Grid FES projections have a negative carbon intensity in 2050 due to electricity generation via BECCS. As a sensitivity, the pathway was remodelled using the Leading the Way FES projection, which has a carbon intensity of negative 0.043 kg CO_2/kWh in 2050. This projection brings the combined emissions of the four sectors to just below zero in 2050 (-16 kt CO_2), this projection of emissions is shown in Figure 2-9. The transport sector is the only sector that has net negative emissions (due to its 100% dependence on grid electricity in 2050). This sector alone balances out the net positive emissions from the other sectors.

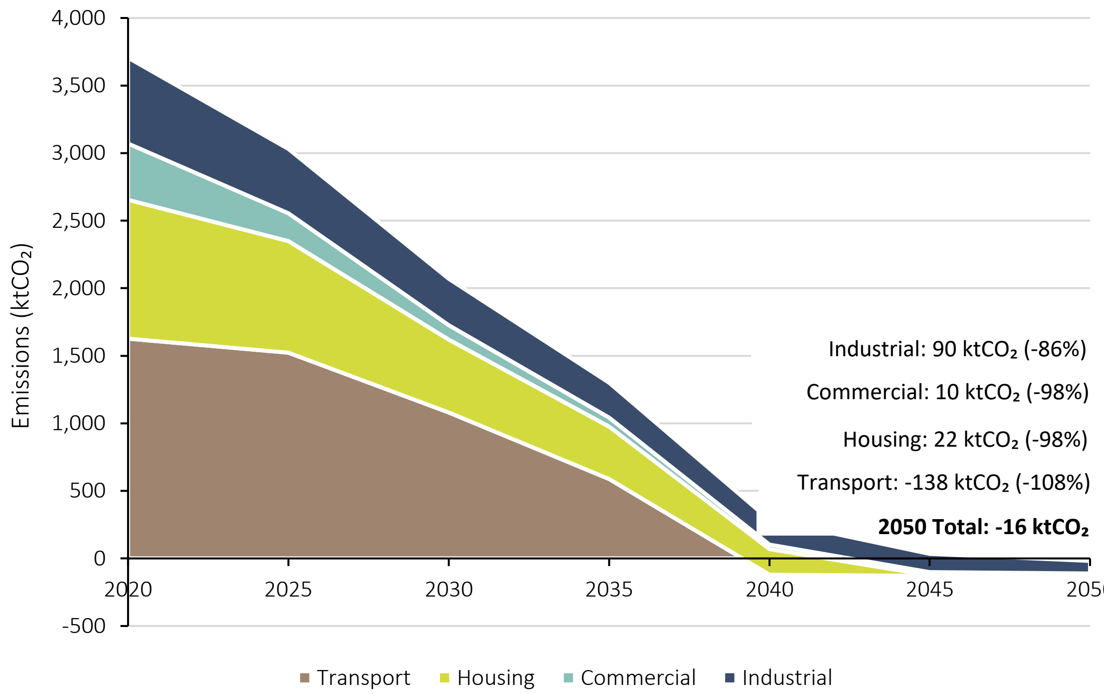


Figure 2-9: Pathway Carbon Emissions Projection under FES Leading the Way Electricity Carbon Intensity Projection

[3] Note that the 2021 to 2025 carbon budget spans three years. The remaining carbon budgets span five years.

2.6 Sector Pathways

Transport (Road)

2.6.1 The focus of the transport analysis is road transport. Using 2019 road traffic statistics from the Department for Transport (DfT, 2019), we have estimated the number of trips starting and ending within Oxfordshire. In the base year 4,167 million vehicle miles were travelled for personal trips (private vehicles, buses, and active travel), and 1,108 million vehicles miles travelled by freight (LGVs and HGVs). Details of how our methodology aligns with Oxfordshire's Local Transport and Connectivity Plan (LTCP) are outlined in Section 3.3.2.

2.6.2 The base year carbon emissions from transport in Oxfordshire (as determined from local authority emissions statistics) were determined to be 1,627 kt CO_2. Using the national breakdown of trip types from the 2019 National Travel Survey (DfT, 2019), the split of carbon emissions by purpose of journey has been estimated and is shown in Figure 2-10. Based on Origin-Destination matrices derived from mobile network data, it has been estimated that 49% emissions are from journeys through Oxfordshire, 22% originate in Oxfordshire, 21% terminate in Oxfordshire and 8% are internal (England's Economic Heartland, 2022).

2.6.3 Despite representing approximately 21% of the vehicle miles in Oxfordshire, freight is responsible for 37% of the carbon emissions in the base year. Freight has the highest carbon emissions per vehicle mile; over 4.5 times greater than that of passenger cars. Following freight, travel for leisure[4] and commuting are the next biggest contributors towards emissions.

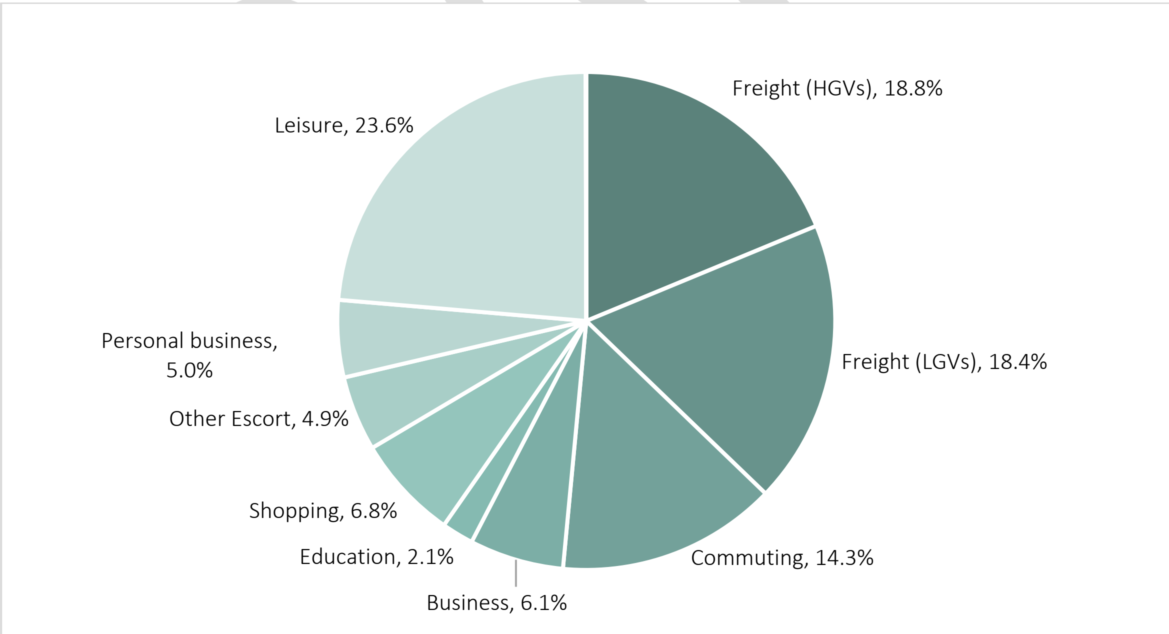


Figure 2-10: Oxfordshire Total Transport Carbon Emissions by Journey Purpose

2.6.4 The pathway model has disaggregated the sectoral emissions between personal trips, LGVs and HGVs. The personal trip miles include all the journey purposes detailed in Figure 2-10 above, excluding the LGV and HGV categories. The personal trip miles can either be avoided/reduced (through travelling less), shifted to other means of travel (such as active

[4] Leisure travel includes: visiting friends at home and elsewhere, entertainment, sport, holiday and day trips.

travel or public transport) or satisfied by private vehicles whose emissions have been improved (such as electric vehicles).

2.6.5 Growth in the transport sector has been modelled to follow the trajectory of housing sector growth. As determined from the base year data, in 2019 the personal trip miles required per household was 14,000 miles. Using the assumed number of new households built each year (see Section 2.6.13 on the housing sector below), the number of total new personal trip miles required each year was scaled accordingly. For example, by 2050, when 138,000 new households have been built, the transport sector requires an extra 1,959 million personal trip miles above the base year requirement (this is prior to applying any demand reduction methods to reduce number of trips). The number of freight miles was increased with the same trajectory, following the percentage increase of personal trip miles each year. For instance, the number of personal trip miles increases by 10% in 2025 (compared to 2020), and the number of freight miles was also assumed to increase by 10% over the same period.

2.6.6 The strategy for decarbonising transport follows the transport hierarchy's principles of avoiding/reducing trips, shifting modes (e.g. personal vehicle miles to transition away from private vehicles towards public transport and active travel), and lastly a rapid switch to zero emissions technologies across all vehicles as shown in Figure 2-11.

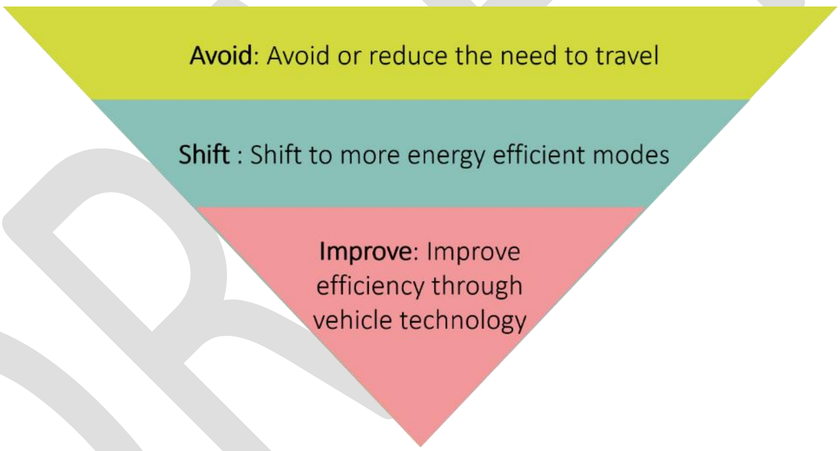


Figure 2-11: Transport Hierarchy

2.6.7 The emissions abatement ambition for the transport sector is greater than the other sectors modelled. As per the Oxfordshire LTCP (OxonCC, 2022), the ambition for transport is to achieve net zero by 2040, without any negative emissions (offsets or GGRs). This level of ambition is deemed achievable as the technological solutions are largely in place (with the exception of zero emission HGV solutions) and regulatory mechanisms (e.g. the phase out of fossil fuel cars and LGVs) have been announced to support the necessary shifts. Demand reduction and mode shift assumptions are also included to align to the LTCP.

2.6.8 A summary of the key model inputs for the transport sector has been detailed in Table 2-4. The pathway reaches its full ambition by 2040, any change beyond that year is due to continued growth of the sector.

2.6.9 In line with the transport hierarchy, the number of private vehicles miles is reduced firstly by a reduction in demand (25% reduction in vehicle miles by 2040), then secondly by a 10% mode shift of private vehicles (cars and motorcycle) miles to public transport (buses and coaches) and active travel modes. The number of freight miles (both LGVs and HGVs) required is reduced by efficiency measures such as aerodynamics, and propulsion and operational efficiency.

2.6.10 It is assumed that private vehicles and LGVs will largely be decarbonised through electrification, while the technology pathway for public transport and HGVs is still uncertain. For both public transport and HGVs, it is assumed that 100% of the vehicle stock has zero tail-pipe emissions. The precise mix of electric versus hydrogen will have an impact on the energy supply needs. The energy supply pathway assumes a system-optimal generation mix based on current technologies. Hydrogen increases the overall energy requirement of the system, therefore it has been assumed that 100% of the vehicle stock is electric.

Year	2020	2025	2030	2035	2040	2045	2050
Demand Reduction							
Demand Reduction of Personal Trips vs. Baseline (% of Vehicle Miles)	0%	-10%	-20%	-25%	-25%	-25%	-25%
Mode Shift of Personal Trips vs. Baseline (% of Vehicle Miles)	0%	-5%	-10%	-10%	-10%	-10%	-10%
Freight Trip Efficiency	0%	5%	10%	10%	10%	10%	10%
Vehicle Stock Changes							
Private Vehicles (Cars & Motorcycles): Electric	3,777 (<1%)	25,000 (7%)	120,000 (36%)	200,000 (61%)	343,029 (100%)	359,369 (100%)	375,710 (100%)
Public Transport (Buses & Coaches): Zero Carbon	0 (0%)	200 (5%)	1,000 (19%)	2,000 (36%)	6,174 (100%)	6,751 (100%)	7,328 (100%)
LGVs: Electric	0 (0%)	2,500 (6%)	15,000 (35%)	35,000 (76%)	49,508 (100%)	53,158 (100%)	57,077 (100%)
HGVs: Zero Carbon	0 (0%)	200 (4%)	900 (19%)	2,800 (55%)	5,456 (100%)	5,858 (100%)	6,290 (100%)

Table 2-4: Transport Sector Key Pathway Inputs

2.6.11 As shown in Figure 2-12, in the base year the energy demands of transport, and consequently its source of emissions, are almost completely fulfilled by petroleum and diesel fuels. By 2040, with all vehicle stock having converted to ZEVs (including HGVs), all energy demands are satisfied by zero carbon sources. In the pathway, this has been modelled to be supplied by 100% grid electricity and green hydrogen, resulting in a small quantity of emissions in 2040 (43 kt CO_2), which is a 97% reduction against the base year.

2.6.12 Due to the demand reduction, mode shift and freight efficiencies implemented in the pathway, the proportion of energy demand between modes of travel change over time. In 2020, the use of private vehicles (cars and motorcycles) dominated the energy requirements of the sector, whereas in 2040 freight requires a larger proportion. More aggressive demand reduction in personal trip miles was modelled, hence this change over time. Public transport's proportion of the sector's energy demand increases over time with the introduction of mode shifting personal vehicle miles onto public transport and active travel.

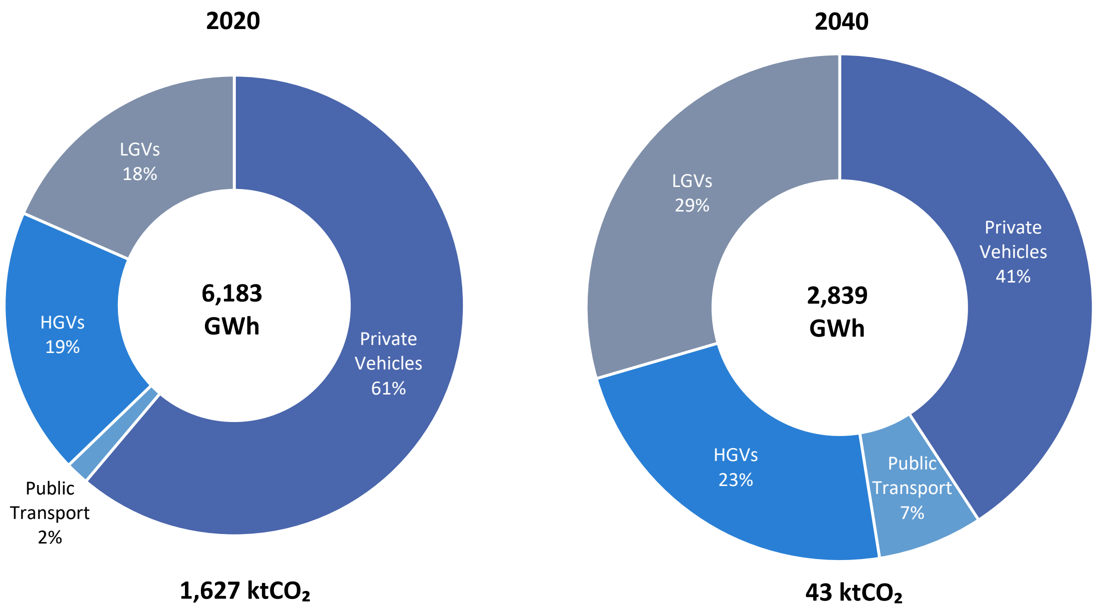


Figure 2-12: Transport Sector Pathway Energy Mix and Carbon Emissions in 2020 and 2040

Domestic

2.6.13 There were circa 300,000 homes in Oxfordshire in the base year, of which 17% were rated EPC A or B, 30% rated EPC C, and 53% rated EPC D or below (see Figure 2-13). The pathway has modelled a retrofit of all existing properties to bring them up to at least EPC B standard, meaning that 83% of the base year stock requires energy efficiency improvements.

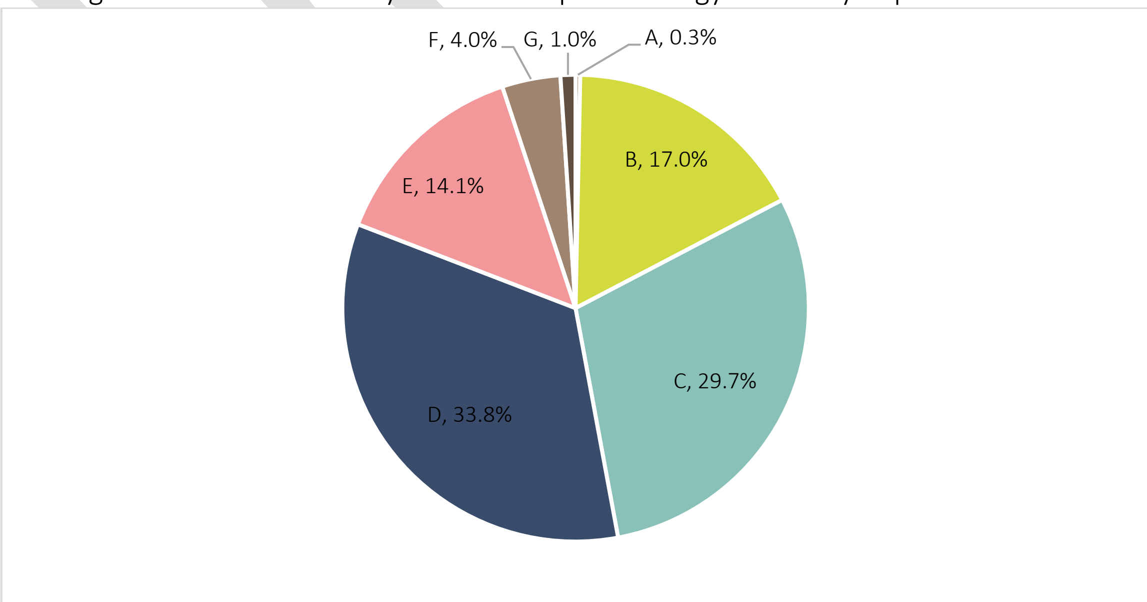


Figure 2-13: Oxfordshire 2020 Housing Stock by EPC Rating (Department for Levelling Up, Housing and Communities, 2022)

2.6.14 Oxfordshire's continued housing growth is embedded into the modelling. From 2021 to 2050, the average number of new homes built each year has been modelled to be just over 4,600 which aligns with Oxfordshire's six Local Plans. By 2050, the total number of homes reaches 438,000.

2.6.15 The overarching strategy for decarbonising this sector is to adopt stringent energy efficiency standards for any new builds (e.g. Passivhaus), to retrofit existing buildings to bring them up to EPC B or above, deploy solar PV on rooftops and to electrify heating via air source heat pumps (in both existing and new builds).

2.6.16 A summary of the key model inputs for the housing sector has been detailed in Table 2-5. From 2030 onwards, the target is for new builds to be built to Passivhaus Plus standards. This provides further tightening of standards beyond the Future Homes Standard (expected to be required from 2025), which is an ambitious target. Both the Passivhaus Plus and Premium standards stipulate on-site renewable generation targets (which have been modelled to be delivered by solar PV) (Passivhaus Trust). The Passivhaus Plus and Premium developments generate more electricity than they consume, therefore, new build properties from 2030 onwards are net exporters to the grid. The retrofit of solar PV to existing households has been modelled. The latest Feed-in-Tariff (FiT) data from 2019 showed that that approximately 3.4% of the households in Oxfordshire were claiming solar PV FiT and that the average size of PV installation in the county was 3.7kW (BEIS, 2019). The pathway has modelled an increasing number of existing households retrofitted with PV, reaching 25% of the existing (2020) housing stock by 2050. It was assumed that the average installed capacity of PV installations would remain at 3.7kW. Note that the household electricity demands do not include electric vehicle charging as this demand is accounted for in the transport sector.

2.6.17 The adoption of air source heat pumps is the key enabler of space heating and domestic hot water decarbonisation in the housing sector. As such, it has been modelled that by 2040, 80% of the existing and new build properties will be heated by heat pumps. Note that Oxfordshire is participating in two Heat Pump Ready projects in Oxford City and Cherwell District under the BEIS Heat Pump Ready programme.

Year	2020	2025	2030	2035	2040	2045	2050
New Builds							
Housing Standards for New Builds	Current Part L	Future Homes Standard	Passivhaus Plus	Passivhaus Plus	Passivhaus Premium	Passivhaus Premium	Passivhaus Premium
% New Developments with Heat Pumps	0%	20%	80%	80%	80%	80%	80%
Existing Properties							
Number of Existing Properties EPC B and Above	53,028 (18%)	54,000 (18%)	70,000 (23%)	150,000 (50%)	250,000 (83%)	300,806 (100%)	300,806 (100%)
Number of Heat Pumps (Existing Homes)	0	750 (<1%)	5,000 (2%)	35,000 (12%)	100,000 (33%)	240,000 (80%)	240,000 (80%)

Table 2-5: Housing Sector Key Pathway Inputs

2.6.18 The remaining properties not heated by electrically driven heat pumps in 2050 have been modelled to switch over to district heating or bioenergy, while a proportion of existing builds remain connected to the gas grid. A comparison of the energy supply mix in the base year and in 2050 has been provided in Figure 2-14.

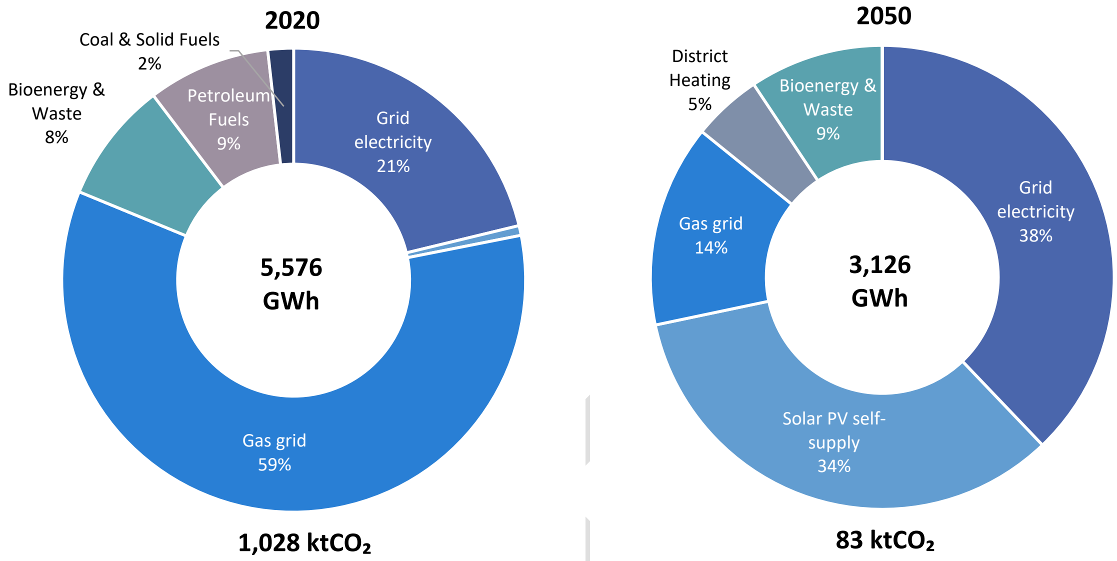


Figure 2-14: Housing Sector Pathway Energy Mix in 2020 and 2050

Industrial & Commercial

2.6.19 The industrial and commercial sector is presented as a single sector in this work, however, different modelling inputs were applied to industrial and commercial buildings and processes as it is recognised that the pathway towards decarbonisation across each of these will differ. For example, the heating requirements of commercial buildings (dominated by offices, retail and storage units) will differ to that in industrial buildings, which may require high temperature processes.

2.6.20 The number of rateable (those subject to business rates) properties in Oxfordshire as of March 2020 was 21,940 (Valuation Office Agency, 2020). As of June 2022, 13,509 non-domestic EPCs had been lodged in Oxfordshire, which implies that about 60% of the industrial and commercial building stock have an EPC (Department for Levelling Up, Housing and Communities, 2022). Expanding the coverage of non-domestic EPCs would help to gain a better understanding of the non-domestic building stock within the county.

2.6.21 Non-domestic EPC data is less revealing in terms of energy consumption breakdown and building fabric present than its domestic counterpart, but it is useful in that it provides the sub-sector with and an estimate of the floor area for each building. By assuming that the non-domestic EPC data is representative of the whole non-domestic building stock in Oxfordshire, a breakdown of the sub-sectors and their proportions of total building stock (assessed by floor area) has been provided in Figure 2-15. Using the average floor area per building determined from the non-domestic EPC data (719m^2/building) and the total number of rateable properties in Oxfordshire, the total floor area of all industrial and commercial buildings was estimated to be 15,779,076m^2. Of this total floor area, 12% was attributed to industrial buildings, the remaining to commercial.

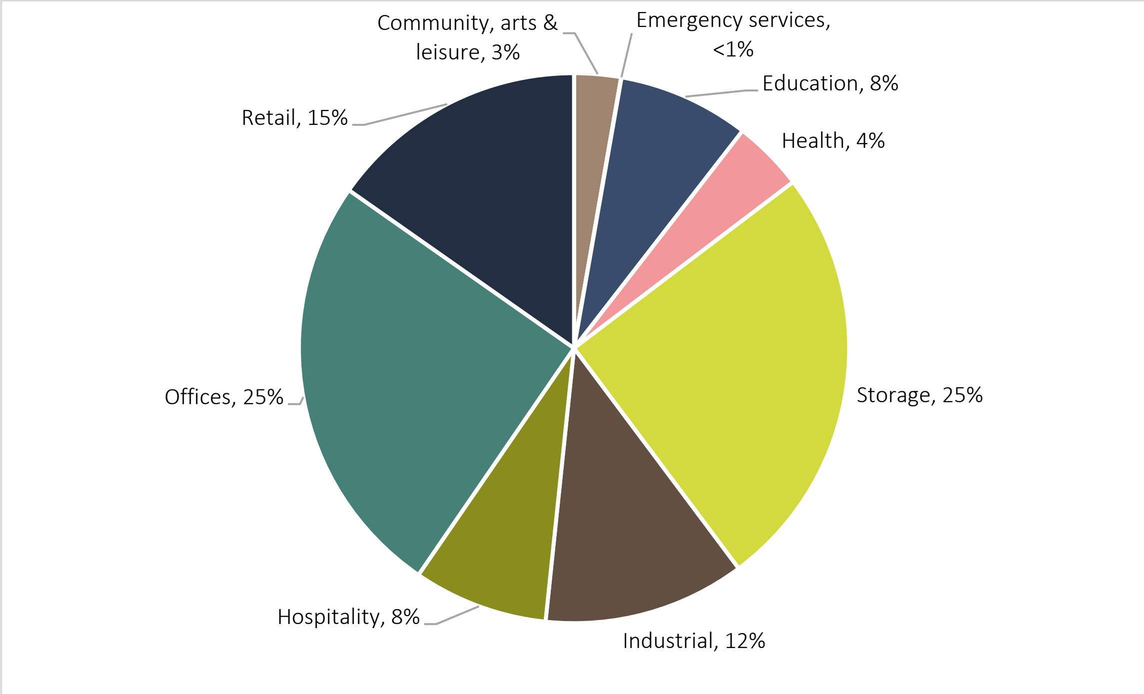


Figure 2-15: Industrial and Commercial Buildings in Oxfordshire by Floor Area (Department for Levelling Up, Housing and Communities, 2022)

2.6.22 Growth in this sector was modelled to follow the trajectory of the growth in the housing sector by assuming the number of new jobs created for each new household. The energy consumption of the industrial and commercial sectors was broken down by end use using average energy intensities of non-domestic sub-sectors obtained from the national non-domestic Building Energy Efficiency Survey (BEES) (BEIS, 2014-15). (See the Technical Appendix for more information.)

2.6.23 The overarching strategy for decarbonising commercial and industrial buildings has been to build new stock to a high energy efficiency standard, to retrofit a proportion of the existing stock over time to improve their energy efficiency, fuel switch the heating and hot water, and process loads over to lower carbon alternatives, then to install a substantial amount of solar PV onsite to offset the use of grid electricity.

2.6.24 It is recognised that there is a great variety of building types and energy demands within the industrial and commercial sector, therefore, the approach stipulated in this pathway may not reflect the best approach in all cases. The pathway presented here is the expected aggregate impact of the wide variety of measures which may be deployed across this sector. Beyond technological measures, effective management and organisational decision making will be key. One-off investment decisions and ongoing facilities management both have an important role in achieving net zero.

2.6.25 Decarbonising the heat demands within non-domestic buildings, particularly for high temperature process loads, will be challenging, hence the pathway is less ambitious in this respect when compared to the housing sector. The pathway recognises that reliance on fuels within the non-domestic sector (particularly in industrial settings) is likely to remain for some time. As detailed in 2.4.3 above, the pathway has not placed a reliance on green hydrogen becoming a widely available zero carbon fuel, hence no switching to hydrogen has been modelled in the industrial and commercial sectors (though the gas grid changes in composition over time to 20% hydrogen by 2030). There are upstream (Scope 3) emissions associated with the production of hydrogen (particularly in the case of "grey" or "blue" hydrogen which is generated from natural gas), therefore any pathway with a heavy reliance on hydrogen as a fuel must consider its lifecycle impacts. The pathway has modelled a modest electrification of heating loads and a switch away from high carbon intensity fuels (petroleum, coal) towards lower carbon fuels (biomass, gas grid).

2.6.26 The key inputs applied to the pathway for the industrial sector are shown in Table 2-6 and the impact on the sector's energy mix and carbon emission by 2050 is shown in Figure 2-16.

Year	2020	2025	2030	2035	2040	2045	2050
Energy Efficiency Improvements							
% Building Existing Stock Retrofitted (to achieve abatement potential)	-	0%	10%	20%	30%	40%	50%
% New Building Stock Achieving Full Abatement Potential	50%	100%	100%	100%	100%	100%	100%
Heating and Hot Water Fuel Mix							
Gas Grid	26%	26%	26%	26%	25%	25%	25%
Direct Electric	2%	6%	10%	14%	17%	20%	22%
Electricity – Heat Pumps (ASHP & GSHPs)	0%	5%	9%	13%	17%	20%	23%
Bioenergy & Waste	24%	25%	26%	26%	26%	26%	25%
Petroleum, Coal, Solid Fuels	48%	38%	29%	21%	14%	8%	4%
Process Load Fuel Mix							
Gas Grid	17%	17%	17%	17%	18%	18%	19%
Direct Electric	36%	38%	41%	43%	45%	47%	49%
Bioenergy & Waste	24%	26%	28%	30%	30%	31%	31%
Petroleum, Coal, Solid Fuels	24%	19%	14%	10%	7%	4%	2%
On-Site Solar PV Capacity							
Solar PV Installed Capacity (MWp)	0	117	227	337	402	474	511

Table 2-6: Industrial Sector Key Pathway Inputs

2.6.27 The energy demand of the industrial sector in 2050 is similar to that in 2020, as the growth of the sector offsets the reduction from energy efficiency measures. The carbon emissions, however, are substantially reduced. By 2050, they have been reduced by 78% to 140 kt CO2. This is due to a near eradication of high carbon intensity fuels (petroleum, coal and solid fuels), the decarbonisation of the electricity grid, and the self-supply of solar PV electricity.

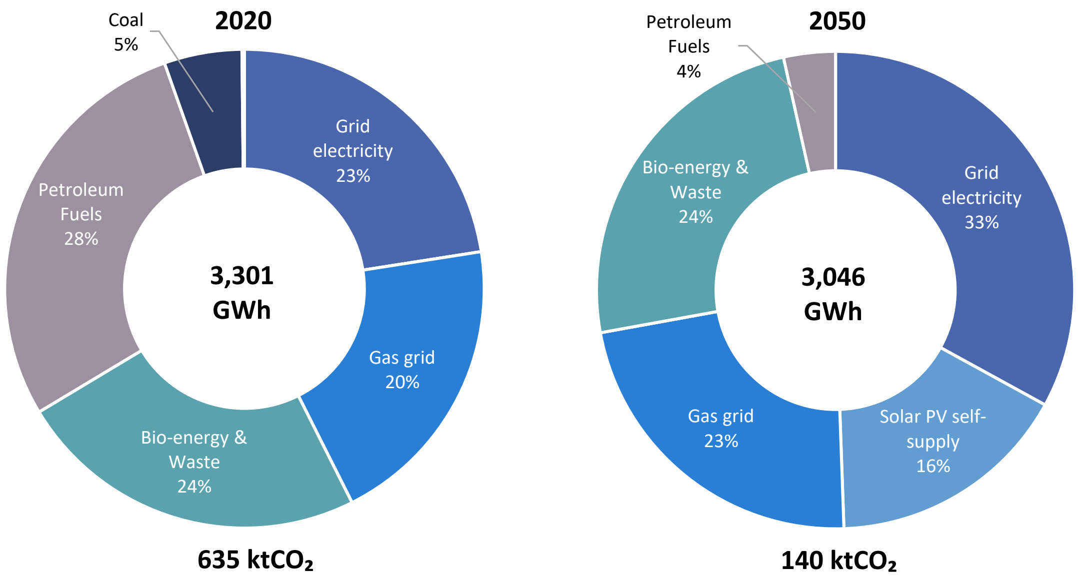


Figure 2-16: Industrial Sector Pathway Energy Mix in 2020 and 2050

2.6.28 The key inputs applied to the pathway for the commercial sector are shown in Table 2-7, the impact on the sector's energy mix and carbon emission by 2050 is shown in Figure 2-17.

Year	2020	2025	2030	2035	2040	2045	2050
Energy efficiency improvements							
% Building Existing Stock Retrofitted (to achieve abatement potential)	-	0%	10%	20%	30%	40%	50%
% New Building Stock Achieving Full Abatement Potential	50%	100%	100%	100%	100%	100%	100%
Heating and hot water fuel mix							
Gas Grid	79%	68%	56%	46%	36%	29%	22%
Direct Electric	19%	16%	14%	11%	9%	8%	6%
Electricity – Heat Pumps (ASHP & GSHPs)	0%	13%	27%	39%	50%	59%	67%
Bioenergy & Waste	0%	1%	2%	3%	3%	4%	5%
Petroleum, Coal, Solid Fuels	2%	2%	1%	1%	1%	0%	0%
Process load fuel mix							
Gas Grid	52%	46%	39%	33%	28%	24%	20%
Direct Electric	46%	53%	60%	66%	72%	76%	80%
Petroleum & Coal	1%	1%	1%	1%	0%	0%	0%
On-site solar PV Capacity							
Solar PV Installed Capacity (MWp)	0	189	368	546	650	767	827

Table 2-7: Commercial Sector Key Pathway Inputs

2.6.29 Like the change seen in the industrial sector pathway, the overall energy demand of the commercial sector in 2050 is similar to that in 2020. The growth of the sector offsets the increasing energy efficiency of the building stock. However, the carbon emissions have dramatically reduced by 87% in 2050 compared to the base year. Through switching most heating demands over to electricity (via heat pumps or direct electric), electricity constitutes 82% of the sector's energy demand in 2050. Approximately half of this electricity is met by on-site solar PV. The use of self-supplied PV and a decarbonised electricity grid leads to deep emissions reductions in this sector.

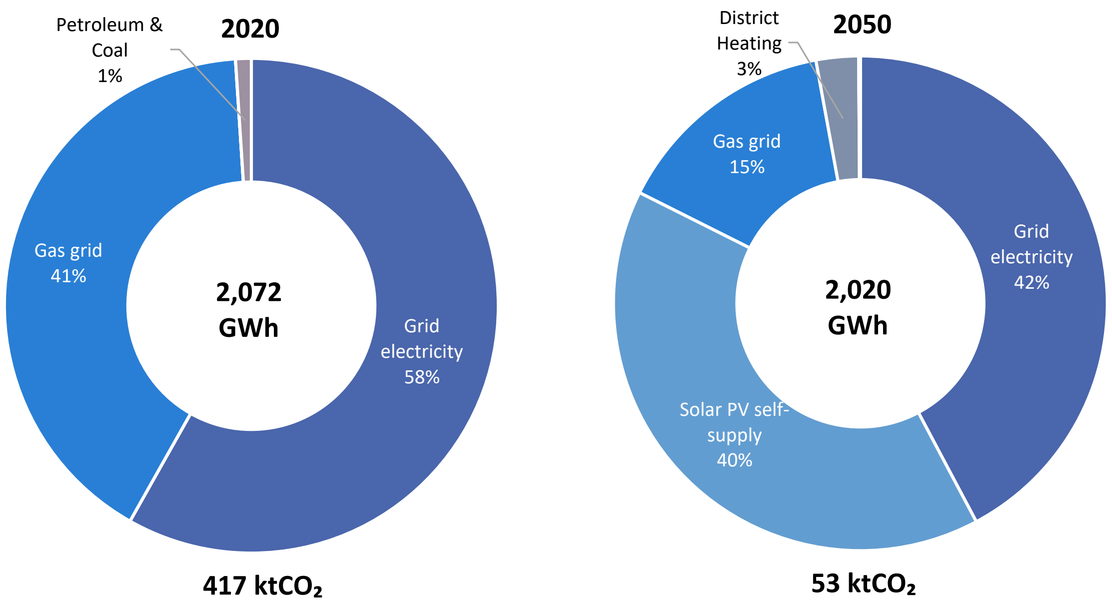


Figure 2-17: Commercial Sector Pathway Energy Mix in 2020 and 2050

2.7 Key Findings

2.7.1 The Pathway Modelling has demonstrated that dramatic changes are required in each sector to reach a sufficient level of decarbonisation required to achieve net zero. A summary of the key findings is outlined below.

Solar Capacity

2.7.2 The previous PaZCO work set out an ambitious target for Oxfordshire to account for 6% of the national solar PV installed capacity under the FES Leading the Way scenario. By 2050, this would require an installed capacity of 5,314 MWp in Oxfordshire (this is greater than the capacity in previous PaZCO work as a result of incorporating the latest FES projections). In 2019, Oxfordshire accounted for just under 3% of the national total at 389 MWp. The resulting scale-up required to meet the pathway goals has been demonstrated in Figure 2-18.

2.7.3 By 2030, Oxfordshire would have to quadruple its installed PV capacity, requiring an average annual deployment of 120 MWp from 2020 to 2030. To reach the 2050 goal, the capacity of PV in Oxfordshire would have to increase 13 times against the base year deployment, requiring an annual average deployment of 164 MWp across the 30-year period. This is a substantial deployment rate considering the total deployment in the base year is in the region of 400 MWp. Delivery of this ambition will require a significant increase in PV installations on existing buildings (both commercial and domestic) and ground mounted arrays.

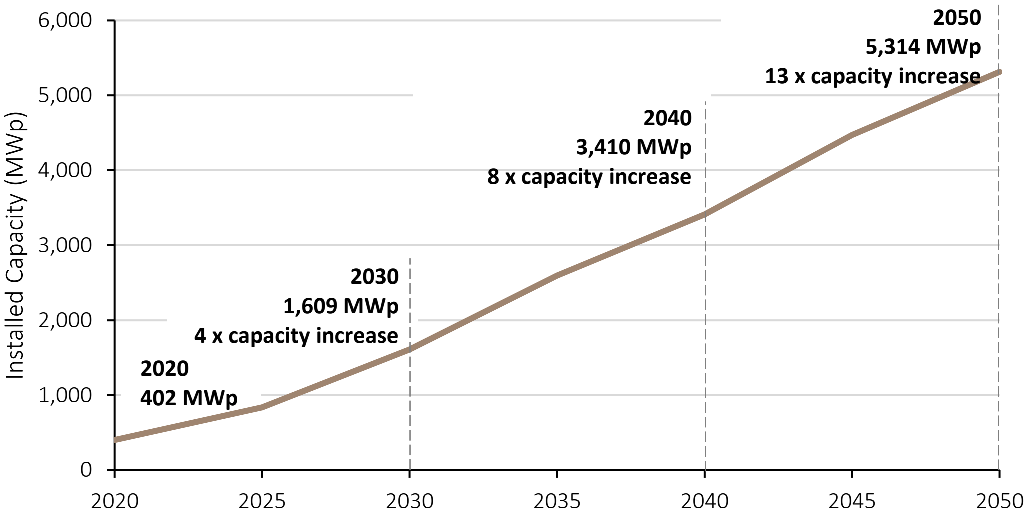


Figure 2-18: Pathway Installed PV Capacity in Oxfordshire

Electric & Zero Emission Vehicles

2.7.4 The scale-up of ZEVs required is arguably even more ambitious. In the base year, just under 4,000 ZEVs formed part of the existing vehicle stock. By 2040, the pathway had modelled 100% switch to ZEVs (including LGVs and HGVs). This is equivalent to a 105 times increase in the total number of ZEVs in Oxfordshire, requiring that just under 20,000 new ZEVs enter the stock each year over the 20 year period. This scale-up will be particularly challenging for HGVs, where battery technology has not advanced to a level where it is seen as a likely alternative to conventionally fuelled vehicles.

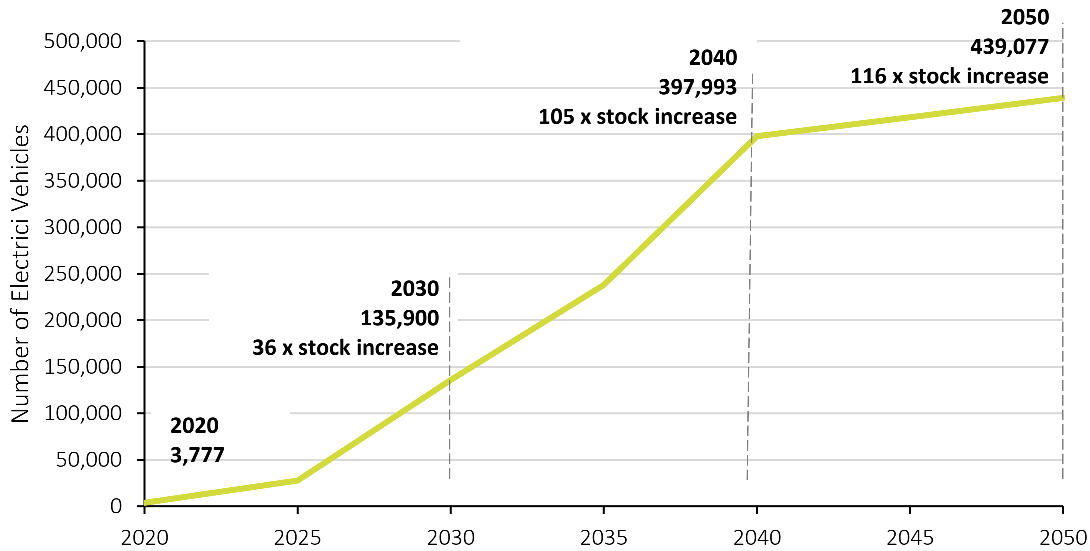


Figure 2-19: Pathway Number of ZEVs

Domestic Sector

2.7.5 The domestic sector has three key challenges:

- Ensuring new builds are built to a high energy efficiency standard (such as Passivhaus Plus).

- Retrofitting existing properties to improve their energy efficiency.
- Retrofitting heat pumps to existing properties.

Table 2-8 shows the scale-up required on these three ambitions.

2.7.6 Evaluating these ambitions against what has already been achieved nationally puts these Oxfordshire targets into perspective. In 2019, a total of 27,000 heat pumps were installed in the UK (Energy Saving Trust, 2021). Under the pathway between 2041 and 2045, this rate of annual heat pump deployment will be required in Oxfordshire alone. As of November 2020, there were a total of 1,300 Passivhaus accredited buildings in the UK (Homebuilding & Renovating, 2022). However, the pathway requires over 4,000 Passivhaus Plus properties to be built annually from 2030 onwards.

Year	2021 – 2025	2026 – 2030	2031 - 2035	2036 – 2040	2041 – 2045	2046 – 2050
Heat Pump Retrofits to Existing Properties						
Cumulative Heat Pump Retrofit	750	5,000	35,000	100,000	240,000	240,000
Annual Rate of Heat Pump Retrofit Required	150	850	6,000	13,000	28,000	0
Energy Efficiency Retrofits to Existing Properties						
Cumulative Energy Efficiency Retrofits	972	16,972	96,972	196,972	247,778	247,778
Annual Rate of Retrofit Required	194	3,200	16,000	20,000	10,161	0
Number of Passivhaus Housing Built						
Cumulative Passivhaus Housing Built	0	0	21,788	43,576	65,363	87,151
Annual Rate of Passivhaus Required	0	0	4,358	4,358	4,358	4,358

Table 2-8: Pathway Housing Energy Efficiency and Heat Pump Targets

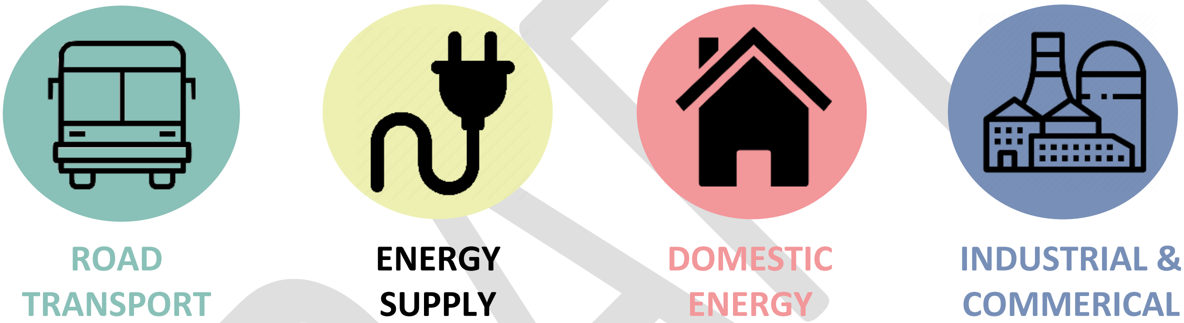
3 Net Zero Route Maps

Chapter at a Glance
This Chapter sets out a series of Route Maps to net zero for Oxfordshire across transport, energy supply, domestic energy and industrial & commercial sectors.

3.1 Purpose

3.1.1 2050 net zero targets can feel distant. However, by deconstructing goals into a clear trajectory of emissions, a clear and tangible pathway to success can be presented. A key output of this work is therefore five high-level Route Maps. The Route Maps include four sectoral Route Maps, (focused on the highest emitting sectors) and an overarching decarbonisation Route Map. The Route Maps provide an overview of Oxfordshire's net zero vision to 2050, supported by clear interim targets.

3.1.2 The Route Maps are intended for a high-level audience with an aim to clearly communicate the pace of activity required across the four sectors:



3.1.3 The Route Maps provide key targets aligned to milestones at 2025, 2030, 2040 and 2050. The milestones support a monitoring framework that can be utilised to motivate, advance, and continually drive the reduction in CO_2 emissions in Oxfordshire. An important first step is successful delivery of the 14 tangible actions that are detailed in Chapter 4.

3.2 Development Process

3.2.1 The Route Maps were developed via the process shown in Figure 3-1.:

Figure 3-1: Route Map Development Process

Development Stage	Activities
Baseline Evidence & Pathway Modelling	The net zero targets/pathway requirements depicted in the Route Maps have been extracted from the Baseline Evidence and Pathway Modelling. This informed the development of the following quantified targets, deemed key for achieving net zero by 2050. • **Overarching:** Total emissions by each sector listed below. • **Transport:** Demand reduction, modal shift, increase in freight efficiency and the electrification of vehicles. • **Energy Supply:** Gas grid mix, solar PV. • **Domestic Energy:** EPC ratings, new build housing standards, heat pump deployment and the fuel mix. • **Industrial & Commercial:** Retrofit of building stock, electrification of processes and electrification of heating and hot water. Chapter 2 discusses the Pathway Modelling methodology and results in detail and Appendix 1 explains the associated general and sectoral assumptions.
Route Maps Development	Route Map development included drawing from national, regional and local strategic documents to summarise the wider activities, pathways and policy that are expected to support the transition to net zero.
Comparison Against PaZCO and Oxford Results	The initial Route Map targets were compared to aspirations and outputs of the original PaZCO report, the Zero Carbon Oxford Roadmap and Action Plan Report (Carbon Trust, 2021) and the Local Transport and Connectivity Plan (LTCP) to identify and address any inconsistencies.
Stakeholder Engagement and Feedback	The underlying assumptions and data and the draft Route Maps were shared with key stakeholders via a Baseline Report, Baseline Consultation Sessions, Thematic Workshops and Focus Groups and feedback incorporated.
Revised Pathway and Route Maps Development	Following stakeholder feedback, the Route Maps were revised to ensure they align with existing context, and are ambitious, yet feasible with the ability to meet the net zero by 2050 target.

Table 3-1: Summary of Route Map Development Process Activities

i. Significant action is required to meet net zero targets, both at a national scale and within Oxfordshire. Ambitious challenges require ambitious solutions, and the Route Maps reflect Oxfordshire's drive to decarbonise by 2050, detailing the emissions reductions necessary by certain milestones (2025, 2030, 2040) in order for the county to be net zero by the aspired date. The following sections provide the finalised five strategic Route Maps.

3.3 Alignment with Local Transport & Connectivity Plan Targets

3.3.1 Oxfordshire's Local Transport and Connectivity Plan (LTCP) (OxonCC, 2022) specifies the following targets:

- A zero carbon transport network by 2040.
- Replace or remove 1 out of every 4 (25%) current car trips in Oxfordshire by 2030.

- Replace or remove 1 out of every 3 (33%) current car trips in Oxfordshire by 2040.
- Increase the number of cycle trips in Oxfordshire from 600,000 to 1 million cycle trips per week by 2030.
- Deliver a transport network that contributes to a climate positive future by 2050.

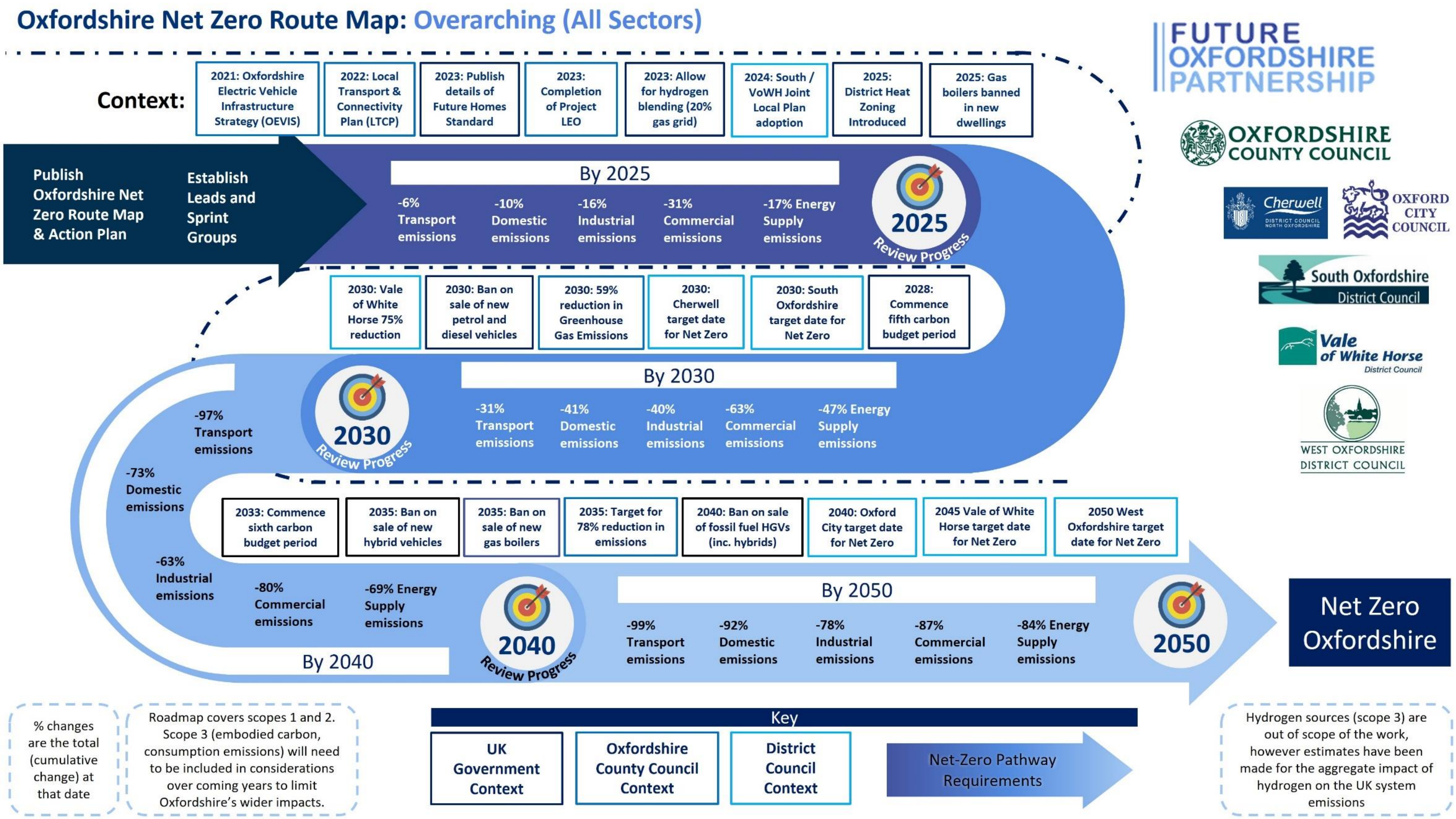
3.3.2 The Transport Route Map targets are aligned to the above LTCP targets, in particular delivering a zero carbon transport network by 2040. As this is a study in carbon emissions, we have added an additional conversion from the trip-based targets expressed in LTCP to vehicle mile impacts. This is because it is the total number of non-zero carbon vehicle miles that drive carbon emissions. For example, if the county achieves trip reduction targets but only addresses short-distance trips, this will generate a relatively small reduction in carbon emissions compared to scenarios where the full breadth of trip types are addressed. We have assumed that there will a bias towards shorter-distance trips within the LTCP targets, but that longer-distance trips will also be targeted. Table 3-2 sets out how the LTCP targets have been expressed as vehicle mile reductions within the Route Maps.

Target Date	Trip Reduction Targets (LTCP)	Targeted Vehicle Miles Impacts (Net Zero Route Map)
2030	25% reduction in trips	20% reduction in miles
2040	33% reduction in trips	25% reduction in miles

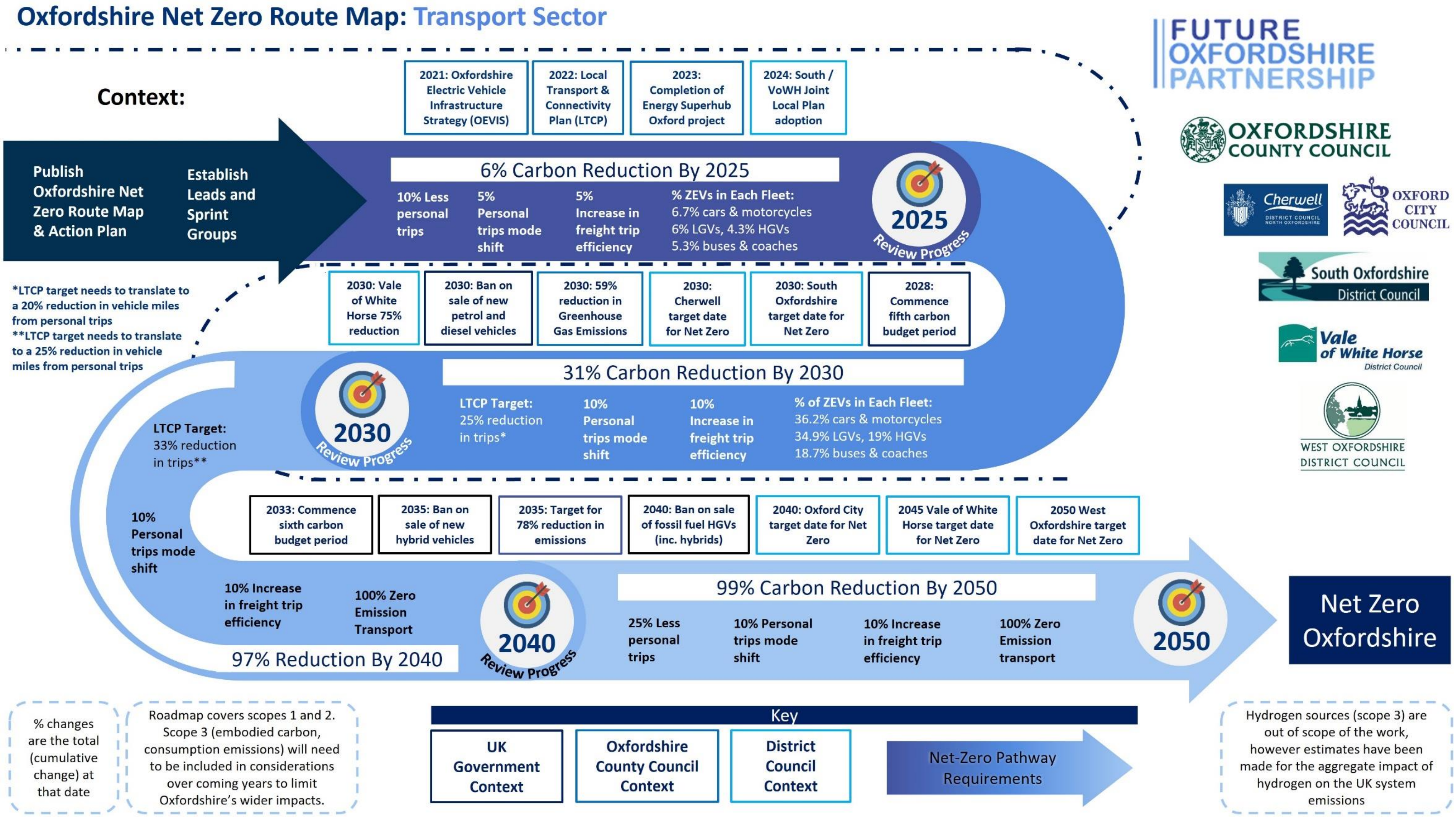
Table 3-2: Relationship Between LTCP Trip Reduction Targets and Net Zero Route Map Targets for Vehicle Miles

3.3.3 The Transport Route Map includes the LTCP target with an asterisk to explain the translation.

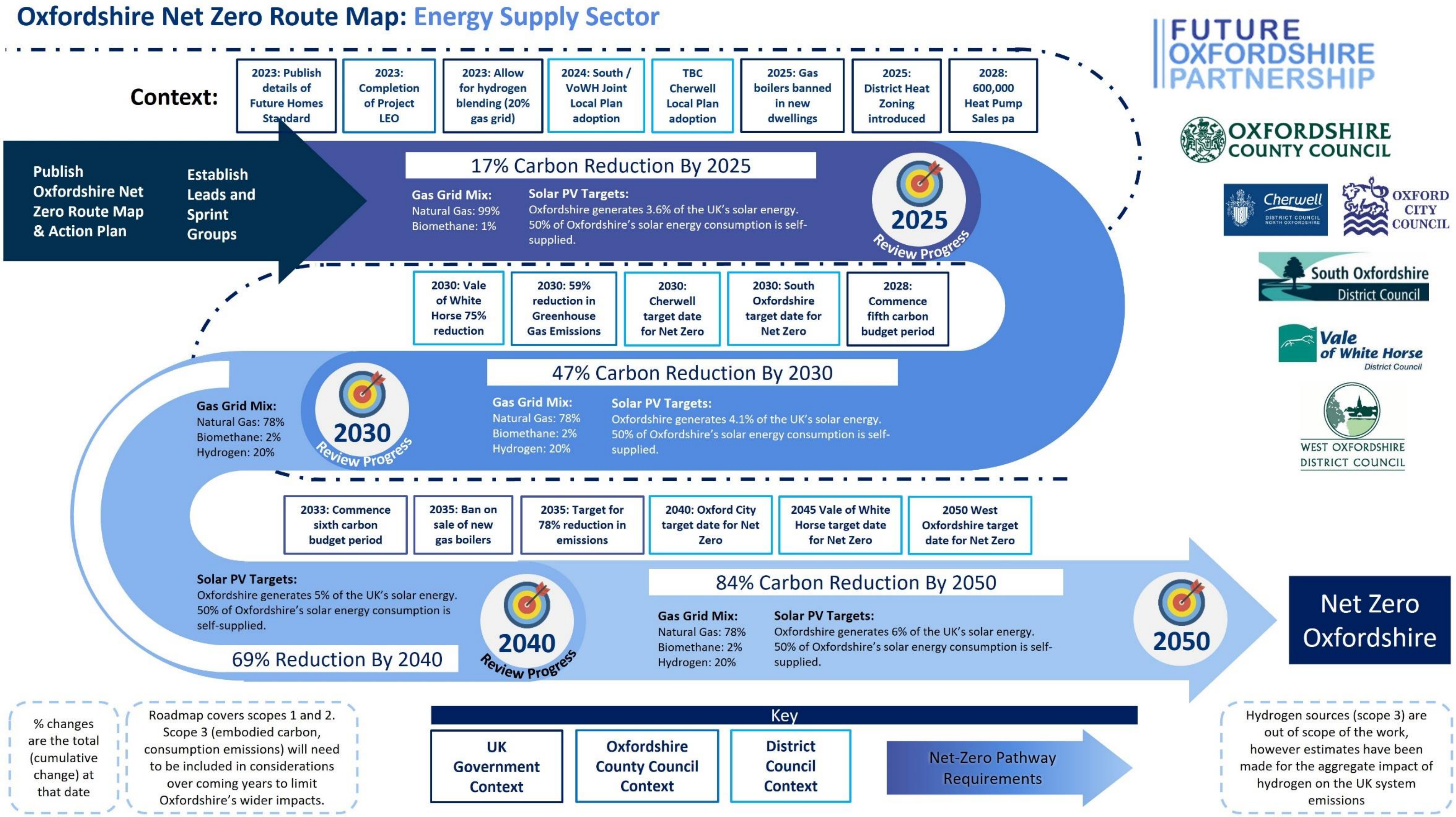
3.4 Overarching Route Map



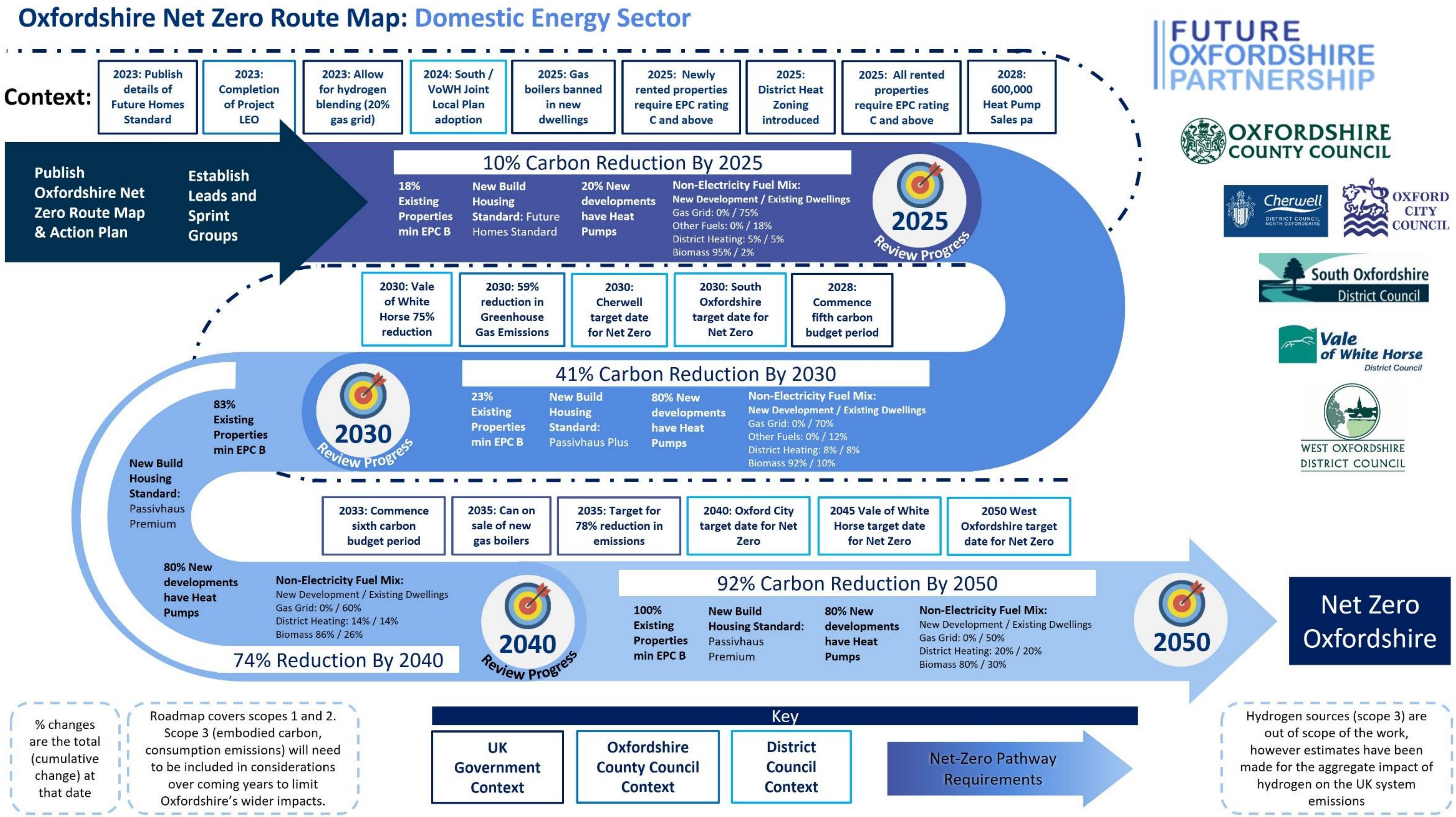
3.5 Transport Route Map



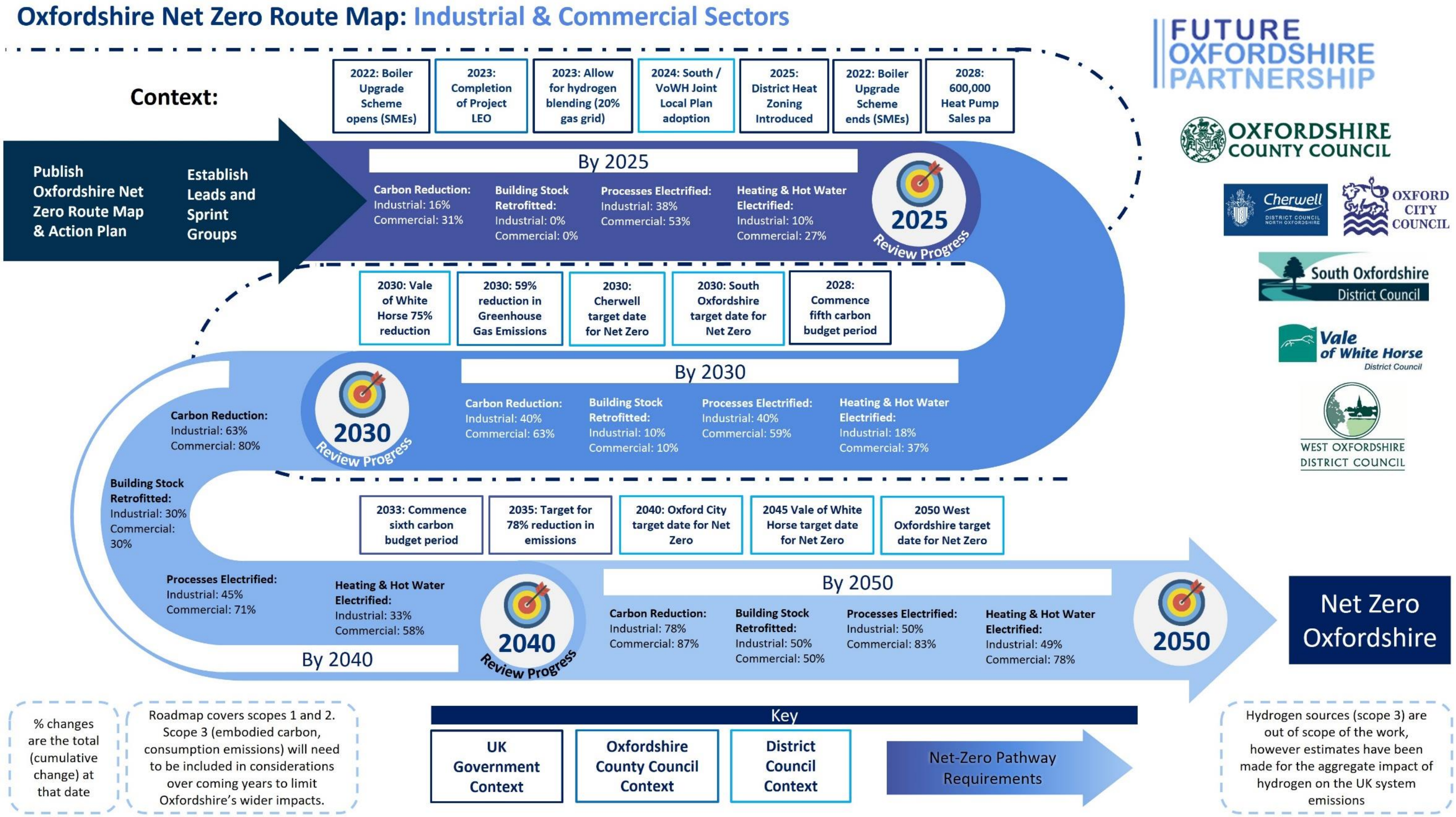
3.6 Energy Supply Route Map



3.7 Domestic Energy Route Map



3.8 Industrial & Commercial Route Map



3.9 Next Steps

3.9.1 The Joint Action Plan which follows (Chapter 4) is directly informed by these strategic sectoral Net Zero Route Maps, outlining precise, achievable actions that work to deliver the specific sectoral decarbonisation requirements and contributing to the wider target of a net zero Oxfordshire.

3.9.2 A monitoring and evaluation table for the Route Maps is provided in Appendix B, providing an important mechanism to review and track progress.

4 Joint Action Plan

Chapter at a Glance
This Chapter sets out the key short-term actions required to accelerate Oxfordshire's delivery of net zero emissions in the form of a Joint Action Plan.

4.1 Action Plan Purpose

4.1.1 The purpose of the Joint Action Plan is to provide direction, channelling the wider decarbonisation focus into a set of collective actions that can or need to be started over the short-term. The Joint Action Plan provides a portfolio of actions. Some actions will deliver measurable results over the next 3-5 years to empower and demonstrate success. Others will be multi-year programmes supporting longer-term success, thereby helping to set Oxfordshire on the right trajectory to address the Route Map targets. Successful progress across the portfolio of actions will demonstrate that significant savings can be delivered through local action.

4.1.2 The Joint Action Plan does not replace individual organisation's net zero strategy and workplans, or statutory documents such as Local Plans or Local Transport Plan but complements and supports their delivery. Collaboration on these workstreams aims to support effective use of member organisations' resources, avoid duplication of effort, help scale programmes to secure investment and provide clearer working structures to support knowledge transfer and sharing of information and best practice.

4.2 Action Development Process

4.2.1 Oxfordshire has successfully made significant reductions in carbon emissions over the last decade. A key starting point in developing the Action Plan was therefore to identify initiatives and projects that are already in motion, to ensure that the actions build on and compliment, existing work. The Route Map and modelling have evidenced that there is a need to substantially scale up of current activities, and therefore whilst we recognise existing projects, we must also acknowledge that they require significant expansion to meet the Route Maps ambitions.

4.2.2 The Action Plan has been developed to create a set of realistic and tailored steps that simultaneously build on and accelerate Oxfordshire's net zero transition. The Action Plan was informed by the updated Net Zero Pathway Modelling (Section 2) and the key sectoral milestones identified within the Route Maps (Section 3). The success of the Action Plan will be underpinned by collaboration including from businesses, policy makers and residents. As a result, the actions have been informed by an extensive stakeholder engagement process (see). Co-producing the actions in partnership with key stakeholders sought to ensure that

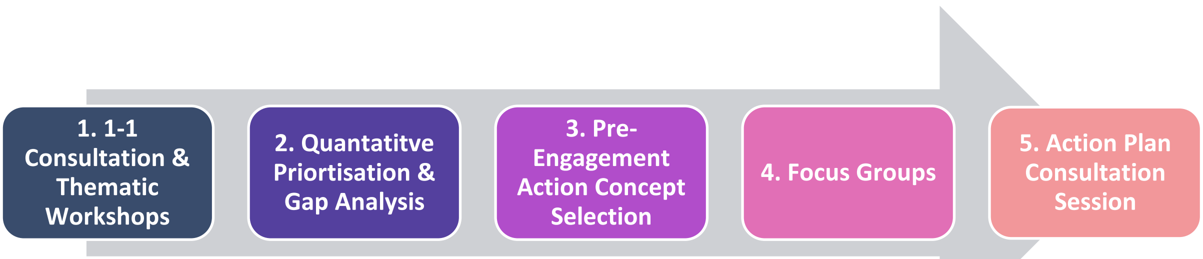


Figure 4-1: Summary of the Stakeholder Engagement Process

the final set of actions, whilst focused on those which can be led or significantly influenced by the Oxfordshire local authorities, build on local expertise and knowledge, and crucially that key stakeholder buy-in has been obtained. In addition to collaborative sessions undertaken by City Science, the draft Action Plan has been evolved and finalised by the Environmental Advisory Group officers representing each of the Oxfordshire Local Authorities. Continued buy-in and collaboration will be vital to driving the actions forward and maximising success.

Development Stage	Engagement Activities
1-1 Consultations and Thematic Workshops	14 in-depth sessions were held with key stakeholders to gain an understanding of the ongoing low-carbon initiatives and activities within Oxfordshire's local authorities and to identify any gaps. This process was followed by five thematic workshops, consisting of: Transport – Freight Transport – Rural Industrial & Commercial Retrofit/Domestic Finance The first four workshops explored the gaps and opportunities across the key carbon emitting sectors. The fifth workshop, which focused on funding recognised the fundamental importance of finance and funding to deliver the actions and to support the county with the net zero transition.
Quantitative Prioritisation and Gap Analysis	Suggested action outputs from the workshop sessions were documented, further categorised, sorted and similar actions aggregated. Each action with two or more votes from workshop participants was analysed using a multi-criteria assessment that took account of: expected carbon impact, cost, alignment with the route map and co-benefits. Gap analysis was undertaken to ensure the suite of actions taken forward to the prioritisation stage was sufficient to meaningfully respond to the Route Map ambitions across all areas. All actions were then prioritised through applying a priority score derived from the multi-criteria assessment and were subsequently ranked.
Pre-Engagement Action Selection	The action prioritisation stage and 1-1 consultations provided key themes which were used to inform the focus groups. The three top ranking actions identified were emailed to focus group attendees before the session, asking participants to vote on the top two priority actions that they would like to see discussed in further detail.
Focus Groups	Nine focus groups were held in total. The sessions supported the development of high level business cases for the two priority actions (as identified via the voting process outlined above). For each action, discussions focused on the relevant implementation steps, funding requirements, owners/champions and any risks and dependencies. During the wrap up of each session, feedback was obtained on which actions stakeholders would like to see in the Final Report.

Action Plan Consultation Session	The process concluded with an Action Plan Consultation session where a draft of the initial priority actions (emerging from focus group discussions) were presented for further feedback and to finalise the set of actions to formally take forward into the Action Plan. Following stakeholder feedback, the actions were updated to ensure they build on existing activities (avoiding duplication), and are ambitious, yet feasible with the ability to execute meaningful change over the next three to five years.

Table 4-1: Further Detail of Stakeholder Engagement Activities

4.2.3 The section below outlines the priority actions. These actions build on existing activities to support the significant scale up of measures required to meet Oxfordshire's net zero commitments. Whilst ambitious these short-term actions are embedded in realism to support successful delivery.

4.3 Action Plan

4.3.1 An overview of the joint actions is outlined in *Table 4-2*. It includes the sectoral emissions that the action supports. Due to the urgency of the climate emergency, we propose that all actions are mobilised over the next year. However, we recognise that some actions are more complex than others. We have therefore allocated each action with a time-frame as follows:

- **Short-term:** Actions which can be successfully implemented over the next 12 months.
- **Medium-term:** Actions which can be successfully implemented or scaled over the next 2-3 years.
- **Long-term:** Actions which can be successfully implemented or scaled over the next five years.

4.3.2 The Action Plan also includes a number of enabling actions (such as planning policies and finance) and some measures that go beyond Scope 1 and 2 – for example the actions to address consumption emissions. The inclusion of these actions reflects the priorities of key stakeholders and support a wider portfolio of carbon reductions. They also reflect a whole-system approach to decarbonisation which aligns with the PaZCO vision.

Sector	No.	Action
	1	Expand and scale-up retrofit delivery.
	2	Scale up programmes to address the retrofit skills gap.
	3	Develop a collective purchasing approach that supports the widespread deployment of rooftop solar on existing buildings.
	4	Develop an on-going Local Area Energy Planning (LAEP) function.
	5	Collaborate with town and parish councils to accelerate the roll out of publicly accessible EV charge points.
	6	Share knowledge in the preparation of Local Plans and development of net zero policies.
	7	Explore new funding mechanisms to support delivery of net zero actions.
	8	Develop a strategic active travel network.
	9	Develop a tailored and place-based transport demand management campaign.
	10	Identify and deliver low emissions freight charging and last mile delivery hubs at suitable sites across the county.
	11	Identify existing activities across Oxfordshire which contributes to the development of a circular economy including green skills, waste management, design and manufacture. Seek to build upon these to facilitate progress to a more circular economy.
	12	Explore opportunities to enhance carbon sequestration through land use change, including targeted habitat restoration and creation.
	13	Embed climate change into decision making across Oxfordshire's local authorities.
	14	Embed net zero carbon and circular economy principles into procurement processes across Oxfordshire's local authorities.

Table 4-2: Overview of the Action Plan

4.4 Action Implementation

4.4.1 A recommended Convening Lead is assigned to each action to guide delivery and provide active support, helping to secure buy-in from key stakeholders and the wider community. Delivery will be underpinned by 'Sprint Groups', which consist of relevant individuals and organisations that share a particular subject specialism to maximise efficiency in delivering solutions to specified decarbonisation problems, particularly through collaborative action. This approach mirrors that of ZCOP, thereby supporting consistency across the county. As the near-term actions are completed, the group will evolve existing actions or select and work up new actions, based on any changes in context. Once actions have been successfully delivered, the Sprint Group will disband, and a new working group will be established to drive forward new actions.

4.5 The Priority Actions

BUILDING DECARBONISATION PROGRAMME

Recommended Sponsor: Future Oxfordshire Partnership

Overview: The domestic sector currently accounts for 26% of countywide emissions, the industrial sector for 16% and commercial 11%. To meet the Route Map targets, the rate and scale of buildings retrofit needs to be significantly expanded across all sectors. The priority actions in this programme identify where joint working can enable this, drawing on experience from existing activities in this area. Whilst delivery at scale may be limited by the national policy and funding context, it is recognised that supply chain, finance and demand need to grow in pace with one another in this area, and there are local actions that can be taken to support this. Ensuring all new builds meet net zero carbon requirements is enabled through implementation of planning policies and guidance (Action 7 in Enabling Actions).

Route Map Alignment: By 2030 over 16,000 properties will need to be retrofitted to above EPC B standard to mitigate GHG emission from Oxfordshire's domestic sector. This equates to 54 properties per week from 2024. By 2040, air source heat pumps (identified as the key enabler of heat and domestic hot water decarbonisation) will be in use in 80% of existing properties and all new build properties. In commercial and industrial buildings, energy efficiency retrofits and high energy efficiency standards for new builds will save an estimated 40 kt CO_2/yr in the commercial sector and 79 kt CO_2/yr for the industrial sector. Whilst these savings are offset by growth of the sector, electrification of heating can still reduce emissions by 87% by 2050 compared to the base year, with the expectation that over half of the sector's energy demand in 2050 is met by on-site solar PV.

Current Barriers to Delivery:

- Lack of consistent funding support – particularly short-term funding.
- Shortage of skilled retrofit installers and vertical siloes within the retrofit supply chain making it difficult to deliver 'whole house retrofit'.
- Generating demand in households who are Able-to-Pay.
- Customer journey needs improvements, particularly around awareness and consideration of available services.

- Grid constraints challenging electrification of heat (see LAEP workstream).

Priority Actions (Detailed Below):
1. Take actions that address barriers to scale-up retrofit delivery.
2. Scale up programme to address the retrofit skills gap.
3. Develop a collective purchasing approach that supports the widespread deployment of rooftop solar on existing buildings.

Timescale: Medium Term Action	Theme: Retrofit
Action 1: Expand and scale-up retrofit delivery.	
Overview	Bring together expertise and experience gained from existing programmes (including Cosy Homes, the Sustainable Warmth and Home Upgrade Grant Schemes, Better Housing Better Health Programme, Energy Solutions Oxfordshire and activities led through the ZCOP programme) to coordinate existing activity on retrofit (across Unable-to-Pay and Able-to-Pay customer groups).
Route Map Alignment	By 2030 over 16,000 properties will need to be retrofitted to above EPC B standard (equivalent to 54 properties per week from 2024, and 30% of commercial and 20% of industrial building stocks retrofitted with best available technology). Retrofitting an average EPC D property to average EPC B standard could save 0.8 t CO_2/yr per property for those remaining on gas and 2.1 t CO_2/yr per property for those replacing gas heating for a heat pump. For 16,000 properties that would equate to 13 kt CO_2 and 33 kt CO_2 annually.
Convening Lead	Proposal: Oxfordshire County Council
Collaboration	Collaboration between councils and key external partners pools shared experience to build on existing programmes and coordinate scaled up delivery of retrofit across all markets (e.g., low-income households, Able-to-Pay market, renters etc).
Implementation	1. Establish a working group to review and share existing evidence on barriers such as retrofit labour provision (skills gap and retrofit pipelines), research (Heat Pump Ready feasibility studies), and shared learning from innovation programmes 2. Promote delivery of existing capital programmes for homes in fuel poverty working with Districts and City Council to maximise the opportunity for local retrofit delivery, including working with referral bodies (e.g. voluntary sector) to boost engagement with hard to reach households. 3. Position Oxfordshire to bid for future funding for homes in fuel poverty. 4. Develop the offer for different customer groups, including able-to-pay and businesses, 5. Share expertise and learnings to enable retrofit in listed and historic buildings. 6. Seek funding streams to support SME energy efficiency measures replicating Community Renewal Funded workstream.

Co-benefits	Address fuel poverty and therefore support better health. Minimise vulnerability to energy price rises. Provides assurance to installers resulting in an increase in training and employment opportunities.
Risks & Dependencies	• Capabilities of the supply chain. • Securing financing to deliver at the scale required. • The appeal of retrofit solutions to householders and businesses. • Reputational importance of quality installation.
KPIs	Number of homes retrofitted to EPC B or better

Timescale: Medium Term Action	Theme: Retrofit
Action 2: Scale up programme to address the retrofit skills gap.	
Overview	Experience in the County of delivering homes retrofit across all sectors shows that capacity of supply chain is the most material barrier to scale. Retrofit and clean heat in new homes is a £1.5bn opportunity to 2030 in Oxfordshire. Building on existing activity) to establish a network of training courses will help increase the number of people with retrofit experience, bridge the current skills gap and ensure installers can meet the uplift in demand.
Route Map Alignment	Availability of skilled installers will enable retrofit of over 16,000 housing properties to above EPC B standard by 2030.
Convening Leads	Proposal: Oxfordshire Local Enterprise Partnership
Collaboration	Collaborative working can support current activity to build on and extend existing local training opportunities by bringing together relevant scheme leads, employers and Further Education Colleges (including Oxfordshire's Inclusive Economy Partnership).
Implementation	1. Establish a working group to provide a forum to support the upscale of existing activity through training courses to cover the range of skills required for successful retrofit programmes. 2. Meet and engage with local suppliers to understand their needs, including supporting apprenticeship opportunities. 3. Define the skills gap and develop an Action Plan to address barriers and identify resourcing requirements. 4. Consider use of social value policies to require suppliers to contribute to green skills training and work experience opportunities.
Co-benefits	Increase in employment opportunities. Increase in availability of apprenticeship schemes. Upskill the existing workforce.
Risks & Dependencies	A lack of long-term funding to support supply chain investment in staff and the resource constraints of Higher Education Colleges.
KPIs	Number of apprenticeships offered and retention rates

Timescale: Medium Term Action	Theme: Renewables
Action 3: Develop a collective purchasing approach that supports the widespread deployment of rooftop solar on existing buildings.	
Overview	Solar is identified as the county's greatest low carbon energy generation resource. There is significant potential to expand local solar PV generation (often under permitted development rights) on existing commercial and domestic buildings to meet net zero targets. A collective purchasing approach across Oxfordshire will help reduce the costs and accelerate roll out of rooftop PV.
Route Map Alignment	Increase Oxfordshire's locally generated solar capacity on existing buildings, both commercial and domestic. Oxfordshire currently contributes 3% to the UK's solar PV capacity. By 2050 the ambition is for Oxfordshire's share to reach 6%. That equates to 1,609 MW of installed PV in 2030 and 5,314 MW in 2050.
Convening Leads	Proposal: Oxford City Council
Collaboration	Collaboration across Oxfordshire local authorities and key external stakeholders will build on existing programmes (e.g. ZCOP actions) and identify opportunities, prepare supporting infrastructure and achieve end-user buy in for this programme.
Implementation	1. Establish a working group to review and coordinate the development of a collective purchasing approach that can be applied across the county, considering potential to grow local supply chain. 2. Data developed through Project LEO may be used to inform numbers and locations for roll out of scheme (including potential for network connections). 3. Develop the collective purchasing approach and go to market.
Co-benefits	• Help to buffer householders from rapidly rising energy costs. • Provide confidence of the supply chain, resulting in investment in staff (e.g. training, recruitment). Support resilience of the local energy network.
Risks & Dependencies	• Access to high quality data to inform decision making. • Supply chain issues (e.g. for PV components). • District network operator (DNO) connections approval process (which is highly regulated). • The importance of good customer experience, and the public acceptability/desirability of solar panels on homes.
KPIs	Number and size of roof top solar installations delivered through this programme

NET ZERO CARBON ENERGY SYSTEMS PROGRAMME

Proposed Sponsor: Future Oxfordshire Partnership

Overview: Oxfordshire has achieved significant success in delivering innovative energy solutions, including two of three national smart local energy demonstrator projects (Project LEO and Energy Superhub Oxford). To achieve the net zero carbon targets, the county not only needs to reduce energy demand from our homes and businesses but also needs to significantly scale up local renewable generation. This is against a backdrop of significant local grid constraints which have limited renewables coming forward. Achieving this through a coordinated local area energy planning approach (drawing on the LEO energy data and mapping tools) with ongoing dialogue between network operators, local planning authorities and other key stakeholders will ensure development of cost-effective and appropriate place-based solutions.

Route Map Alignment: Installed solar PV capacity needs to quadruple by 2030 and increase 13 times compared to the base year to achieve the 2050 goal, requiring an annual average deployment of 164 MWp across the 30-year period. This is a substantial increase from current deployment rates of around 400 MWp, and will require scale up of PV installations on existing buildings (both commercial and domestic) as well as additional ground mounted arrays. Other actions, such as transition to heat pumps and installation of electric vehicle charging, will also require coordinated support for the electrical grid.

Priority Actions:

4. Develop a Local Area Energy Planning function for Oxfordshire.

Timescale: Medium Term Action	Theme: Cross Cutting
Action 4: Develop an on-going Local Area Energy Plan function for Oxfordshire.	
Overview	A Local Area Energy Planning approach can provide a geospatial view of energy use, generation and network capacity across Oxfordshire. This will help identify the most appropriate place-based and cost-effective options to deliver net zero, optimising infrastructure investment plans to deliver a net zero carbon energy system which can support both the electrification of heat and transport and the upscale of renewable generation (including identification of suitable locations for deployment of larger, strategic scale renewable generation). The approach will also enable targeted demand reduction programmes (supporting the building decarbonisation Action 1 and deployment of rooftop solar at scale, Action 3). This action is supported by Action 7 which encourages local authorities to share knowledge on the evidence needed to support the inclusion of strong net zero policies to enable the roll out of low carbon technologies and scale up of renewable generation in appropriate locations..

Route Map Alignment	Addresses substation capacity to respond to the switch to increased electrification (for instance vehicles and heating of homes and commercial buildings). Supports Oxfordshire's ambition to deliver 6% of the UK's PV capacity (an increase from 3% at present), equating to 1,609 MW of installed PV in 2030 and 5,314 MW in 2050. Supports roll out of building retrofit. Optimises investment needed for delivery
Convening leads	Proposal: Oxfordshire County Council
Collaboration	Collaborative working between the councils, electricity and gas network operators, communities and key external stakeholders will support development of the most cost-effective programmes to achieve a net zero carbon energy system. Ongoing strategic dialogue between the DNOs, local authority planning and energy teams, and other key stakeholders will ensure a joined-up approach to identify and support necessary upgrades to local energy networks.
Implementation	1. Establish a working group (including County, District and City Councils and other key stakeholders) to develop a framework for a countywide local area energy planning approach that aligns with local planning functions and can inform delivery of energy system planning at a range of scales. 2. Use energy mapping capabilities to: baseline energy use and generation resources in Oxfordshire; identify optimum sites for deployment of ground mount solar PV, for example, in locations where there may be synergies between new developments, transport hubs, the roll out of EV charging infrastructure, affording opportunities for smart local energy systems. 3. Develop a costed plan for delivery of technical analysis to identify optimal energy system transition pathway and cost-effective projects/programmes. 4. Identify investment requirements (for inclusion in the Oxfordshire Infrastructure Strategy (OxIS), where appropriate) and funding streams to enable delivery. 5. Use the data and evidence from the LAEP approach to support a review of the Oxfordshire Energy Strategy.
Co-benefits	Supports grid flexibility and optimises use of existing infrastructure. Enables transition to zero carbon vehicles, improving air quality. Supports transition to low carbon heating. Enables increased connection of renewable generation sources.
Risks & Dependencies	• Builds on Project LEO and requires ongoing collaboration to implement successfully. • Links to the Oxfordshire Energy Strategy and will provide evidence to support refresh of the strategy. • Supports identification of investment needs in the OxIS.
KPIs	To be determined

DECARBONISATION OF TRANSPORT – EV INFRASTRUCTURE

Proposed Sponsor: Future Oxfordshire Partnership

Overview: The Local Transport and Connectivity Plan sets out the framework to achieve net zero emissions from the county's road transport sector by 2040. The priority action below supports the uptake of electric vehicles across the county, in rural areas in particular, and is identified as an area where collaboration through the FOP will enhance delivery and draw on existing collaboration, to develop funding bids (for example City and County Council development of the LEVI bid. Further activity to support transport decarbonisation (Actions 9, 10 and 11) is included in the Action Plan as a programme of work led by LTCP governance structures.

Priority Actions:

5. Collaborate with town and parish councils to accelerate the roll out of publicly accessible electric vehicle charge points.

Timescale: Medium Term Action	Theme: Vehicle Electrification
Action 6: Collaborate with town and parish councils to accelerate the roll out of publicly accessible electric vehicle charge points.	
Overview	This action accelerates the roll out of EV charging infrastructure, supporting increased uptake of electric cars and small vans by improving access to charge points, particularly in rural areas where gaps in the charging network remain. The work will complement existing projects, such as the Park and Charge project, OxGul-e and DoorSTEP trials, and support delivery of the Oxfordshire Electric Vehicle Infrastructure Strategy.
Route Map Alignment	Activity supports the following Route Map targets for 2030: 120,000 electric cars and motorcycles registered within the county. 15,000 electric LGVs registered within the county.
Convening Leads	Proposal: Oxfordshire County Council
Collaboration	Collaboration across Oxfordshire local authorities and with key external stakeholders will support existing programmes to accelerate the roll out of EV charging points, particularly in rural areas. It also provides opportunity to explore community led approaches such as in the Plug in Suffolk project.
Implementation	1. Accelerate delivery of the OVEIS through Working with town and parish councils to explore opportunities and review possible locations for publicly accessible charge point installation. 2. Liaise with DNOs to determine required network connections at an early stage. 3. Develop a costed delivery plan and identify funding streams to enable delivery. 4. Liaise with delivery partners to support the procurement process and facilitate ongoing knowledge sharing.

	5. Engage with work conducted by the Strategic Transport Body in this area including mapping and funding approaches.
Co-Benefit	Support social equity by providing charge point access for households without off street parking and commercial users without depots. If local companies deliver the charge points, it could support local jobs and upskilling. Support cleaner air.
Risks & Dependencies	• Unexpected legal issues (e.g. land ownership, access). • Electricity constraints (e.g. local substation capacity). • Availability and the capacity of community car parking.
KPIs	Number of publicly accessible charge point sockets delivered

ENABLING ACTIONS

Proposed sponsor: Future Oxfordshire Partnership

Overview: Delivery of the buildings decarbonisation and net zero energy programmes will be supported by adoption of net zero policies and guidance, and by identifying and securing new, innovative and long- term funding streams.

Route Map Alignment: Enabling actions support delivery of priority actions.

Current Barriers to Delivery: National policy uncertainties and 'stop-start' funding programmes hinder consistency and pace of delivery.

Priority Actions (Detailed Below):

6. Develop shared guidance to inform preparation of net zero planning policies.
7. Explore new funding mechanisms to support delivery of net zero actions.

Timescale: Short Term Action	Theme: Cross Cutting
Action 7: Share knowledge in the preparation of Local Plans and development of net zero policies.	
Overview	Local planning policy is an area where local authorities have influence on shaping the built environment. All Local Planning Authorities in Oxfordshire are currently preparing Local Plans with the ambition to set within policy the highest standards required to meet local and national carbon reduction targets. This action facilitates local authorities to share knowledge during the preparation of Local Plans, which supports and encourages the introduction of policies that align with net zero targets.
Route Map Alignment	Adopt stringent energy efficiency policies for any new builds to ensure developments are built to Passivhaus Plus by 2030. Deploy solar PV on new builds. Electrify heating via heat pumps (80% of new builds by 2030). Scale up local renewable generation.
Convening Leads	Proposal: Cherwell District Council, Oxford City Council, South Oxfordshire District Council, Vale of White Horse District Council, West Oxfordshire District Council.
Collaboration	Collaboration supports knowledge sharing in the preparation of local plans to align with authorities' net zero targets.

Implementation	1. Establish a working group to share knowledge in the preparation of local plans. 2. This action includes the identification of best practice for robust net zero policies and evidence bases. This includes methodologies to assess the carbon impact of Local Plans and approaches to establishing the right locations, potential allocations, and impacts of development and large-scale ground mounted strategic and community solar, as well as wind and other large-scale strategic renewable energy projects (where appropriate). The potential for local benefits from the delivery of ground mount solar schemes should also be considered. 3. Following adoption of policies by local planning authorities, supplementary plans/ guidance could potentially support policy implementation.
Co-benefit	Clean energy and green and active travel improve air quality and health. Energy efficient buildings reduce energy costs, helping to address fuel poverty and supporting better health. Supports resilience of the local energy network.
Risks & Dependencies	Building consensus between local planning authorities. Resource challenges of planning and climate teams. Achieving buy-in from developers.
KPIs	Supplementary Planning Documents / design guide in place

Timescale: Medium Term Action	Theme: Cross Cutting
Action 8: Explore new funding mechanisms to support delivery of net zero actions.	
Overview	Securing the appropriate funding to deliver the outlined actions is integral to Oxfordshire's net zero journey, with finance acting as either a key enabler or barrier to success. Alongside conventional funding sources (including grants from national government and the allocation of local authority budgets), more innovative approaches will need to be adopted (e.g. green bonds, development of insetting schemes), to realise the benefits of local investment and ownership of assets.
Route Map Alignment	Securing finance enables all other priority actions.
Convening Leads	To be determined
Collaboration	Joint working to identify new funding mechanisms and improve responsiveness for funding bids.
Implementation	1. Convene a working group to review opportunities for new funding mechanisms to finance delivery of priority actions, for example green bonds and 'insetting' which could support the creation of private finance stream into Oxfordshire's programmes. 2. Develop business cases to pilot the most promising models.
Co-benefit	To be determined
Risks & Dependencies	Many interventions are not financially viable in the open market without subsidy/tax.

	Traditional appraisal methods (e.g. WebTAG) do not recognise the true value and impact of reducing carbon, limiting the ability to fund certain infrastructure. Mitigation costs will rise: IPCC states that a 'do nothing' approach increases net climate change mitigation costs (e.g addressing increased flooding). Change requires revenue (for instance to support ongoing maintenance) as well as capital funding. Route Map delivery requires significant scale which needs to be firmly understood. Local authorities have numerous statutory responsibilities that need to be maintained. Largely unable to direct resources and funding away from these areas to decarbonisation. Limits on financial powers to borrow, invest and tax etc.
KPIs	To be determined

NET ZERO TRANSPORT NETWORK

Proposed Sponsor: Oxfordshire County Council

Overview: In line with the Oxfordshire Local Transport and Connectivity Plan's (LTCP) transport hierarchy, the number of private vehicles miles will be reduced firstly by a reduction in demand (25% reduction in vehicle miles by 2040), then secondly by a 10% mode shift from private vehicles (cars and motorcycle) miles to public transport (buses and coaches) and active travel modes. Freight carbon emissions (both LGVs and HGVs) will be reduced by efficiency measures such as aerodynamics, and propulsion while improvements to operational efficiency can reduce overall miles travelled.

As Highways Authority, Oxfordshire County Council's will play a convening role in delivering a net zero transport network by 2040, as outlined in the LTCP and supporting strategies. Recognising that significant work is already underway in a variety of areas, the priority actions set out here identify where collective action can be used to best effect to support delivery of the LTCP ambition.

Route Map Alignment: As per the LTCP, the ambition for the transport sector is to achieve net zero by 2040, without any negative emissions (offsets or GGRs). This level of ambition is deemed achievable as the technological solutions are largely in place (with the exception of zero emission HGV solutions), and regulatory mechanisms (e.g. the phase out of fossil fuel cars and LGVs) have been announced to support the necessary shifts. Demand reduction and mode shift assumptions are also included to align to the LTCP. It is assumed that private vehicles and LGVs will largely be decarbonised through electrification, while the technology pathway for public transport and HGVs is still uncertain.

Priority Actions (Detailed Below):

8. Develop a Strategic Active Travel Network.
9. Develop tailored and place-based transport demand management campaigns.
10. Identify and deliver low emissions freight charging and last mile delivery hubs at suitable sites across the county.

Timescale: Long-Term Action	**Theme: Modal Shift**
Action 9: Develop a Strategic Active Travel Network.	
Overview	Develop a countywide approach to walking and cycling connectivity between main destinations or corridors and prioritise interventions to such routes. The Strategic Active Travel Network (SATN) will enhance the potential of inter-town routes, while also providing a strategic approach to walking and cycling in small and dispersed settlements in rural areas. It will be focused on facilitating regular journeys (such as commuting) while acknowledging that parts of the network can also be important leisure routes. The SATN will complement Local Cycling and Walking Infrastructure Plans (LCWIPs) that focus on increasing walking and cycling activity in and around large population centres, and ZCOP projects.
Route Map Alignment	By 2030 the Route Map ambition is for a 10% mode shift of personal trips (from private vehicles to sustainable modes).

Convening leads	Proposal: Oxfordshire County Council Active Travel Hub
Collaboration	Collaborative working between the Oxfordshire local authorities and key stakeholders will ensure the SATN is embedded within the implementation of the Local Transport and Connectivity Plan's monitoring framework, through incorporating LTCP policies such as greenways, Traffic Management Plans, parking management, public transport. The SATN will inform Area and Corridor Travel Planning.
Implementation	1. Bring together key stakeholders to review evidence and identify key opportunities/places that require active travel links, including any existing routes with gaps. This should include collaborative working with ZCOP to progress projects that align with LTCP targets. 2. Consider opportunities along canal routes, and where routes can be designed and managed to provide and improve habitats, biodiversity and landscapes. 3. Draw on existing frameworks, such as the LTCP, LCWIPs, and Oxfordshire Rights of Way Improvement Plan, to develop project proposals to deliver new greenways. This should include identifying any supporting mechanisms required (e.g. traffic management, resourcing requirements, potential funding sources and initial design options). 4. Engage/consult stakeholders to gain feedback and support and identify schemes to take forward to delivery (e.g. Slow Ways). 5. Embed action within emerging area and corridor travel plans (Part 2 of the LTCP).
Co-benefits	Public health benefits from a shift to active travel. Improving air quality. Supports more connected communities.
Risks & Dependencies	Ensuring joined-up thinking (e.g. across geographic boundaries District, City and County). Ability to access funding and securing political and public support. This action also needs to be supported by complimentary mechanisms (e.g. cycle training that addresses confidence and safety, and safe bike storage options).
KPIs	Total length of new footpaths and other rights of way delivered

Timescale: Long Term Action	**Theme: Demand Reduction**
Action 10: Develop tailored and place-based transport demand management campaigns.	
Overview	Reduce private car use by targeting places with appropriate demand reduction and mode shift messages. A countywide campaign provides a consistent message and presents potential cost saving benefits. The campaign should align with, and build on, similar campaigns already in place, for instance, the Oxfordshire Bus Marketing and Communications Campaign funded by Oxfordshire County Council, Go-Ahead and Stagecoach. The campaign should also promote

	measures within school travel plans that seek to encourage walking, cycling and bus use.
Route Map Alignment	By 2030 the Route Map ambition is for a: 20% reduction in vehicle miles from personal trips. 10% mode shift of personal trips (private vehicles to sustainable modes). Personal trips (private vehicle and public transport) accounted for 1,022 kt CO_2 in the base year (63% of road transport emissions). Reducing these personal trips by 20% would lead a carbon saving of circa 200 kt CO_2.
Convening leads	Proposal: Oxfordshire County Council
Collaboration	The collaborative working in this action aims to identify and/or develop local data to produce localised travel planning. This will support tailored communications campaigns for local communities on what actions they can take to achieve the necessary trip reduction and modal shift.
Implementation	1. Establish a working group between travel planners and communications. 2. Develop a place-based and persona-based approach using existing data and tools to map out current journeys and identify demand reduction and modal shift opportunities. 3. Develop tailored, active campaigns to target these opportunities; for example, including car sharing options as an alternative to private car ownership and promotion of e-bikes as an option for covering distances up to 10 miles. Engage with community groups (e.g. the CAG network) to develop place-specific campaigns for local communities. 4. Complement the campaign by developing active travel plans for anchor institutions in Oxfordshire, including updating School Travel Plans (public and private schools) and supporting development of plans for large businesses and their employees.
Co-benefits	Public health benefits from a shift to active travel. Improve air quality. Reduce car dependency to reduce community severance. Increased bus patronage creates income to invest in improved services.
Risks & Dependencies	This action must be supported by complementary mechanisms including: • Actively discouraging car use. • Active travel infrastructure improvements. • Investment and improvements in bus services. As behaviour change will need to be sustained, appropriate messaging that acknowledges seasonality (e.g. cold/wet periods) should be considered.
KPIs	Passenger journeys on local bus services (per annum)

Timescale: Medium Term Action	Theme: Freight Decarbonisation
Action 11: Identify and deliver low emissions freight charging and last mile delivery hubs at suitable sites across the county.	
Overview	Identify and deliver sites for freight-only EV charging (initially focusing on LGV needs) and last mile delivery hubs to support the transition to zero emission freight. This action will build on ZCOP's work collaborating with major landlords to maximise land use opportunities, encouraging data sharing, and developing consistent procurement and implementation strategies. It will also consider the emerging Central Oxfordshire Travel Plan and Oxfordshire Freight and Logistics Strategy to ensure policy alignment. In addition, this action will identify infrastructure to future-proof HGV infrastructure requirements (for example hydrogen), and consider larger vehicle charging at future Transport Hubs.
Route Map Alignment	By providing dedicated freight infrastructure this action will help accelerate the uptake of electric vans and efficient last mile deliveries. It aligns with the following Route Map targets for 2030: 15,000 electric LGVs registered within the county. Improving freight trip efficiency by 10%. Each charge point could save circa 18 t CO_2/year (by offsetting use of conventionally fuelled goods vehicles with EVs)
Convening leads	Proposal: Oxfordshire County Council
Collaboration	Local authorities play an enabling role to deliver this action. We will require collaboration with the key stakeholder groups, including the freight sector, to identify charging locations to meet demand.
Implementation	1. Bring together key stakeholders to act as a forum to support engagement with the freight industry and to understand their charge point and last mile delivery needs. 2. Use the data gathered to identify potential locations for hubs. 3. Engage with landowners (potentially via ZCOP) to secure suitable sites. 4. Develop a business case and secure funding for delivery. 5. Engage with DNOs at early stage to secure grid connections.
Co-benefits	Supports cleaner air. Provide EV charging solutions for businesses who do not have depots.
Risks & Dependencies	Competing pressures on land (e.g. housing) Electricity supply constraint Consumer demand (e.g. next day deliveries) Funding Technology uncertainty (e.g. HGVs) The attractiveness of this opportunity for landowners.
KPIs	Number of freight charge points and consolidation centres delivered

CIRCULAR ECONOMY

Proposed Sponsor: Oxfordshire Resources & Waste Partnership

Overview: A more circular economy will result in reduced consumption, resources being kept in use for longer, goods being repairable and recyclable at end-of-life, and a reduction in waste. The circular economy will support green skills and job development, a consequential improvement in the local economy, resilience to market shocks and bring benefit to the community for members most at need.

Route Map Alignment: Circular economy initiatives will reduce embodied carbon emissions from reduced purchasing of new products.

Current Barriers to Delivery:

- Funding and resources.
- Decoupling growth from sustainability.

Priority Action (Detailed Below):

11. Identify existing activities across Oxfordshire which contribute to the development of a circular economy including green skills, waste management, design and manufacture. Seek to build upon these to facilitate progress to a more circular economy.

Timescale: Medium Term Action	Theme: Circular Economy
Action 11: Identify existing activities across Oxfordshire which contribute to the development of a circular economy including green skills, waste management, design and manufacture. Seek to build upon these to facilitate progress to a more circular economy.	
Overview	Oxfordshire is a forward thinking, sustainably-minded county. There is a lot of existing activity such as the CAG network of over 100 community-based groups working on grass roots environmental and sustainability projects. However, to develop a coherent response to the challenges, better linkages between existing activities need to be made. Partners can work together to identify, enhance and progress opportunities and to draw them together. An existing partnership focusing on waste reduction exists which could be engaged with a widened focus.
Route Map Alignment	Ensure strong alignment with key themes outlined in PaZCO such as: Promoting collaboration. Circular Economy initiatives. Tackling Embodied Carbon. Reducing waste.
Convening leads	Proposal: Oxfordshire County Council
Collaboration	Engage with existing programmes, identify new opportunities, and build on the emerging Oxfordshire County Council's Circular Economy Strategy.
Implementation	1. Convene a workshop for collaborators to identify existing activity. 2. Establish more, and raise the profile of, community repair and community share hubs. Continue development of the emerging Oxfordshire County Council Circular Economy Strategy. 3. Scope future opportunities for development and expansion of existing programmes. 4. Identify funding streams to enable delivery, if available.

	5. Scope green skill development opportunities in Oxfordshire.
Co-benefits	Supports community cohesion. Reduced costs to households. Reduces consumption and carbon. Reduce waste disposal.
Risks & Dependencies	Must ensure delivery is inclusive to all, that the items are of good quality, that there is strong demand to reduce the need for storage, and that safety standards are adhered to. Must identify suitable venues to hold hubs.
KPIs	To be determined

NATURE RECOVERY & CARBON SEQUESTRATION

Proposed Sponsor: Local Nature Partnership

Overview The Local Nature Partnership (LNP) brings together key stakeholders in the land use and biodiversity sector. Collaboration across the Oxfordshire local authorities (as members of the LNP) can support development of activities to enhance carbon sequestration.

Route Map Alignment: Land use has a crucial part to play in reaching net zero. Large amounts of carbon are stored in soils and vegetation globally, and land can be either a source or a sink of greenhouse gas emissions depending on how it is managed.

Land Use, Land-Use Change & Forestry (LULUCF) acted as a net sink of emissions in Oxfordshire in 2019 with net negative emissions of -117 kt CO_2.

Current Barriers to Delivery:

- Land use tensions (e.g. avoiding loss of high grade farmland (grades 1, 2 and 3a)).
- Demand for alternative land uses such as development, bioenergy, large-scale renewables or others.

Priority Action (Detailed Below):

12. Explore opportunities to enhance carbon sequestration through land use change, including targeted habitat restoration and creation.

Timescale: Long Term Action	Theme: Nature Recovery
Action 12: Explore opportunities to enhance carbon sequestration through land use change, including targeted habitat restoration and creation.	
Overview	Assessing the carbon sequestration potential of a range of habitat types, aids identification of suitable sites for habitat creation, restoration and protection projects which maximise co-benefits (e.g. flood risk management, air quality management, and creating green spaces for recreation).
Route Map Alignment	This action supports carbon storage and strongly aligns with current climate initiatives outlined in PaZCO, such as building the Nature Recovery Network. The Route Map acknowledges that some emission sources are difficult to decarbonise. In these cases, this action can support locally based carbon off-setting or in-setting solutions.
Convening leads	To be determined
Collaboration	Local authorities will play an enabling role through their planning function and membership in the Local Nature Partnership.

	Wider collaboration, including with landowners and land managers will be key to developing a shared approach.
Implementation	1. Convene a working group to explore opportunities where collaboration can support habitat protection, recovery and creation to enhance carbon sequestration (alongside a range of other co-benefits), for example, through planning requirements. 2. Consider options and mechanisms to identify and monitor sites. 3. Identify funding sources and delivery partners to support the approach.
Co-benefits	• Carbon sequestration options provide a range of other benefits including biodiversity, natural flood management, air and water quality improvement, soil erosion protection and green spaces for recreation.
Risks & Dependencies	• Requires a co-ordinated strategic partnership to ensure the right approach at the right location, and one that also supports nature corridors. • At the national level, there is a lack of carbon standards for all habitats (e.g. standards only exist for woodland and peatland but not for meadows). • Private landowners face many competing pressures.
KPIs	To be determined

COUNCIL-LED ACTIONS

Proposed sponsor: Each Local Authority

Overview: Each Local Authority in Oxfordshire is already putting in place delivery plans to meet their respective climate action targets. This provides an opportunity for shared learnings through already established forums of councils and other key stakeholders.

Route Map Alignment: Oxfordshire has established a clear consensus on the need for climate action. All of Oxfordshire's local authorities have declared climate emergencies and have committed to carbon neutral council operations by 2030 (or 2025 at South Oxfordshire District Council) and have set area-wide goals of delivering net zero by 2050 or sooner.

Current Barriers to Delivery:

- Lack of consistent funding to support council-led climate action.
- Lack of corporate knowledge needed to embed climate action across organisations.
- Lack of protocols to embed climate action in decision making.

Priority Actions (Detailed Below):

13. Embed climate change into decision making across Oxfordshire's local authorities.
14. Embed net zero carbon and circular economy principles into procurement processes across Oxfordshire's local authorities.

Timescale: Medium Term Action	Theme: Cross Cutting
Action 13: Embed climate change into decision making across Oxfordshire's Local Authorities.	

Overview	In line with their respective climate action declarations, each Oxfordshire local authority is currently putting in place processes and mechanisms to ensure carbon is factored into decision making. To achieve this, councils have set targets to upskill internal council staff and to ensure carbon impact is embedded into decision making, particularly for high carbon impact services and contracts.
Route Map Alignment	Positioning net zero at the forefront of all decision making will facilitate the rate of change necessary to decarbonise, aligning with the following Route Map 2030 sectoral emissions reduction requirements: -31% in transport emissions -41% in domestic emissions -40% in industrial emissions -63% in commercial emissions -47% in energy supply emissions
Convening leads	Each of Oxfordshire's local authorities.
Collaboration	Although actions will be individually led within respective councils, facilitating shared learning will lead to service improvements for all organisations and help identify joint working opportunities, and joint training opportunities where there is a shared skills gap.
Implementation	1. Councils develop their respective programmes to roll out training programmes for staff to improve carbon literacy and signpost to existing resources, including monitoring and reporting of progress. 2. Establish knowledge sharing function in current inter-council forums. 3. Inform yearly service planning. 4. Once council programmes are established, consider bringing learnings to a forum to share knowledge with broader stakeholders (e.g. community organisations and SMEs) to assist them in the roll out of similar programmes.
Co-benefits	Demonstrates Oxfordshire's local authorities are leading by example. Improves carbon literacy across all council staff.
Risks & Dependencies	The mechanisms developed need to be simple, accessible and user friendly, otherwise there is a risk that they will not implemented. Given local authority resource constraints, if there are any cost increases there is a risk of push-back. Regional and cross-Council foci for joined-up working, communications, decision-making and collaboration will be crucial. Engaging with suitably qualified trainers and gaining their support and buy-in to extend the reach of the programme. Similarly, securing in-kind training or sponsorship from local businesses. Ensuring the knowledge is embedded and that high impact areas are prioritised.
KPIs	% staff completing carbon awareness courses

Timescale: Long-Term Action	Theme: Cross Cutting

Action 14: Embed net zero carbon and circular economy principles into procurement processes across Oxfordshire's local authorities.	
Overview	This action ensures that suppliers/contractors adhere to and contribute to councils' net zero policies and targets.
Route Map Alignment	Supports alignment with the following Route Map 2030 sectoral emissions reduction requirements: -31% in transport emissions -41% in domestic emissions -40% in industrial emissions -63% in commercial emissions -47% in energy supply emissions Circular economy initiatives will reduce embodied carbon emissions from reduced purchasing of new products.
Convening Leads	Each of Oxfordshire's local authorities.
Collaboration	Although actions will be individually led within respective councils, facilitating shared learning will lead to service improvements for all organisations and help identify joint working opportunities.
Implementation	1. Councils develop their respective programmes to embed standards within procurement and contract requirements including monitoring and reporting. 2. Bring together representatives from procurement teams to form a working group to facilitate share learnings and where possible, use joint purchasing power to influence supply chain. 3. Establish a forum for other Oxfordshire Institutions to share knowledge and enable a scaled-up approach.
Co-benefits	• Demonstrates Oxfordshire's local authorities are leading by example.
Risks & Dependencies	• The size and scale of local authorities means embedding change can take time. Due to resource constraints and political cycles, councils do not always have the luxury of making long-term procurement decisions. • It will require a significant cultural change to embed this action.
KPIs	% of suppliers meeting council's net zero carbon and circular economy principles

5 Key Findings & Next Steps

Chapter at a Glance

This Chapter highlights key findings identified through the development of the Route Map and Action Plan, including the scale of the challenge, the significance of securing finance, ensuring collaboration and an innovative approach, and risk and dependencies.

5.1 Key Findings

Scale of the Challenge

5.1.1 Oxfordshire has championed noteworthy decarbonisation efforts over the last decade. However, even with this strong track record in emissions reductions, the scale of the challenge to achieve net zero carbon by 2050 at latest remains significant.

5.1.2 As noted earlier in the report, it is important to recognise that delivery of the priority actions set out in this programme will not meet the scale of change needed to deliver countywide decarbonisation, but will sit within a wider programme being delivered through strategies, policies, action plans, guidance documents and projects already operating across the county. For instance, countywide strategies such as the Local Transport and Connectivity Plan, Oxfordshire Infrastructure Strategy, individual authority's climate action plans, and collaborative projects (such as Project LEO) which draw on the skills of business, academia, social enterprises and local authorities. Their successful delivery is both complemented by and dependent on a broad package of wider initiatives, as well as the co-operation and collaboration of governments, businesses and citizens.

Climate Adaptation

Climate adaption is the process of protecting a community from the effects of climate change, whilst simultaneously building a long-term resilience to the evolving environment. The process itself is open-ended and it can take many forms, but ultimately policies work to ensure that communities, or groups within these communities, can recover faster and quicker to climate related events that are likely to increase in frequency and may prove harmful. Climate change impacts will not be universally experienced, instead they will disproportionately affect those least able to respond and recover from changes in climate variability and the associated impacts. For example, Oxfordshire's poorer residents will find it more difficult to recover from flood events or may be less able to afford air conditioning or heating to cope throughout harsher seasons. As a result, Oxfordshire will need to employ adaptation measures to ensure that climate impacts are minimised, but importantly equitable, across the county. This will involve managing risks with a long-term perspective, as well as considering climate change alongside wide social, economic, political and environmental prioritises, to create a more holistic, heathier and stronger community.

Whilst this issue is not directly covered within the Action Plan, it is complementary to its core focus: mitigation. Mitigation measures seek to prevent the environment from changing, whereas adaptation seeks to help people live in this changed environment. Despite appearing to be separate themes, implementing them both in tandem results in an optimal strategy whereby communities strive to limit their exposure to climate change impacts whist ensuring that they are equipped to deal with these events if they occur. Crucially, adaption has to be guided by local priorities, some local authorities might be more prone to flooding and therefore measures would centre on providing adequate flood defences, whereas other regions may have a higher index of deprivation and therefore the focus should be on monetary support. Regardless of the specific adaption need, it is vital for Oxfordshire to stimulate adaptation conversations to ensure that communities are fully prepared for inevitable changes in the environment that climate change will uncover.

Collaboration

5.1.3 The scope of this report identifies joint actions which the Oxfordshire Local Authorities can take. However, we also recognise the need for wider action and the importance of building and sustaining successful and productive co-working relationships across the public, private and third sectors to enable delivery of significant and high impact decarbonisation solutions. Oxfordshire is fortunate enough to have strong existing partnerships and collaborations on which to build, and which are increasingly successful in securing innovation and infrastructure funding (e.g., ZCOP, Project LEO). These encompass the innovation and energy sectors as well as a widespread community voice, with over 100 CAGs managing a wide variety of projects at a local level. Tapping into this significant community power, pooling resources, and encouraging knowledge transfer will work to cumulatively increase each organisation's sphere of influence whilst acting as a vital tool to mobilise action at every scale across the county.

Financing

5.1.4 The Pathways to Zero Carbon Oxfordshire report sets out the scale of investment needed between now and 2030 to support the transition to net zero (table 5.1). Securing the appropriate funding to execute the priority actions set out above is an integral part of Oxfordshire's net zero journey, with finance acting as either a key enabler or barrier to success. Whilst a fundamental component, finance is historically difficult to secure. It requires ongoing attention; taking forward the enabling Priority Action 7 - to identify innovative approaches to sit alongside conventional funding sources (including grants from national government and the allocation of local authority budgets) – will be critical to support delivery of other actions where additional funding will be required.

	Investment 2021–2030	Notes
Transport		
Active travel	£100m	
Vehicle fleet decarbonisation	£240m	Majority of additional investment needed is focused on LGVs, HGVs and buses, as it is expected that the total cost of ownership for battery-electric passenger-cars equals or even undercuts current costs for conventional vehicles before 2030
Electric charging infrastructure	£150m	Includes public and private
Rail electrification	£125m	Based on 50% of the non-electrified[60] multi-track line being electrified at an average cost per km of £1,750,000.[61]
Buildings		
Housing retrofit and heat pumps	£1.5bn	Assumes that costs of (re-)training the workforce are met at national level as part of a strategic re-positioning of the economy to meet decarbonisation targets. Assume £25K per retrofit; £10K per HP. Majority of investment is private.
Business advice and engagement services	£50m	Assume a network of 100 decarbonisation consultants working with local businesses (upscaling OxFutures) @ £50K per consultant per year
Renewable energy		
Solar generation	£630m	Based on CAPEX installation costs of £750/kWp and OPEX of £7000/MW/year.
Grid infrastructure	£450m	Based on £30bn UK CAPEX network investment in CCC's balanced pathway, scaled by Oxfordshire's forecast demand contribution.
Battery Storage (supply side)	£100m	Based on CAPEX installation costs of £500/kWe and OPEX of £25000/MW/year.
Land use & natural ecosystems		
Strong planning policy	Low cost	Strengthen planning policy to protect carbon-rich habitats, encourage green roofs and rooftop solar, and mandate compact, walkable low carbon development. Green roofs expected to reduce building heating and cooling costs and walkable neighbourhoods expected to deliver healthcare savings.
Awareness raising to encourage low meat diets	Low cost	Expected to reduce healthcare costs
Tree planting	£113m	Planting 22,600 ha of tree and agroforestry cover by 2050 at £5000 per ha of cover.59
Plant 8,500 km of hedgerows	£44m	Based on estimate of £526/100m for 8,500 km of species-rich hedge including hedgerow trees.[62]
Habitat restoration	£31m	Estimated £800 per ha for 9000 of meadows and £8000 per ha for 3000 ha of wetlands

Table 5-3 *Estimated investment to support emission reductions by 2030 (PAZCO, 2021)*

Innovation

5.1.5 An innovative approach to delivering the actions will be needed. The approach should limit dependencies on national funding and support secure sustainable, stand-alone programmes (such as for retrofit). It should also mitigate against external risks (such as national policy uncertainties), and ensure the required pace of delivery is maintained and insulated from 'stop-start' policies and funding which have been flagged as a key barrier. This includes sourcing and accessing alternative funding opportunities, supporting and bringing inventive technology into the mainstream, and encouraging communities to adopt novel solutions to local problems. Learning from others through applying and tailoring best practice case studies from across the UK and internationally can be yet another innovative avenue to accelerate the decarbonisation progress within Oxfordshire.

5.2 Risks & Dependencies

5.2.1 Successful delivery of the Route Map and Action Plan, and thereby Oxfordshire's vision to become a net zero County by 2050, is subject to a range of internal and external factors. The key risks are summarised below (Figure 4-2).

Political

Policy & funding commitment from national government: Current national commitments fall short of the Net Zero 2050 goal (E.g. no phase out date for heavies; new builds are not Net Zero)

Powers: All Oxfordshire local authorities lack relevant political powers / control in key areas

Cultural Change: Delivering net-zero requires a cultural change that buys-in to and prioritises the climate emergency by embedding carbon into key decision making

Consistency / Clarity: Stop / Start policies have created uncertainty (e.g. to the retrofit supply chain). Clear, long-term policies are required to close the gap between current trajectories and Net Zero

Communication Plan & Behaviour Change Strategy: Strong communication is Required to achieve a lasting impact of the Oxfordshire Net Zero Route Map & Action Plan

Economic

Traditional appraisal methods: Traditional methods (e.g. WebTAG) do not recognise the true value and impact of reducing carbon, limiting the ability to fund certain infrastructure

Mitigation costs will rise: IPCC states that a 'do nothing' approach increases net climate change mitigation costs (e.g addressing increased flooding)

Role of growth: Conflict between growth objectives and decarbonisation objectives e.g. housing

Viability: Many interventions are not financially viable in the open market without subsidy/tax

Revenue funding: Change requires revenue (for instance to support ongoing maintenance) as well as capital funding

Local funding scalability: Route Map delivery requires significant scale which needs to be firmly understood

Social & Inclusivity

Social change: We need a transformational change to the way we live to deliver Net Zero. This requires the support and commitment of residents, businesses and the public sector

Public awareness: Currently most people are unaware of the scale of the challenge and action required, despite a myriad of co-benefits (e.g. cleaner air; more connected communities)

Competing messages: Marketing (for unsustainable products) and disinformation are widespread, creating a challenge for communications

Skills: Lack of scaled skills development pipelines across key sectors and supply chains

Technology

Technological solutions at scale: There are currently technology gaps including: Zero emission HGV, heat decarbonisation and and energy storage (in particular long-term)

Technology uncertainty: Uncertainty in key areas risks creating extended inaction e.g. hydrogen vs. electrification for HGVs

Technology optimism: Reliance on future negative emissions technologies (e.g. carbon capture and storage), creates a risk of future gaps

Electrical grid capacity: The electricity system will require reinforcement to achieve the required levels of electrification

Mis-information / Skills: Difficult to navigate technology choices due to complexity

Legal

Legal frameworks: There is a disparity in Governmnet Policy between the legal frameworks that exist to support Net Zero commitments

Legal challenges: In planning in particular, there is conflict between National Planning Policy Framework and the Net Zero commitment, fueling apprehension related to reexamining Local Plans

Statutory responsibilities: Local authorities have numerous statutory responsibilities that need to be maintained. Largely unable to direct resources and funding away from these areas to decarbonisation.

Legislative powers: Numerous restrictions on what Local Authorities are able to do above and beyond statutory responsibilities

Financial powers: Limits on financial powers to borrow, invest and tax etc

Figure 4-2: Risks and Dependencies Across Key Areas

Mitigating Risks

5.2.2 During development of the Route Map and Action Plan we have mitigated risks by prioritising changes that can be made at a local level, thereby supporting resilience that is independent of political shifts at both a national and local scale. The Route Map and Action Plan targets also aim to strike a balance between realism and ambition, ensuring that progress is tangible and actionable within the three-to-five-year focus of this Report.

5.3 Governance

5.3.1 A strong governance process needs to be put in place to ensure accountability for delivery of the actions. We recommend this uses the existing partnership structures appropriate to each suite of actions and that a convening lead is identified for each action to lead from the front and coordinate the activities needed to deliver the change.

5.4 Monitoring and review

5.4.1 Progress against the emission reduction targets outlined in the Route Map (and summarised in Appendix B) and activities against all priority actions should be monitored and reported to the Future Oxfordshire Partnership Environmental Advisory Group at regular intervals; Action Plan progress will be reported utilising KPIs identified in the Route Map report (Appendix D). As the work packages evolve more detailed targets can be developed for each action.

5.4.2 Recognising that the FOP Strategic Vison includes achieving net zero carbon by 2040, it is suggested that the monitoring and review process can help identify areas where more ambitious targets may be developed as delivery progresses to enable net zero (in certain sectors) by the earlier date.

5.4.3 Reporting will be coordinated by the EAG officer group. We recommend that through the mobilisation phase, the status of all projects within the Action Plan should be reviewed by the EAG at least every six months.

5.4.4 The action plan focuses on the key activities needed over the next three to five years to accelerate Oxfordshire's transition to decarbonisation, particularly in relation to the key sectors. Achieving the "Oxfordshire leading the way" scenario will require collective action over the next 25-30 years to achieve net zero, and the route maps give insight on how further actions will be layered in future years to ensure maximum impact to 2030 and beyond. However, it is also recognised that the plan will be a flexible and living document. It will need to be reviewed and updated in response to changes in the policy and legislative climate, technological advancements, future opportunities and the results of annual monitoring.

5.4.5 We recommend that the trajectories (based on the sectoral route maps) are reviewed every three to five years to ensure they reflect recent activities, remain up to date and aligned with the latest baseline evidence (based on the same agreed methodology as set out in the Route Map and Action Plan). This review will also inform future priority actions.

Appendix A: Technical Assumptions

Energy Supply

The pathway placed a heavy reliance on the electricity grid decarbonising; two pathway carbon emissions projections were presented based on two different projections electricity grid carbon intensity. The carbon intensities of these two projections have been provided at the five-yearly intervals in Table A-1. The FES projection goes negative from 2035 onwards as it assumes power generation from BECCS.

Electricity Carbon Intensity Projection ($kgCO_2/kWh$)	2025	2030	2035	2040	2045	2050
Government Green Book	0.122	0.051	0.025	0.015	0.009	0.007
Future Energy Scenarios (FES) – Leading the Way	0.051	0.005	-0.018	-0.043	-0.043	-0.043

Table A-1: Electricity Grid Carbon Intensity Projections

The factors provided are the emissions at point of consumption of electricity, and therefore account for losses along the transmission and distribution networks. The Green Book projections provide emissions in CO_2 equivalent (not CO2 alone); therefore, the use of these projections is a slight overestimate for our CO2 modelling. However, CO2 is the principal greenhouse gas in this emission source; the 2021 UK GHG Conversion factors report that CO2 constitutes 99% of the CO2 equivalent emissions in 2021 (BEIS, 2021).

The pathway did not assume that the gas grid would be fully decarbonised by a 100% switch to hydrogen. Instead, it assumed that the gas grid would have a take up of 20% hydrogen. Beyond this level of hydrogen concentration, domestic boilers and cookers would have to be adapted, leading to widespread disruption, hence increasing hydrogen concentration beyond this level is a barrier.

An increase in biomethane injection from Anaerobic Digestion (AD) to the grid has been assumed. The Didcot biomethane injection point currently contributes ~1% to the gas mix in Oxfordshire, and this could be expected to rise as population rises. The biomethane concentration in the gas grid starts at 1% in the base year (2020) then rises linearly from 2025 to 2% by 2030.

The assumed gas grid composition and the overall carbon intensity of the gas grid at each of the 5-year intervals are shown in Table A-2.

Assumed Gas Grid Composition	2020	2025	2030	2035	2040	2045
Natural gas	99%	99%	78%	78%	78%	78%
Biomethane (AD)	1%	1%	2%	2%	2%	2%
Hydrogen	0%	0%	20%	20%	20%	20%
Gas grid carbon intensity ($kgCO_2/kWh$)	0.188	0.182	0.143	0.143	0.143	0.143

Table A-2: Gas Grid Composition and Carbon Intensity Projection

The pathway has modelled that district heating networks will play a role in providing low-carbon heat for the domestic and commercial sectors. The majority of heat for district heating networks is currently supplied by natural gas (via central boilers or combined heat and power plants). As the heating plant is centralised, district heating offers increased flexibility to swap out current heating plant for renewable and low-carbon alternatives. Whilst this idea is attractive, it is expected that the gas grid will continue to supply much of district heating demands for quite some time. The fuel mix assumed for district heating networks has been provided in Table A-3.

Assumed District Heat Network Fuel Mix	2020	2025	2030	2035	2040	2045	2050
Natural gas	95%	95%	40%	40%	40%	40%	40%
Biomass	5%	5%	10%	10%	10%	10%	10%
Electricity via heat pumps (ASHP/GSHPs)	0%	0%	50%	50%	50%	50%	50%
District heat carbon intensity ($kgCO_2/kWh$)	0.174	0.174	0.074	0.070	0.066	0.066	0.066

Table A-3: District Heating Fuel Mix and Carbon Intensity Projection

Transport (Road)

The approach in modelling the transport sector was to split out the total vehicles miles travelled by all road vehicles into personal trips (private vehicles, public transport, and active travel) and by freight (LGVs and HGVs). The model inputs would then impact on each of the vehicle categories accordingly.

The base year number of miles travelled within Oxfordshire was determined from 2019 Road Traffic Statistics (DfT, 2019). This provides vehicle mileage for a number of vehicle categories (Cars & Taxis, LGVS, HGVs etc). To estimate the mileage by journey purpose (commuting, business, leisure etc), average trip statistics from the National Travel Survey (DfT, 2019) were used.

The number of vehicles in the base year was determined from 2020 Vehicle Registration Statistics (DfT, 2020), which provides the numbers of licenced vehicles split by vehicle category. Using the mileage determined from the Road Traffic Statistics, an average mileage travelled per vehicle could be determined (see Table A-4).

The number of vehicles miles travelled each year changes over time due to increases from growth (see paragraph 2.6.5) and decreases due to the demand reduction and mode shifting inputs. See Table A-5 for the full projection of vehicle miles required by each vehicles category.

Over time, an increasing number of EVs is modelled to displace the existing vehicle stock. The number of vehicles applied in the inputs are converted to a number of miles travelled using the averages detailed in Table A-4. The energy consumption of any new EV is then determined by an average energy consumption per mile travelled (also detailed in Table A-4).

	Average miles travelled per vehicle (miles)	EV Average energy consumption per mile (kWh/mile)
Private Vehicle (Car & Motorcycle)	9,922	0.34
Public Transport (Bus & Coach	15,405	0.80
Freight (LGV)	21,150	2.00

Table A-4: Transport Vehicle Key Assumptions

Year	2020	2025	2030	2035	2040	2045	2050
Personal miles - baseline							
Annual Personal Trip Demand (vehicle miles) - existing	4,167,764,383	4,167,764,383	4,167,764,383	4,167,764,383	4,167,764,383	4,167,764,383	4,167,764,383
Annual Personal Trip Demand (vehicle miles) - new developments	-	418,207,981	730,580,515	1,037,872,129	1,345,163,743	1,652,455,357	1,959,746,971
Personal Trip miles – after demand reduction	4,167,764,383	3,750,987,945	3,334,211,506	3,125,823,287	3,125,823,287	3,125,823,287	3,125,823,287
Mode Share (Car & Motorcycle Share of Total Miles) - existing	95.8%	91.0%	86.2%	86.2%	86.2%	86.2%	86.2%
Mode Share (Bus & Coach Share of Total Miles) - existing	0.6%	1.2%	1.8%	1.8%	1.8%	1.8%	1.8%
Mode Share (Active Share of Total Miles) - existing	3.7%	7.9%	12.0%	12.0%	12.0%	12.0%	12.0%
Personal Miles (Car & Motorcycle) - existing	3,991,000,000	3,412,305,000	2,873,520,000	2,693,925,000	2,693,925,000	2,693,925,000	2,693,925,000
Personal Miles (Bus & Coach) - existing	23,000,000	44,068,311	59,943,663	56,197,184	56,197,184	56,197,184	56,197,184
Personal Miles (Active) - existing	153,764,383	294,614,634	400,747,843	375,701,103	375,701,103	375,701,103	375,701,103
Personal Miles (Car & Motorcycle) - new developments	-	264,799,466	411,187,923	547,630,201	709,771,725	871,913,249	1,034,054,773
Personal Miles (Bus & Coach) - new developments	-	14,519,427	22,546,167	30,027,540	38,918,049	47,808,558	56,699,066
Personal Miles (Active) - new developments	-	97,068,291	150,730,322	200,746,355	260,183,033	319,619,711	379,056,389
Personal Miles (Car & Motorcycle) - total	3,991,000,000	3,677,104,466	3,284,707,923	3,241,555,201	3,403,696,725	3,565,838,249	3,727,979,773
Personal Miles (Bus & Coach) - total	23,000,000	58,587,737	82,489,830	86,224,724	95,115,233	104,005,742	112,896,251
Personal Miles (Active) - total	153,764,383	391,682,925	551,478,165	576,447,458	635,884,136	695,320,814	754,757,492
Personal Miles (All) - total	4,167,764,383	4,127,375,128	3,918,675,918	3,904,227,384	4,134,696,094	4,365,164,805	4,595,633,516
Freight Miles							
Baseline-Annual Freight Trip Demand (vehicle miles)	1,108,162,461	1,219,359,338	1,310,749,909	1,407,392,238	1,511,160,060	1,622,578,742	1,742,212,386
Freight Miles After Efficiency Benefits	1,108,162,461	1,161,294,608	1,191,590,827	1,279,447,489	1,373,781,873	1,475,071,583	1,583,829,442
Annual HGV Miles	263,548,098	276,184,221	283,389,401	304,283,862	326,718,882	350,808,049	376,673,324

Annual LGV Miles	844,614,362	885,110,387	908,201,425	975,163,627	1,047,062,991	1,124,263,534	1,207,156,118

Table A-5: Transport Vehicle Miles Projection

The fleet mix projected under the pathway is show in Table A-6. Following the base year, the total number of vehicles required for each vehicle category is determined by the vehicle miles projection (Table A-5) divided by the assumed average miles travelled by that vehicle category (Table A-4). It is assumed that any uptake of EVs displaces conventional vehicles present in the existing stock. The vehicles stock is 100% electric by 2040, the number of EVs continues to grow beyond this year due to growth of the sector.

Year	2020	2025	2030	2035	2040	2045	2050
Private Vehicles (Cars & Motorcycles)							
Cars & Motorcycles: Electric	3,777	25,000	120,000	200,000	343,029	359,369	375,710
Cars & Motorcycles: Hybrid[5]	2,396	2,396	0	0	0	0	0
Cars & Motorcycles: Other ULEV Fuels*	338	338	0	0	0	0	0
Cars & Motorcycles: Conventional ICE	391,757	342,849	211,037	126,688	0	0	0
Total Cars and Motorcycles	**398,268**	**370,583**	**331,037**	**326,688**	**343,029**	**359,369**	**375,710**
Public Transport (Buses & Coaches)							
Buses & Coaches: Electric	0	200	1,000	2,000	6,174	6,751	7,328
Buses & Coaches: Conventional ICE	1,493	3,603	4,355	3,597	0	0	0
Total Buses & Coaches	**1,493**	**3,803**	**5,355**	**5,597**	**6,174**	**6,751**	**7,328**
Freight (LGVs)							
LGVs: Electric	0	2,500	15,000	35,000	49,508	53,158	57,077
LGVs: Conventional ICE	43,885	39,350	27,942	11,108	0	0	0
Total LGVs	**43,885**	**41,850**	**42,942**	**46,108**	**49,508**	**53,158**	**57,077**
Freight (HGVs)							
HGVs: Electric	0	200	900	2,800	5,456	5,858	6,290
HGVs: Conventional ICE	4,401	4,412	3,832	2,281	0	0	0
Total HGVs	**4,401**	**4,612**	**4,732**	**5,081**	**5,456**	**5,858**	**6,290**
All Vehicles							
Total Vehicles	457,202	430,003	393,221	392,629	413,321	434,292	455,561

Table A-6: Transport Pathway Fleet Mix

The energy demands and emissions split by fuel type for each year of the transport pathway projection have been detailed in Table A-7 and Table A-8.

Energy Demand (GWh)	2020	2025	2030	2035	2040	2045	2050
Petroleum and diesel fuels	6,183	5,754	4,087	2,353	0	0	0
Grid electricity[6]	0	157	797	1,664	2,839	3,021	3,212
Total Energy Demand	**6,183**	**5,911**	**4,884**	**4,017**	**2,839**	**3,021**	**3,212**
Reduction against baseline		4%	21%	35%	54%	51%	48%

Table A-7: Transport Pathway Energy Demand by Fuel Type

Emissions (ktCO_2)	2020	2025	2030	2035	2040	2045	2050
Petroleum and diesel fuels	1,627	1,514	1,075	619	0	0	0
Grid electricity[6]	0	19	41	41	43	28	22
Total Emissions	**1,627**	**1,533**	**1,117**	**661**	**43**	**29**	**22**
Reduction against baseline		6%	31%	59%	97%	98%	99%

Table A-8: Transport Pathway Emissions by Fuel Type

[5] Some hybrid and alternative fuelled vehicles were present in the base year data, these are displaced by EVs over time
[6] Assumed 100% grid electricity, no direct supply of renewables

Housing

A complete list of model inputs used for the Housing sector projection are detailed in Table A-9.

Existing properties were decarbonised through a 100% energy efficiency retrofit to EPC B and via retrofitting 80% of the properties with heat pumps. As determined from base year Oxfordshire EPC data, the energy consumption of EPC B properties was modelled to be 11,492kWh/year for heating, and 2,813kWh/year for power demands. The fuel mix for non-heat pump heated buildings changes over time with a switch to biomass and district heating, though it has been modelled that some existing properties will remain connected to the gas grid.

New builds are built to ambitious energy efficiency standards (see Table A-9) and the vast majority are heated by heat pumps. Those not heated by heat pumps are heated by district heating networks and biomass. No new builds are connected to the gas grid from 2025 onwards to reflect the Government's 2025 gas boiler ban.

The retrofit of solar PV to existing households has been modelled. The latest Feed-in-Tariff (FiT) data from 2019 showed that that approximately 3.4% of the households in Oxfordshire were claiming solar PV FiT and that the average size of PV installation in the county was 3.7kW (BEIS, 2019). The pathway has modelled an increasing number of existing households retrofitted with PV, reaching 25% of the existing (2020) housing stock by 2050. It was assumed that the average installed capacity of PV installations would remain at 3.7kW.

Year	2020	2025	2030	2035	2040	2045	2050
Existing properties							
Number of Existing Properties EPC B and Above	53,028	54,000	70,000	150,000	250,000	300,806	300,806
% Existing Properties EPC B and Above	17.6%	18.0%	23.3%	49.9%	83.1%	100.0%	100.0%
Number of Heat Pumps (Existing Homes)	-	750	5,000	35,000	100,000	240,000	240,000
% Existing Properties with Heat Pumps	-	0%	2%	12%	33%	80%	80%
% of Existing Properties Retrofitted with Solar PV	3.4%	5.0%	7.5%	10.0%	15.0%	20.0%	25.0%
Non-electrically heated existing properties fuel mix							
Gas grid	76%	75%	70%	65%	60%	55%	50%
Petroleum, coal & solid fuels	13%	10%	7%	3%	0%	0%	0%
District heating	0%	5%	8%	11%	14%	17%	20%
Bioenergy & Waste	11%	10%	15%	21%	26%	28%	30%
New builds							

Housing Standards for New Builds	Current Part L	Future Homes Standard	Passivhaus Plus	Passivhaus Plus	Passivhaus Premium	Passivhaus Premium	Passivhaus Premium
% New Developments with Heat Pumps	0%	20%	80%	80%	80%	80%	80%
Non-electrically heated new build fuel mix							
Gas grid	70%	0%	0%	0%	0%	0%	0%
Petroleum, coal & solid fuels	0%	0%	0%	0%	0%	0%	0%
District heating	5%	5%	8%	11%	14%	17%	20%
Bioenergy & Waste	25%	95%	92%	89%	86%	83%	80%

Table A-9: Housing Sector Key Model Inputs

New builds have been modelled to meet stringent energy performance standards in the pathway, with all new builds built to Passivhaus Plus from 2030 onwards. The energy intensity assumptions of the new build standards are shown in Table A-10. An average floor area of 94.4m^2 (determined from Oxfordshire EPC data) was used to convert the intensities to an annual energy demand. Both Passivhaus standards stipulate a target for on-site renewable energy generation, this generation exceeds the heating and power demands, meaning that these households are net exporters to the grid.

Energy Efficiency Standard Energy Intensities (kWh/m^2/yr)	Heating	Other	On-site Generation	Total
Current Part L	60.0	37.3	0.0	97.3
Future Homes Standard	15.0	37.3	0.0	52.3
Passivhaus Plus	15.0	30.0	-60.0	-15.0
Passivhaus Premium	15.0	15.0	-120.0	-90.0

Table A-10: Housing Sector New Build Energy Intensities

The energy demands and emissions split by fuel type for each year of the housing pathway projection have been detailed in Table A-11 and Table A-12.

Energy Demand (GWh)	2020	2025	2030	2035	2040	2045	2050
Electricity	1,221	1,325	1,388	1,486	1,709	2,210	2,241
Gas grid	3,308	3,346	3,037	2,452	1,564	476	441
District heating	0	224	345	408	353	129	151
Bioenergy & Waste	471	478	709	818	710	273	292
Petroleum, coal & solid fuels	577	430	278	120	0	0	0
Total Energy Demand	**5,576**	**5,803**	**5,756**	**5,285**	**4,337**	**3,089**	**3,126**
Reduction against baseline		*-4%*	*-3%*	*5%*	*22%*	*45%*	*44%*
Electricity Mix							
Solar PV self-supply	38	55	100	251	454	756	1,058
Grid electricity demand	1,183	1,270	1,288	1,236	1,255	1,455	1,184

Table A-11: Housing Pathway Energy Demand by Fuel Type

Emissions (ktCO_2)	2020	2025	2030	2035	2040	2045	2050
Grid electricity	256	156	66	31	19	14	8
Gas grid	621	608	435	351	224	68	63
District heating	0	39	28	32	27	10	11

Bioenergy & Waste	0	0	0	0	0	0	0
Petroleum, coal & solid fuels	151	113	73	31	0	0	0
Total Emissions	**1,028**	**916**	**602**	**445**	**270**	**92**	**83**
Reduction against baseline		11%	41%	57%	74%	91%	92%

Table A-12: Housing Pathway Emissions by Fuel Type

Industrial & Commercial

In contrast to the data on domestic buildings, the non-domestic building stock is less well documented and understood. Non-domestic EPC data provides some useful insight, its coverage of the building stock is reasonable, but the contents of the data are less insightful. According to the Valuation Office, the number of rateable properties in Oxfordshire as of March 2020 was 21,940. As of June 2022, 13,509 non-domestic EPCs had been lodged in Oxfordshire, which implies that about 60% of the industrial and commercial building stock has an EPC.

Non-domestic EPCs provide an indication of energy efficiency via an A to G scale similar to the domestic EPC, and they provide an estimate of primary energy usage (kWh/m^2/year), but they do not provide a breakdown of energy by fuel type nor by end use (electricity, heating, hot water etc).

By assuming that the non-domestic EPC coverage is representative of the whole non-domestic building stock, we can make estimates of the split of energy between sub-sectors, end uses and fuel types. The national Building Energy Efficiency Survey (BEES) (BEIS, 2014-15) conducted in 2014-15 provides mean energy intensities (kWh/m^2) for sub-sectors of non-domestic buildings, broken down by end use (heating, hot water, lighting, catering etc). Using these average energy intensities and the floor areas provided in the non-domestic EPC data, average energy intensities for electricity, heating and hot water, and process loads were developed for commercial buildings and industrial buildings.

Growth in this sector was modelled to follow the trajectory of the growth in the housing sector. Using an assumed number of new jobs per every new house built, and an amount of floor area required per job (determined by using base year floor area and employment data from the (Office for National Statistics (ONS), 2020), a projected growth in the total floor area from the industrial and commercial sectors was determined.

The industrial sector has a total floor area of 1.8 million square meters in 2020, which rises to 2.8 million by 2050. The commercial buildings account for 13.9 million m^2 in 2020, rising to 21 million m^2 by 2050. For both sectors, it is recognised that some of the existing building stock will be demolished over time, and new builds will take their place. A demolition rate of 1% of floor area is applied each year in the pathway; where existing stock is demolished, new building stock of equivalent floor area takes its place.

Average energy intensities (kWh/m^2) for non-heating electricity, heating and hot water, and process loads were developed for industrial and commercial buildings. These were determined by using the estimated total floor areas, the base year energy consumption and average energy intensities of sub-sectors and end uses from the national Building Energy Efficiency Survey (BEES) (BEIS, 2014-15).

The potential to reduce these energy intensities was informed by the BEES study which provided abatement factors for electricity and fuel consumption for sub-sectors of non-domestic buildings. These abatement factors were percentage energy reductions that could be achieved on electricity and fuel demands within each sub-sector. They represented the effect of replacing current equipment with the most efficient alternative; the abatement factors are therefore a total technical potential. The abatement factors did not account for likelihood of equipment being replaced or whether take-up would be limited due to barriers or site-specific factors. To account for this, the abatement factors were arbitrarily reduced by 25% in an attempt to provide a more achievable abatement potential. The abatement potentials and the base year energy intensities applied to commercial and industrial buildings have been provided in Table A-13.

Energy Intensity ($kWh/m^2/yr$)	Commercial Energy Intensity ($kWh/m^2/yr$)	Commercial Abatement Potential (%)	Industrial Energy Intensity ($kWh/m^2/yr$)	Industrial Abatement Potential (%)
Electricity (non-heating)	67	24%	366	30%
Heating and hot water	53	31%	1,126	37%
Process loads (cooking, laundry, industrial processes)	21	31%	18	37%

Table A-13: Industrial and Commercial Base Year Energy Intensities and Abatement Potentials

The energy demands and emissions split by fuel type for each year of the industrial pathway projection have been detailed in Table A-14 and Table A-15.

Energy Demand (GWh)	2020	2025	2030	2035	2040	2045	2050
Electricity	744	917	1051	1181	1300	1407	1506
Gas grid	662	696	689	685	684	686	691
Bioenergy & Waste	785	817	800	786	777	772	742
Petroleum, coal & solid fuels	1110	966	751	548	375	229	107
Total Energy Demand	**3,305**	**3,400**	**3,293**	**3,202**	**3,137**	**3,096**	**3,046**
Reduction against baseline		*-3%*	*0%*	*3%*	*5%*	*6%*	*8%*
Electricity Mix							
Solar PV self-supply	0	115	223	331	394	465	501
Grid electricity demand	744	802	828	850	905	943	1,005

Table A-14: Industrial Pathway Energy Demand by Fuel Type

Emissions ($ktCO_2$)	2020	2025	2030	2035	2040	2045	2050
Grid electricity	156	99	43	21	14	9	7
Gas grid	124	127	99	98	98	98	99
Bioenergy & Waste	0	0	0	0	0	0	0
Petroleum, coal & solid fuels	354	309	240	175	120	73	34
Total Emissions	**635**	**534**	**381**	**294**	**232**	**180**	**140**
Reduction against baseline		16%	40%	54%	64%	72%	78%

Table A-15: Industrial Pathway Emissions by Fuel Type

The energy demands and emissions split by fuel type for each year of the commercial pathway projection have been detailed in Table A-16 and Table A-17.

Energy Demand (GWh)	2020	2025	2030	2035	2040	2045	2050
Electricity	1203	1330	1396	1464	1531	1597	1664
Gas grid	844	777	658	544	447	366	297
District heating	0	10	21	31	41	49	56
Petroleum & Coal	21	19	15	11	7	5	2
Total Energy Demand	**2,072**	**2,139**	**2,092**	**2,052**	**2,027**	**2,017**	**2,020**
Reduction against baseline		-3%	-1%	1%	2%	3%	3%
Electricity Mix							
Solar PV self-supply	0	186	361	536	638	752	811

Energy Demand (GWh)	2020	2025	2030	2035	2040	2045	2050
Grid electricity demand	1,203	1,144	1,035	928	892	845	853

Table A-16: Commercial Pathway Energy Demand by Fuel Type

Emissions ($ktCO_2$)	2020	2025	2030	2035	2040	2045	2050
Grid electricity	252	141	53	23	14	8	6
Gas grid	158	141	94	78	64	52	43
District heating	0	2	2	2	3	4	4
Petroleum & Coal	6	5	4	3	2	1	1
Total Emissions	**417**	**289**	**154**	**107**	**83**	**65**	**53**
Reduction against baseline		31%	63%	74%	80%	84%	87%

Table A-17: Commercial Pathway Emissions by Fuel Type

Appendix B: Route Map Monitoring Table

Emissions ($ktCO_2$)	2020	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2040	2045	2050
Total Emissions	**3,706**	**5%**	**7%**	**9%**	**12%**	**17%**	**23%**	**28%**	**34%**	**39%**	**59%**	**83%**	**90%**	**92%**
Transport (road)	1,627	2%	3%	5%	6%	11%	16%	21%	26%	31%	59%	97%	98%	99%
Housing	1,028	4%	7%	9%	11%	17%	23%	29%	35%	41%	57%	74%	91%	92%
Commercial	417	12%	18%	24%	31%	37%	44%	50%	57%	63%	74%	80%	84%	87%
Industrial	635	6%	10%	13%	16%	21%	25%	30%	35%	40%	54%	63%	72%	78%

Appendix C: Action Plan Monitoring Tables

Solar PV Installed Capacity (MWp)														
Year	2020	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2040	2045	2050
Total Capacity	402	575	662	749	836	990	1,145	1,300	1,455	1,609	2,596	3,410	4,470	5,314
Grid Supply Capacity	402	408	412	415	418	495	573	650	727	805	1,298	1,705	2,235	2,657
On-Site Installed Capacity	0	167	251	334	418	495	573	650	727	805	1,298	1,705	2,235	2,657
On-Site Installed Capacity Breakdown by Sector														
Housing	0	22	34	45	56	65	74	83	92	101	255	462	770	1,078
Commercial	0	76	114	151	189	225	261	297	332	368	546	650	767	827
Industrial	0	47	70	94	117	139	161	183	205	227	337	402	474	511
Institutional	0	22	33	44	55	66	76	87	97	108	160	190	224	242

Table C-1: Solar PV Installed Capacity Action Plan Monitoring

Transport (road)														
Year	2020	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2040	2045	2050
Demand Reduction														
Demand Reduction of Personal Trips vs. Baseline (% of Vehicle Miles)	0%	-4%	-6%	-8%	-10%	-12%	-14%	-16%	-18%	-20%	-25%	-25%	-25%	-25%
Mode Shift of Personal Trips vs. Baseline (% of Vehicle Miles)	0%	-2%	-3%	-4%	-5%	-6%	-7%	-8%	-9%	-10%	-10%	-10%	-10%	-10%
Freight Trip Efficiency	0%	2%	3%	4%	5%	6%	7%	8%	9%	10%	10%	10%	10%	10%
Vehicle Stock Changes														
Private Vehicles (Cars & Motorcycles): Electric	3,777	12,266	16,511	20,755	25,000	44,000	63,000	82,000	101,000	120,000	200,000	343,029	359,369	375,710
Public Transport (Buses & Coaches): Electric	0	80	120	160	200	360	520	680	840	1,000	2,000	6,174	6,751	7,328
LGVs: Electric	0	1,000	1,500	2,000	2,500	5,000	7,500	10,000	12,500	15,000	35,000	49,508	53,158	57,077
HGVs: Electric	0	80	120	160	200	340	480	620	760	900	2,800	5,456	5,858	6,290

Table C-2: Transport (Road) Sector Action Plan Monitoring

Housing														
Year	2020	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2040	2045	2050
New Builds														
Housing Standards for New Builds	Current Part L	Current Part L	Current Part L	Current Part L	Future Homes Standard	Future Homes Standard	Future Homes Standard	Future Homes Standard	Future Homes Standard	Passivhaus Plus	Passivhaus Plus	Passivhaus Premium	Passivhaus Premium	Passivhaus Premium
% New Developments with Heat Pumps	0%	8%	12%	16%	20%	32%	44%	56%	68%	80%	80%	80%	80%	80%
Number of Heat Pumps Installed in New Homes (Cumulative)	0	0	0	0	1,308	2,541	3,516	4,398	5,140	7,529	24,959	42,389	59,819	77,250
Existing Properties														
Number of Existing Properties Retrofitted to EPC B and Above (Cumulative)	0	389	583	777	972	4,172	7,372	10,572	13,772	16,972	96,972	196,972	247,778	247,778
Number of Heat Pumps Retrofitted (Existing Homes)	0	300	450	600	750	1,600	2,450	3,300	4,150	5,000	35,000	100,000	240,000	240,000

Table C-3: Housing Sector Action Plan Monitoring

Industrial														
Year	2020	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2040	2045	2050
Energy Efficiency Improvements														
% building existing stock retrofitted (to achieve abatement potential)	0%	0%	0%	0%	0%	2%	4%	6%	8%	10%	20%	30%	40%	50%

% new building stock achieving full abatement potential	50%	70%	80%	90%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heating and Hot Water Fuel Mix														
Gas grid	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	25%	25%	25%
Direct electric	2%	4%	4%	5%	6%	7%	8%	8%	9%	10%	14%	17%	20%	22%
Electricity – heat pumps (ASHP and GSHPs)	0%	2%	3%	4%	5%	6%	7%	7%	8%	9%	13%	17%	20%	23%
Bioenergy & Waste	24%	24%	25%	25%	25%	25%	25%	26%	26%	26%	26%	26%	26%	25%
Petroleum, coal, solid fuels	48%	44%	42%	40%	38%	36%	34%	33%	31%	29%	21%	14%	8%	4%
Process Load Fuel Mix														
Gas grid	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	18%	18%	19%
Direct electric	36%	37%	37%	38%	38%	39%	39%	40%	40%	41%	43%	45%	47%	49%
Bioenergy & Waste	24%	25%	25%	26%	26%	26%	27%	27%	28%	28%	30%	30%	31%	31%
Petroleum, coal, solid fuels	24%	22%	21%	20%	19%	18%	17%	16%	15%	14%	10%	7%	4%	2%

Table C-4: Industrial Sector Action Plan Monitoring

Commercial														
Year	2020	2022	2023	2024	2025	2026	2027	2028	2029	2030	2035	2040	2045	2050
Energy Efficiency Improvements														
% building existing stock retrofitted (to achieve abatement potential)	0%	0%	0%	0%	0%	2%	4%	6%	8%	10%	20%	30%	40%	50%
% new building stock achieving full abatement potential	50%	70%	80%	90%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Heating and Hot Water Fuel Mix														
Gas grid	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	25%	25%	25%
Direct electric	79%	75%	72%	70%	68%	66%	63%	61%	58%	56%	46%	36%	29%	22%
Electricity – heat pumps (ASHP and GSHPs)	19%	18%	17%	17%	16%	16%	15%	15%	14%	14%	11%	9%	8%	6%
Bioenergy & Waste	0%	5%	8%	10%	13%	16%	19%	21%	24%	27%	39%	50%	59%	67%
Petroleum, coal, solid fuels	0%	0%	1%	1%	1%	1%	1%	2%	2%	2%	3%	3%	4%	5%
Process Load Fuel Mix														
Gas grid	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	17%	18%	18%	19%
Direct electric	52%	50%	48%	47%	46%	45%	43%	42%	40%	39%	33%	28%	24%	20%
Bioenergy & Waste	46%	49%	50%	52%	53%	54%	56%	57%	59%	60%	66%	72%	76%	80%
Petroleum, coal, solid fuels	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%	0%	0%

Table C-5: Commercial Sector Action Plan Monitoring

Bibliography

BEIS, 2014-15. *Building Energy Efficiency Survey.* [Online]
Available at: https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees

BEIS, 2019. *Sub-national electricity consumption data.* [Online]
Available at: https://www.gov.uk/government/collections/sub-national-electricity-consumption-data

BEIS, 2020. *2020 UK Greenhouse Gas Emissions, Final Figures.* [Online]
Available at:
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1051408/2020-final-greenhouse-gas-emissions-statistical-release.pdf
[Accessed 23 09 2022].

BEIS, 2020. *Sub-national electricity consumption data.* [Online]
Available at: https://www.gov.uk/government/collections/sub-national-electricity-consumption-data

BEIS, 2020. *Sub-national gas consumption data.* [Online]
Available at: https://www.gov.uk/government/collections/sub-national-gas-consumption-data

BEIS, 2020. *Sub-national residual fuel consumption data.* [Online]
Available at: https://www.gov.uk/government/collections/sub-national-consumption-of-other-fuels

BEIS, 2020. *Sub-national road transport consumption data.* [Online]
Available at: https://www.gov.uk/government/collections/road-transport-consumption-at-regional-and-local-level

BEIS, 2020. *UK territorial greenhouse gas emissions national statistics.* [Online]
Available at: https://www.gov.uk/government/collections/uk-territorial-greenhouse-gas-emissions-national-statistics

BEIS, 2021. *Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal.* [Online]
Available at: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

BEIS, 2021. *Greenhouse gas reporting: conversion factors 2021.* [Online]
Available at: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021

BEIS, 2021. *UK local authority and regional greenhouse gas emissions national statistics.* [Online]
Available at: https://www.gov.uk/government/collections/uk-local-authority-and-regional-greenhouse-gas-emissions-national-statistics

Carbon Trust, 2021. *Zero Carbon Oxford Roadmap and Action Plan)..* [Online]
Available at: https://zerocarbonoxford.com/roadmap/

Committee on Climate Change, 2020. *The Sixth Carbon Budget: The UK's path to Net Zero.* [Online]
Available at: https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf
[Accessed 21 06 2022].

Department for Business, Energy & Industrial Strategy (BEIS), 2019. *Sub-regional Feed-in Tariffs statistics.* [Online]
Available at: https://www.gov.uk/government/statistical-data-sets/sub-regional-feed-in-tariffs-confirmed-on-the-cfr-statistics
[Accessed 2022].

Department for Levelling Up, Housing and Communities, 2022. *Energy Performance of Buildings Data:.* [Online]
Available at: https://epc.opendatacommunities.org/

DfT, 2019. *National Travel Survey: 2019.* [Online]
Available at: https://www.gov.uk/government/statistics/national-travel-survey-2019

DfT, 2019. *Road traffic statistics (TRA).* [Online]
Available at: https://www.gov.uk/government/statistical-data-sets/road-traffic-statistics-tra

DfT, 2020. *Vehicles statistics.* [Online]
Available at: https://www.gov.uk/government/collections/vehicles-statistics

Energy Networks Association, 2022. *Britain's gas grid to be ready to deliver hydrogen across the country from 2023, energy networks announce.* [Online]
Available at: https://www.energynetworks.org/newsroom/britains-gas-grid-ready-to-deliver-hydrogen-across-the-country-from-2023-energy-networks-announce

Energy Saving Trust, 2021. *The future of heating in the UK: heat pumps or hydrogen?.* [Online]
Available at: https://energysavingtrust.org.uk/the-future-of-heating-in-the-uk-heat-pumps-or-hydrogen/#:~:text=The%20CCC%20has%20suggested%20that,ambition%20will%20need%20to%20increase.

England's Economic Heartland, 2022. *Decarbonisation Strategy Tool,* s.l.: City Science.

Homebuilding & Renovating, 2022. *Passivhaus: How to Build to This Low Energy Standard.* [Online]
Available at: https://www.homebuilding.co.uk/advice/passivhaus

Office for National Statistics (ONS), 2020. [Online]
Available at: https://www.nomisweb.co.uk/

OxonCC, 2022. *Local Transport & Connectivity Plan.* [Online]
Available at: https://www.oxfordshire.gov.uk/sites/default/files/file/roads-and-transport-connecting-oxfordshire/LocalTransportandConnectivityPlan.pdf

OxonCC, 2022. *Local Transport and Connectivity Plan 2022-2050,* s.l.: s.n.

Passivhaus Trust, 2022. *What is Passivhaus?.* [Online]
Available at: https://www.passivhaustrust.org.uk/what_is_passivhaus.php
[Accessed 28 09 2022].

Passivhaus Trust, n.d. *Passivhaus Criteria.* [Online]
Available at: https://www.passivhaustrust.org.uk/passivhaus_awards/passivhaus-plus-premium/

Valuation Office Agency, 2020. *Non-domestic rating: stock of properties including business floorspace, 2020.* [Online]
Available at: https://www.gov.uk/government/statistics/non-domestic-rating-stock-of-properties-2020