Lancashire
Independent Economic Review

Final Report:

# Lancashire Net Zero Pathways Options

Appendices

# Notice

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# Appendices

# Appendix A. Evidence review

Appendix A presents the results of the evidence review undertaken to inform the study. It covers the following types of evidence:

- Policy and industry reports
- Sectoral guidance
- Selection of case studies

## A.1. Policy and Industry Reports Review

A review has been undertaken of current and planned sectoral and cross-sectoral national, regional and local policies and industry reports to identify what is already underway and the level of alignment with Net Zero targets.

**Table A-1 - National policy review**

| Document | Key Objectives / Targets / Policy | Implications for study |
|---|---|---|
| Decarbonising Transport: Setting the Challenge (2020) | Document discussing the existing challenges facing the transport sector and the require steps to develop the transport decarbonisation plan.<br>To deliver a transport system that is net zero, the document outlines 6 key strategic priorities for the transport decarbonisation plan:<br>• Accelerating modal shift to public and active transport<br>• Decarbonisation of road vehicles<br>• Decarbonising how we get our goods<br>• Place-based solutions<br>• UK as a hub for green transport technology and innovation<br>• Reducing carbon in a global economy | This report was a precursor to the Transport Decarbonisation Plan. |
| Transport Decarbonisation Plan (2021) | The TDP sets out a series of actions and timings that will decarbonise transport by 2050 and deliver against carbon budgets as part of the Government's ambition to achieve Net Zero across the economy by 2050 and align with the 2015 Paris Agreement.<br>The TDP considers action for decarbonisation in terms of 6 priority themes**:**<br>• Accelerating modal shift to public and active transport<br>• Decarbonising road transport<br>• Decarbonising how we get our goods<br>• UK as a hub for green transport technology and innovation<br>• Place-based solutions to emissions reduction<br>• Reducing carbon in a global economy<br>The plan largely focusses on drawing together existing relevant policy, initiatives and funding and focuses particularly on decarbonising vehicles through new technology and fuel. It also recognises the need for changes in travel behaviour and spatial planning, noting that local and regional authorities are often best placed to | The TDP was published in July 2021, at the end of the process of developing scenarios for this study and therefore did not directly influence the scenarios produced. However, the plan represented a consolidation and continuation of existing policy in relation to decarbonising the transport sector and therefore the measures tested are consistent with its contents. |

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| | implement these measures as part of place-based emissions reductions.<br>The TDP suggests that local authorities will be supported by streamlined funding, aligned to decarbonisation requirements and focussed around revitalised LTPs which will need to identify how programmes of transport investment will deliver carbon reductions and carbon pathways. The DfT will also support authorities by publishing a Transport Decarbonisation Toolkit to provide guidance and support on implementing sustainable transport measure and by reviewing and revising the scheme business case appraisal rules. | |
| Reducing Emissions from Road Transport: The Road to Zero Strategy (2018) | This document produced by the Department for Transport sets out the strategic vision for the UK to reduce emissions of all pollutants, including NO2, through on-road transportation. It sets out an ambition to end the sale of conventional petrol and diesel vehicles by 2040 – now surpassed by more recent announcements, where the Government committed to a ban on sale of these vehicles by 2030 as part of its ten-point plan[1]. It also sets out an ambition to see up to 70% of car sales (and 40% of van sales) that are ultra-low emissions by 2030.<br>The strategy commits to reduce emissions from existing vehicles by increasing availability of alternative fuels, extending the clean retrofit accreditation scheme beyond buses and coaches to LGVs and black cabs, and increasing enforcement. It sets out further measures to support increased uptake of new low-emissions vehicles and support reduction of road freight emissions through industry engagement. | The report relays and defers to the findings of the CCC on electric vehicle (EV), to increase the EV rapid-charging network for HGVs from 2016 by 150% to 1,170 charging points by 2030, and 10X increase on-street 'top-up' charging in the same timeframe, to 27,000.<br>A first-year allowance scheme for businesses, whereby they can offset their investments into EV infrastructure against taxable profits, was available up until 2019.<br>The strategy points to the National Planning Policy Framework (NPPF) to give direction to local authorities. |
| The Future Homes Standard: Summary of Responses, and Government Response (2019) | Now available results from the public consultation on an uplift to the standards for Part L of the building regulations and changes to Part F as a step towards achieving the Future Homes Standards. Below are the proposed changes:<br>• From 2025, the Future Homes Standard will deliver homes that are zero carbon ready<br>• Acknowledge the need to clarify Local Planning Authorities' role in setting energy efficiency requirements<br>• In 2020, introduce an interim uplift in Part L standards<br>• To improve simplicity, a revised package of performance metrics will ensure a fabric first approach<br>• Puts forward a package of measures to improve compliance and reduce the performance gap<br>• Introduction of rigorous arrangements to ensure new homes are being built to new energy efficiency standards | Newly built housing developments will soon be subject to more stringent performance standards, which Lancashire should consider as part of its business as usual in case of any major developments planned. The new guidance to address performance gap will also support LCC with policy setting and monitoring.<br>LCC will need to incorporate any updated requirements for energy efficiency into its policies. |

[1] The Ten Point Plan for a Green Industrial Revolution (publishing.service.gov.uk).

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| Industrial Decarbonisation Strategy (2021) | The strategy document discusses how industry can decarbonise in line with the UK 2050 net zero target, while remaining competitive and avoiding pushing emissions elsewhere. An indicative roadmap is also included.<br>Nine chapters set out how this challenge will be achieved:<br>1. Why we need a strategy and our approach<br>2. Getting investors to choose low carbon<br>3. Getting consumers to choose low carbon<br>4. Adopting low-regret technologies and building infrastructure<br>5. Improving efficiency<br>6. Accelerating innovation of low carbon technologies<br>7. Net zero in a global market<br>8. Levelling Up<br>9. Tracking Progress<br>The indicative roadmap features key event dates such as:<br>• 2023: World's first net zero aligned emissions trading scheme (ETS)<br>• 2025: Two Carbon Capture Clusters<br>• 2030: 20 TWh fossil fuels replaced with low carbon alternatives and two further carbon capture clusters<br>• 2040: World's first net zero cluster<br>• 2050: Emissions to be reduced by at least 90% from 2018. Zero avoidable waste of materials and almost no fossil fuels unless paired with carbon capture.<br><br>Action 4.6 on p.56 is to 'Review policies to address specific barriers faced by less energy-intensive, dispersed industrial sites'. No specific promises are made, but planning reforms and better coordination between decarbonisation and other environmental policies are offered as a way to create the right enabling environment to support such industrial actors. | Business as Usual assessment:<br>• In January 2021, the Government created the UK Emissions Trading Scheme (UK ETS), which is due to cap emissions allowances in line with the UK's Net Zero ambitions by end of 2023. This is intended to use carbon pricing as a tool to signal market demand.<br>• It is too soon to tell what impact this will have on the market, since there is currently a surplus of carbon credits driving the price lower.<br>• Hydrogen consumption could reach 10TWh per year, if limited to industrial clusters where it is produced by 2030 – rising to 16TWh if support is given for harder-to-reach sites.<br>Net Zero pathways:<br>• The report highlights energy intensive industries such as glass, lime and chemicals, which are away from central clusters and total 12.3MtCO2e nationally. For these, Government may encourage uptake of directly supplied hydrogen in re-purposed gas networks or dedicated supply network.<br>• Many technologies needed to electrify low-heat processes are mature and available to industry. The change in price of electricity relative to fossil fuel sources will make this increasingly attractive.<br>• Smart technologies incl. storage will help industry to access energy when it is cheapest and cleanest.<br>Residual removals:<br>• The Government's strategy to encourage negative emissions technologies centres around supporting 'carbon capture clusters', of which Merseyside is the nearest. |
| Resources and Waste Strategy (2018) | The strategy discusses how the use of circular economy, waste minimisation and resource efficiency, we can protect and preserve our stock of materials and the natural environment. Eight chapters explain the key themes for achieving this:<br>1. Sustainable Production<br>2. Helping Consumers Take More Considered Actions<br>3. Resource Recovery and Waste Management<br>4. Tackling Waste Crime<br>5. Enough is Enough: Cutting Down on Food Waste<br>6. Global Britain: International Leadership<br>7. Research and Innovation | The study will need to consider whether its aims and targets meet the timelines necessary to comply with the timelines set for reducing/minimising waste. |

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| | 8. Measuring Progress: Data, Monitoring and Evaluation<br><br>A timeline of key milestones/consultations and targets is also presented:<br>• Double resource productivity by 2050<br>• By 2050 all avoidable waste will be eliminated<br>• Over the course of the 25 Year Environment Plan, avoidable plastic waste will be eliminated<br>• By 2030 work towards eliminate food waste to landfill<br>• By 2025, work towards compostable, reusable or recyclable capabilities for all plastic packaging | |
| England Tree Strategy Consultation (2020) | A consultation aiming to inform the Government update on tree, woodland and forestry policy – looking to increase tree planting, connect people to nature and improve woodland management leading to supporting the economy and helping to address climate change. Trees are stated as “a unique natural asset that play a crucial role in combating the biodiversity and climate crises”.<br>Subject to consultation, the government is looking to increase tree planting to 30,000 hectares per year spread out over the UK by 2025. This will contribute towards the Nature Recovery Network, aiming to either restore or create 500,000 hectares of habitat that is dense in wildlife.<br>The strategy aims to:<br>Protect and improve our trees and woodlands by:<br>• Sustainable management of invasive species<br>• Stronger protection for ancient woodland<br>• Greater proportion of woodland in active management<br>• Adapting treescapes for other uses such as natural flood management<br>Engaging People with Trees and Woodland:<br>• Improving green infrastructure quality, supporting better long-term health<br>• Using Community Forests to improve access to existing woodlands and create new ones<br>Supporting the Economy:<br>• Expanding the market for wood products and upskilling farmers and land managers to add trees into their businesses<br>• Supporting sustainable timber and further sustainable uses such as within energy | The study will need consider the appropriate tree planting / woodland strategy for the given area. |
| UK Peatland Strategy, April 2018 | The UK Peatland Strategy aims to drive and co-ordinate action across the UK, supported by country level plans that will establish a course for peatland conservation and management at a | The study will need to consider the 2040 target for peatland in the context of the |

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| | more detailed level. This strategy recognises there are different peatlands and types of pressures within the UK and seeks to provide common goals across the four devolved administrations of England, Northern Ireland, Scotland and Wales.<br>It was developed to:<br>Support co-ordinated large-scale action to conserve and restore the UK's peatlands;<br>Bring about more widespread sustainable management;<br>Help prioritise and ensure sufficient resources are available for delivery;<br>Continue to promote partnership working and knowledge sharing across different sectors and countries;<br>To co-ordinate monitoring and reporting of peatland condition and functionality to allow the UK to report to EU and International obligations including National Green House Gas (GHG) accounting and Biodiversity conventions amongst others;<br>Implement international recommendations for peatlands including those from the Food and Agriculture Organisation of the United Nations (UNFAO) and Wetlands International;<br>Deliver a strong, unified and cohesive message to funders and policy makers that peatland conservation, restoration and sustainable management should remain high on the agenda.<br>The 2040 target is for two million hectares of peatland in good condition, under restoration or being sustainably managed by 2040. | carbon sequestration analysis for the given area. |
| England Peat Action Plan (2021) | The 25 Year Environment Plan set out ambition to create and deliver a new ambitious framework for peat restoration in England. Peatland restoration will enable peatlands not only to meet their Net Zero contribution, but also contribute to wider environmental goals. Where it is not appropriate to restore lowland peat, we will develop new responsible management measures to make sure that the topsoil is retained for as long as possible and greenhouse gas emissions are reduced.<br>Government will work to ensure all peatlands, not just deep or protected peat, are responsibly managed, or, in good hydrological condition or under restoration management. Government will set a target for peatland restoration as part of the forthcoming Net Zero Strategy, recognising the important role that peat plays in the pathway to net zero emissions.<br>Government will achieve this through:<br>● Developing a more up to date and detailed England peat map by 2024, establishing a clear evidence base on which to build. | The study must consider the peatland restoration strategy in the context of carbon sequestration and wider societal benefits for the given area. |

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| | ● Immediately funding at least 35,000 ha of peatland restoration by 2025, through the Nature for Climate Fund and other sources. This is just the start of our ambition for peatland restoration to 2050 and beyond. The government's new Sustainable Farming Incentive, Local Nature Recovery and Landscape Recovery Schemes will provide the main delivery mechanism for peatland restoration after 2024-25 and our new Nature for Climate grants will act as an important precursor.<br>● By Summer 2022, we will have recommendations for a more sustainable future for our lowland agricultural peatlands, developed by the Lowland Agricultural Peat Task Force. Where the environmental benefits are clear, the delivery of these recommendations may be supported through new schemes that reward farmers and land managers for producing public goods; the sale of peatland carbon credits; and better regulation.<br>● Consult on banning the sale of peat and peat containing products in the amateur sector by the end of this parliament. We will publish a full consultation on phasing out the use of peat in horticulture in 2021. We recognise that the voluntary approach has not delivered.<br>● Continue to protect our peat from fire by both phasing out managed burning and reducing the risk of wildfire.<br>Implementation of the measures above will:<br>● Secure our peatlands' carbon store so they meet their contribution to Net Zero by 2050. This cannot be achieved by only restoring upland peat but will require significant changes to how we manage our lowland peat.<br>● Deliver Natural Flood Management and improve water quality, to increase drought resilience and the sustainability of our water supplies.<br>● Protect and restore our peatland habitats so they are healthy, well-functioning ecosystems rich in wildlife. These wildlife rich peatlands will form a key part of our Nature Recovery Network.<br>● Drive private investment in peatland restoration through natural capital markets that allow the accreditation and sale of the ecosystems services that healthy peatlands can provide.<br>● Protect the historic environment of peatlands so the important evidence of our past can be preserved for the future, and ensure that restoration projects deliver cultural heritage, education and enjoyment, alongside other public goods.<br>Government wants stakeholders to work with us over the coming years to influence the ongoing | |

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| | development of our delivery approach, and to get our peatland back on the road to recovery.<br>We hope stakeholders will:<br>● Apply for funds to deliver peat restoration under programmes such as the Nature for Climate Fund and Investment Readiness Fund.<br>● Work with Natural England on the development of the Implementation Plan.<br>● Work with us on the development of the information tools, including a new peatland map.<br>● Input into the Lowland Agricultural Peat Task Force.<br>● Input into the consultation on measures to phase out peat use in horticulture, with a particular focus on the amateur sector. | |
| The England Trees Action Plan 2021-2024 (2021) | Trees and woodlands can provide huge benefits for people, nature, climate and the economy and the action plan aims to maximise them. Building on ambitions outlined in the 25 Year Environment Plan, Government will focus on:<br>Nature Recovery: Trees and woodlands will form a core part of the Nature Recovery Network, by providing important habitats themselves as well as connecting other wildlife rich habitats. Establishing native woodland has made the greatest contribution to the increase in priority habitats in recent years, and the government will continue to improve the condition and increase the extent of most precious woodland habitats, such as protected sites and irreplaceable ancient woodlands. This will contribute to the global goals to be agreed at the Convention on Biological Diversity in 2021 and the commitment to protect 30% of the land by 2030. The government will continue to support species recovery through Forestry England's reintroduction programme, which has reintroduced pine martens to the Forest of Dean, white-tailed eagles to the Isle of Wight, and two enclosed projects for beaver.<br>Trees and woodlands for climate change mitigation: The Climate Change Committee recommends that the government increase planting across the UK to meet net zero. The government will work with the Devolved Administrations to deliver a UK-wide step change in tree planting and establishment. Woodland carbon offers exciting opportunities for the private sector and other investors and the government will work to develop these markets further.<br>Levelling up through a thriving forest economy: Forestry is an economically important sector, particularly in often neglected parts of England. The government will encourage demand for UK grown timber which can reduce the carbon footprint from imports and reduce emissions by replacing carbon-intensive materials and | The study must recognise the multi benefits trees and woodlands can provide. |

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| | encourage innovative green finance for trees and woodlands. In addition, the government will work with the sector to develop the skills and resources to deliver the ambitions. The government will see that trees and woodlands contribute to the bottom line of more businesses in England.<br>Trees and woodlands for water and soil: Establishing trees and woodlands can impact on water resources, and this may be amplified as the climate changes. The right trees and woodland in the right places along and near rivers and within water catchments present opportunities for improving water quality, for flood alleviation and nature recovery. Soil is critical to supporting trees and woodland and the government will improve the understanding of appropriate soil management to sequester carbon and protect this precious resource from degradation and inappropriate tree establishment.<br>Trees and woodlands for people in town and country: The COVID-19 pandemic has brought home the important role nature plays in improving the wellbeing and mental health and is often most valuable when close to and part of the places the government live, work and play. Trees and woodlands can cool the settlements, improve air quality and contribute to community cohesion and sense of place. The government will take steps to improve public access to trees and woodlands in a responsible way, encourage community-led tree planting and invest in partnerships with communities and local government.<br>Heritage and Landscape: Trees and woodlands are important features in the landscapes. The government will encourage greater landscape scale planning which will enhance and transform landscape character, while protecting and conserving heritage assets from inappropriate tree planting and during woodland management.<br>Trees outside woodlands: Trees throughout the environment such as wood pastures, ancient and veteran trees, scrub, scattered and hedgerow trees contribute to England’s natural beauty and are important spaces for nature. The government must continue to protect and enhance these features. Agroforestry will also play an important role in delivering more trees on farms and in the landscape, improving climate resilience and encouraging more wildlife and biodiversity in the farming systems.<br>Healthy, resilient trees and woodlands: Climate change threatens the trees and woodlands, increasing the risks from pests, diseases, wildfire and long-term changes to growing conditions. The government will act now to help the trees and woodlands adapt, to enhance their resilience to stresses by reducing risks and | |

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| | encouraging greater diversity. The government will respond swiftly to outbreaks of pests and diseases and improve the management of deer and grey squirrels.<br>Government and its arms-length bodies including the Forestry Commission, Natural England and the Environment Agency will play a role in delivering these ambitions, but the government cannot do it alone. The government need the forestry sector, land-owners and managers, investors, the third sector, and communities to help the government meet the challenge. The government will provide funding and guidance, improve regulations, and encourage private finance to enable foresters, land owners, managers, investors and communities to plant and protect the trees. The government will act as a catalyst for the sector, making sure that the grants and the nation's forests deliver high environmental, social, and economic benefits to secure the greatest value for public money.<br>The government hope stakeholders will:<br>• Apply for grants for establishing and managing trees and woodlands;<br>• Access more and better advice and guidance on establishing and managing trees and woodlands;<br>• Work with the government to unlock more private finance to invest in trees and woodlands;<br>• Plant trees particularly where they make the most difference - for water, biodiversity, climate resilience and close to where people live, work and play;<br>• Responsibly enjoy the wonderful wooded landscapes<br>Government intend to spend over £500 million of the £640 million Nature for Climate Fund on trees and woodlands between 2020 and 2025. With this funding, the government aim to at least treble woodland creation rates by the end of this Parliament, reflecting England's contribution to meeting the UK's overall target of planting 30,000 hectares per year by the end of this Parliament. | |
| Agriculture Act (2020) | The Act defines a new role for UK Government in the agricultural market, to provide new forms of support to farmers which are more targeted towards sustainable outcomes than the previous Basic Payments Scheme.<br>There will be a seven-year transition period over to the new system of subsidies. Following that date, plan periods of at least five years will be set out.<br>Measures include improvements in transparency of the supply chain through new requirements on data collection and sharing, and fair dealing obligations on purchasers from farmers; | Business as Usual assessment:<br>• The Act provides a signal that the agricultural assets within Lancashire will start to be directed towards environmental benefits, of which carbon removals may be one; but it is too soon to tell exactly what the public goods will be or their impact on carbon.<br>Net Zero pathways:<br>• *No mention.*<br>Residual removals:<br>• Supporting the improvement of soil may help to increase its carbon stock; other |

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| | subsidies to farmers oriented around developing public goods, notably soil protection and improvement; and regular reporting on food security (at least once every five years). | public goods subsidised may carry further carbon reduction benefits. |
| Energy White Paper (2020) | Building on the Prime Minister's Ten Point Plan for a Green Industrial Revolution, the paper discusses how the UK will transition to a low carbon energy system and achieve net zero emissions by 2050.<br>The six energy systems discussed are:<br>• Consumers<br>• Power<br>• Energy System<br>• Buildings<br>• Industrial Energy<br>• Oil and Gas<br>The key initiatives that feature throughout the paper required for delivery of net zero by 2050 are what make up the Ten Point Plan:<br>• Green Public Transport, Cycling and Walking<br>• Hydrogen<br>• Nuclear Power<br>• Offshore Wind<br>• Jet Zero and Green Ships<br>• Greener Buildings<br>• Carbon Capture, Usage and Storage (CCUS)<br>• Protecting our Natural Environment<br>• Zero Emission Vehicles<br>• Green Finance and Innovation | The paper has application for LCC when considering its pathways to net zero, since it provides an insight into future legislation that will likely be forthcoming in their approximate form. It potentially signals any support that may be forthcoming to local authorities from national government, or the policy direction as a minimum.<br>The Heat Network Transformation Programme commits £122m to support the roll-out of low-carbon space heating solutions focused on heat pumps and the recovery of waste heat. The same initiative will also support local authorities through designated zoning by 2025. This will entail identifying areas with easy connection to low-carbon sources and mandating connection to the low-carbon network.<br>Note that a dedicated Hydrogen Strategy is due to be published imminently, which may contain further policy implications for the county. |
| Committee on Climate Change, *Net Zero: The UK's Contribution to Stopping Global Warming* (2019) | Following a request from the UK governments, this report reassess the UK's long-term emission commitments. The key takeaway is the recommendations for the UK to target net zero greenhouse gas emissions by 2050, with Scotland achieving this sooner in 2045 and Wales only reaching a 95% reduction by 2050.<br>The report states these revised targets will enable the UK to deliver on previous commitments made by signing the Paris Agreement, however, acknowledges the large gap in existing policy that is currently insufficient for delivery of (even the previous 80% reduction) target. | The report by the CCC is the foundation of the net zero by 2050 legislated target. We will seek to offer pathways that provide reductions in alignment with this technical paper and its recommendations. |
| 25 Year Environment Plan (2018) | Setting out the next 25 years of governmental work towards the environment, ten key goals are specified:<br>1. Clean air<br>2. Clean and plentiful water<br>3. Thriving plants and wildlife<br>4. A reduced risk of harm from environmental hazards such as flooding and drought<br>5. Using resources from nature more sustainably and efficiently<br>6. Enhanced beauty, heritage and engagement with the natural environment<br>7. Mitigating and adapting to climate change | Although the focus of this commission is to advise on pathways to net zero carbon emissions, the final project recommendations must ensure that they do not inadvertently entail any backward steps on the goals set out in the Environment Plan.<br>The study should also aim to offer targeted solutions towards these goals, where they are co-benefits to reductions in carbon emissions. |

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| | 8. Minimising waste<br>9. Managing exposure to chemicals<br>10. Enhancing biosecurity<br>To deliver on these goals, six areas of action are identified:<br>• Using and managing land sustainably<br>• Recovering nature and enhancing the beauty of landscapes<br>• Connecting people with the environment to improve health and wellbeing<br>• Increasing resource efficiency, and reducing pollution and waste<br>• Securing clean, productive and biologically diverse seas and oceans<br>• Protecting and improving global environment | |
| Committee on Climate Change, *The Sixth Carbon Budget - The UK's Path to Net Zero* (2020) | The sixth carbon budget covers the period 2033-37 and in order to set the UK on a positive path towards its 2050 net zero target, the Committee on Climate Change (CCC) recommends that the UK reduces greenhouse gas emissions by 78% by 2035 (including aviation/shipping emissions), relative to 1990 levels – a limit of 965 $MtCO_2e$. In the lead up to 2035, the CCC states that emissions should be reduced by 68% by 2030, which meets the UK's Nationally Determined Contribution as part of the UN process (excluding aviation/shipping due to UN convention which reports these separately).<br>Key requirements for delivery of the carbon budget include:<br>• Action across all industries of the economy<br>• By 2030 a significant investment programme will need to be established and reaching approximately £50 billion per year<br>• The majority of investments, including new vehicles and boilers, to be zero carbon by 2030<br>• Healthier diets, reduced waste, car/plane travel, increased efficiency, vast electrification, low-carbon hydrogen (blue or green), CCUS, increased woodland coverage and restored peatlands and increased bioenergy cultivation | Since the recommended carbon budget set out by CCC was adopted into law on 20th April 2021, the study will need to advise on how to meet the target pathway set out. In particular, the mid-period target of 78% reduction is critical to achieving the scope of the study. |
| National Planning Policy Framework (NPPF) (2021) | The NPPF which sets out the government's planning policies for England was revised in July 2021. The most relevant changes in the context of the NZ pathways work are as follows:<br>Chapter 2: Achieving Sustainable Development now acknowledges that members of the UN have agreed to pursue the 17 Global Goals for Sustainable Development in the period to 2030. Minor edits have been made to phrasing, setting out clearly that the environmental objective is now to protect and enhance, and to improve biodiversity, where before the requirement was simply to contribute to these matters.<br>The purpose of the planning system is to contribute to the achievement of sustainable development. At a very high level, the objective of | The study needs to be informed by the revised definition of sustainable development as set out in the revised NPPF. |

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| | sustainable development can be summarised as meeting the needs of the present without compromising the ability of future generations to meet their own needs. At a similarly high level, members of the United Nations – including the United Kingdom – have agreed to pursue the 17 Global Goals for Sustainable Development in the period to 2030. These address social progress, economic well-being and environmental protection.<br>Achieving sustainable development means that the planning system has three overarching objectives, which are interdependent and need to be pursued in mutually supportive ways (so that opportunities can be taken to secure net gains across each of the different objectives):<br>a) an economic objective – to help build a strong, responsive and competitive economy, by ensuring that sufficient land of the right types is available in the right places and at the right time to support growth, innovation and improved productivity; and by identifying and coordinating the provision of infrastructure;<br>b) a social objective – to support strong, vibrant and healthy communities, by ensuring that a sufficient number and range of homes can be provided to meet the needs of present and future generations; and by fostering well-designed, beautiful and safe places, with accessible services and open spaces that reflect current and future needs and support communities' health, social and cultural well-being; and<br>c) an environmental objective – to protect and enhance our natural, built and historic environment; including making effective use of land, improving biodiversity, using natural resources prudently, minimising waste and pollution, and mitigating and adapting to climate change, including moving to a low carbon economy.<br>These objectives should be delivered through the preparation and implementation of plans and the application of the policies in this Framework; they are not criteria against which every decision can or should be judged. Planning policies and decisions should play an active role in guiding development towards sustainable solutions, but in doing so should take local circumstances into account, to reflect the character, needs and opportunities of each area. | |
| Environment Act 2021 | The Environment Act sets out that the Secretary of State may by regulations set long-term targets in respect of any matter which relates to (a)the natural environment, or (b)people's enjoyment of the natural environment. A long-term target in respect of at least one matter within each of the four priority areas: (a)air quality; (b)water; (c)biodiversity; (d)resource efficiency and waste reduction. | The study needs to consider this far-reaching piece of legislation which although not addressing carbon emissions specifically (this is done by the recent Net Zero Strategy) it provides an important framework for net zero pathways in terms of four priority areas: air quality, water, biodiversity and resource efficiency and waste. |

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| | The Act specifically requires the Secretary of State to set by future regulation statutory targets for the recovery of the natural world in two priority areas: air quality (PM2.5 air quality target) and biodiversity (species abundance target) and includes an important new target to reverse the decline in species abundance by the end of 2030. The Secretary of State must also prepare an environmental improvement plan for significantly improving the natural environment for a period no shorter than 15 years.<br><br>Key relevant provisions:<br>Biodiversity Net Gain<br>The Act places a statutory requirement for developments to deliver biodiversity improvements and will require all planning permissions in England (subject to exemptions) to be granted subject to a new general pre-commencement condition that requires approval of a biodiversity gain plan.<br>The planning authority can only approve the biodiversity gain plan if the biodiversity value attributable to a development exceeds the pre-development biodiversity value of the onsite habitat by 10% (known as the 'biodiversity gain objective'). | |
| UK Net Zero Strategy 2021 | The UK's new Net Zero Strategy sets out policies and proposals for decarbonising all sectors of the UK economy to meet our net zero target by 2050. It sets out, for the first time, how the UK Government plans to deliver its emissions targets of Net Zero in 2050 and a 78% reduction from 1990 to 2035 (-63% relative to 2019). It puts forward an achievable and affordable vision that will bring net benefits to the UK.<br><br>Government sets out that the exact technology and energy mix in 2050 cannot be known now, and the path to net zero will respond to the innovation and adoption of new technologies over time. It is expected to rely on the following key green technologies and energy carriers, which interact to meet demand across sectors and to remain low carbon:<br><br>• Electricity from low carbon generation and storage technologies meets higher demand for low carbon power in buildings, industry, transport, and agriculture;<br><br>• Hydrogen can complement the electricity system, especially in harder to electrify areas like parts of industry and heating, and in heavier transport such as aviation and shipping. A range of low carbon production methods could be used; | The study must be guided by, and nested within, this important overarching strategy.<br>Net Zero pathways:<br>• The UK Net Zero Strategy assumes in its high resource scenario (hydrogen based scenario) that 50% of all homes will be converted to 100% hydrogen by 2050. |

<table>
<tr><th>Document</th><th>Key Objectives / Targets / Policy</th><th>Implications for study</th></tr>
<tr><td></td><td>• Carbon capture usage and storage (CCUS) can capture CO2 from power generation, hydrogen production, and industrial processes – storing it underground or using it. This technology also supports negative emissions from engineered greenhouse gas removals – bioenergy with carbon capture and storage (BECCS) and Direct Air Carbon Capture and Storage (DACCS); and<br><br>• Biomass combined with CCUS can remove carbon from the atmosphere and support low carbon electricity and hydrogen generation. Biomass and other wastes can also support low carbon fuels for industry, buildings, and transport.<br><br>It is an ambitious and comprehensive strategy that marks a significant step forward for UK climate policy, setting a globally leading benchmark. Further steps will need to follow quickly to implement the policies and proposals mapped out in the Net Zero Strategy if it is to be a success.</td><td></td></tr>
<tr><td>Industry reports</td><td></td><td></td></tr>
<tr><td>National Grid, ESO Future Energy Scenarios (2020)</td><td>The intention of Future Energy Scenarios (FES) is to stimulate debate and set out feasible pathways to achieve a decarbonised energy system by 2050. The process sees industry being consulted each year and new reports produced on an annual basis with up to date advise.<br>Key objectives for the 2020 report include:<ul><li>Informing energy infrastructure investment</li><li>Energy policy decision making</li><li>Explores the impacts of daily energy consumption between today and 2050</li></ul><u>2020 report:</u><br>Four scenarios are explored with varying decarbonisation speeds and societal change levels:<ul><li>Steady Progression (low speed, low change) – slowest credible decarbonisation</li><li>System Transformation (medium speed, medium change) – hydrogen for heating, lower energy efficiency, supply side flexibility</li><li>Consumer transformation (medium speed, high change) – electrified heating, high energy efficiency, demand side flexibility</li><li>Leading the Way (high speed, very high change) – fastest credible decarbonisation, mixture of hydrogen and electric heating</li></ul>Key takeaways from the report include:<ul><li>Net Zero by 2050 is feasible, but requires immediate action across all technologies and policy areas and complete engagement from society and consumers</li></ul></td><td>Business as Usual assessment:<ul><li>The FES sets out a ‘Steady Progression’ scenario, which is driven by current trends and consumer behaviours – this will lead to 53% of energy coming from renewable sources by 2050.</li></ul>Net Zero pathways:<ul><li>FES sets out three further scenarios, each reaching Net Zero by 2050 but driven by change at different levels in each case.</li><li>No single change scenario works as a ‘reference’ scenario for Lancashire, it can learn from all three.</li><li>Most scenarios point to the role of energy efficiency in homes, paired with heat pumps and smart appliances (50% uptake by 2040 in the Leading the Way scenario). These are measures roll-outs that the county could play a role in facilitating.</li><li>No feasible scenario includes any gas boilers as they are today. Two scenarios include hybrid boilers with natural gas; all scenarios contain some level of district heat provision.</li></ul><br>Residual removals:<br>There is no scenario in which all process emissions from industry will be removed. ‘A mix of hydrogen, electricity and biomass can replace gas and coal to provide heat but</td></tr>
</table>

| Document | Key Objectives / Targets / Policy | Implications for study |
|---|---|---|
| | • Hydrogen and CCUS deployment are essential and industrial demonstrations are required this decade<br>• In a net zero world, the economics behind supply and demand of energy change radically and so new markets must be developed to incentivise flexibility and zero carbon generation investment<br>Whole system thinking is essential for delivering net zero, which is underpinned by open data and digitalisation | *some process emissions remain' (p.23). This is contrary to the claims of ENWL, in which all energy can be sourced renewably.* |

**Table A-2 - Regional policy review**

| Document | Key Objectives / Targets / Policy | Implications for study |
|---|---|---|
| Lancashire Climate Change Strategy (2009)<br>(Cross-sectoral)<br>Link to policy document | The strategy sets out a vision for the county as a 'low-carbon and well adapted Lancashire by 2020'. It addresses national, regional and local policy and identifies adaptation as well as mitigation opportunities. It claims that by 2020 it will have reduced its emissions of $CO_2$ by at least 30% relative to 1990 levels (starting from a base of ~12MtCO2), through action in domestic buildings, transport and economic development. This would be equivalent to an annual saving of **3,237.7 kt$CO_2$**.<br>Expected savings by 2020:<br>• Domestic buildings: 515ktCO2/year<br>• Transport: 431ktCO2/year<br>• Economic and business development: 1,601ktCO2/year<br>• Public sector: 101ktCO2/year<br>• Energy supply: 148ktCO2/year<br>• Natural environment: 17ktCO2/year<br><br>Most of the expected savings were due to be delivered by national policies, with additional action by Lancashire adding a small proportion to these, such as the Lancashire Transport Plan and the Northwest Operational Programme. | Business as Usual assessment:<br>• The strategy points out that up to 27% of emissions reduction (the majority of its 2020 target) could be achieved through existing regional and national policies – but that these are not guaranteed to deliver these reductions.<br>• Nearly half of the above saving was expected from implementation of the EU ETS trading system<br><br>Net Zero Pathways assessment:<br>• This strategy has application up to 2020 and does not acknowledge net zero pathways as this concept was not in use.<br><br>Residual removals:<br>• Tree planting was included as part of the Municipal Waste Management Strategy, expected to deliver savings of 16ktCO2/year. |
| Net Zero NW Cluster Plan (2020)<br>(Cross-sectoral)<br>Link to document | The plan highlights heavy industry as a hard-to-abate sector and sets out a plan to decarbonise industry in the Northwest. It aims to:<br>(1) Explain why the North West of England and North East Wales is the best place to deliver a net zero industrial cluster by 2040;<br>(2) Create an industry led plan for decarbonising industrial processes, which is supported by local government;<br>(3) Quantify the investment opportunity, direct and indirect costs and benefits. Articulate the need for Government support;<br>(4) Consider the role investment in industrial decarbonisation might make to economic growth in the period after short term COVID-19 Recovery activity.<br>It draws on the Clean Growth Strategy (2017) and the Future Energy Scenarios provided by National Grid | Business as Usual assessment:<br>• The region has high potential for offshore wind, which may become a larger part of local energy supply, without direct intervention from LCC.<br><br>Net Zero Pathways assessment:<br>• The plan assumes that some industries will not be able to remove CO2 from processes, but that other industries will be able to connect to the hydrogen network, or else secure their own dedicated supply of hydrogen<br>• See Figure A-1 for breakdown of emissions by industrial sector<br>• Liverpool City is planning for Zero Emissions Refuelling Centres (ZERC), eight hubs that will each provide 2-5MW for electric vehicles. |

| Document | Key Objectives / Targets / Policy | Implications for study |
|---|---|---|
| | (2020), and identifies industry in the region to be 12% of the GVA for heavy industry across the UK.<br>It points to the potential for hydrogen and carbon capture, usage and storage (CCUS) as potential solutions to addressing hard-to-abate emissions. It calls directly on the HyNet development, which is being initially located in Cheshire, but whose network may have relevance for Lancashire in future.<br>The report emphasises the need to think strategically about energy supply and demand, with particular importance placed on the needs of industrial energy consumers, regional networks and local area energy master planning.<br>Lancashire Business Park in Leyland is identified as one of the 14 key industrial zones, where an early connection to a direct hydrogen supply is seen as a priority for decarbonising, ahead of the wider $H_2$ grid. | Residual removals:<br>• The HyNet development may have implications for the county, both in terms of local demand for renewable energy it supplies, and for energy availability to industry and heavy transport.<br>• Some industry may have to relocate to 'industrial hubs' to access core infrastructure that supports efficient use of resources, such as hydrogen.<br>• CCUS will be included as part of these hubs, to support emissions reduction for hard-to-abate sectors. |
| Redefining Lancashire: Our Approach to Recovery (2020)<br>(Cross-sectoral)<br>Link to policy document | This policy sets out a way forward to respond to the COVID-19 pandemic, recognising the differential impact it has had on parts of the community and the local economy. It focuses around four core propositions, and identifies a £62.5m portfolio of investment in the region, including a £2.5m demonstrator project for low-carbon manufacturing.<br>For manufacturing, an industry advisory group is being convened that includes energy and low-carbon sector experts. | Business as Usual assessment:<br>• A procurement and logistics pilot project, 'Buy Lancashire', is underway to encourage local production and distribution of food, with the aim of increasing resilience of networks and also reducing food miles.<br>Net Zero Pathways assessment:<br>• The Greater Lancashire Plan is identified as the initiative that will future-proof Lancashire's infrastructure for a net zero future.<br>Residual removals:<br>• *No mention.* |
| Rubbish to Resources: Waste Management Strategy for Lancashire, 2008-20 (2008)<br>Link to policy document | This strategy renews the importance of a green approach to waste management and identifies key targets and actions to achieve regenerative value from waste. It serves as a framework for policies in sustainable waste management across the 14 local authorities of Lancashire.<br>It also speaks to performance standards and targets for measuring success. It is limited in scope to the municipal waste stream.<br>The plan points to the missed opportunity of sending waste to landfill, in terms of materials that could | Business as Usual assessment:<br>• In 2008, three-stream waste collection was delivered to over 90% of residents in all but one of the districts, and over 95% in 10 of the 14 districts.<br>• The plan aims to stabilise the reported increase in waste arisings, to achieve a 0% growth rate each year compared with 2008.<br>• The plan aims to recycle and compost 61% of municipal waste by 2020.; and to recover 88% of waste by this date (incl. |

| Document | Key Objectives / Targets / Policy | Implications for study |
|---|---|---|
| | be recovered. It also points to methane emissions from buried biodegradable materials as a key driver for the strategy.<br>The vision is sets out is to 'promote a culture whereby waste is recognised as a resource and there is acceptance of responsibility for minimising its production and maximising its recovery'. | Mechanical Biological Treatment processes).<br>Net Zero Pathways assessment:<br>• *This strategy has application up to 2021 and does not acknowledge net zero pathways as this concept was not in use.*<br>Residual removals:<br>• The plan commits to creating new native woodland across Lancashire and Blackpool with 2.5 million trees planted by 2032 (1,200ha).<br>• The authorities will establish a minimum of 10ha per year of new woodland on derelict, underused, neglected and other marginal land.<br>• These measures will contribute to achieving an average saving of 16,000 $tCO_2$ per year by 2020. |
| Landscape Strategy (2000)<br>Link to policy document | The strategy has limited relevance for this assessment since it was produced in 2000 with a period of application only as far as 2016. It makes no reference to carbon emissions of greenhouse gas emissions. | Business as Usual assessment:<br>• *No mention.*<br>Net Zero Pathways assessment:<br>• *This strategy has application up to 2016 and does not acknowledge net zero pathways as this concept was not in use.*<br>Residual removals:<br>• The strategy sets out the opportunities of extensive new woodland planting through the Forest of Burnley and Elwood, as a positive force for change against a trend of decreasing woodland cover due to neglect and grazing pressure; however, it does not refer to any specific planting targets. |
| Lancashire Green Infrastructure Strategy (2009)<br>Link to policy document | Sets out the vision for Lancashire, 'for the development and maintenance of multifunctional green spaces and places' that connect urban with rural areas and improve economic and social outcomes in the region. All residents will have access to green spaces locally. Improve the connectivity between areas, including experience for local residents and visitors alike.<br>All major climate risks that could inhibit growth have green infrastructure solutions, such as sustainable urban drainage (SUDS). Lancashire will invest in green infrastructure as a means of managing increased flood risk, such as Hesket Bank realignment scheme. Green infrastructure will be incorporated into | Business as Usual assessment:<br>• The report does not explicitly mention any interventions past 2019 that will increase or decrease CO2 emissions.<br>• Success metric includes increased cycle paths and footpaths.<br>Net Zero Pathways assessment:<br>• Single reference to the opportunity of green infrastructure to help mitigate and adapt to climate change.<br>Residual removals:<br>• Lancashire will take opportunities to increase its woodland and forests, and plant trees in urban areas, without any specific commitment. |

| Document | Key Objectives / Targets / Policy | Implications for study |
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| | future flood plan developments as a priority.<br>Delivery of the plan will require extensive coordination with other parties, organised around key themes such as Health & Well-being, Tourism, Biodiversity and Climate Change.<br><br>Case study: Partners in Lancashire developed the 120-hectare *Pennine Lancashire Forest Park* centred on a former landfill site, and in reach of multiple deprived communities, with potential to become a regional tourist attraction. | • Key metrics include: (1) increase in street trees in urban areas (+10%); increase in woodland cover (from 6% to 10% by 2030, with intermediate targets); carbon storage – protection of upland peat bogs (primary) and sequestration through tree planting (secondary). |
| Lancashire Local Transport Plan, 2011-21 (2011)<br>Link to policy document | The document sets out a strategy for transport in Lancashire, to enable economic and social activity in an equitable way.<br>The plan identifies high levels of carbon emissions as one of the biggest challenges the county is facing, and aims to reduce the carbon impact of fulfilling Lancashire's transport requirements while meeting traditional commitments and delivering value for money. To this end, it points out the Local Sustainable Transport Fund, which was launched in 2011.<br>The plan has limited relevance for this assessment since the updated plan (LTP4) is due imminently. | Business as Usual assessment:<br>• The plan identifies high-level actions such as improving the range of public transport and active travel options available, engaging with planners so that new developments are located in sustainable locations, and managing peak traffic to reduce congestion.<br>• KPIs include per-capita reductions in transport carbon emissions and reduction in energy use for street lighting, but no specific metrics for improvement are included.<br>Net Zero Pathways assessment:<br>• *This strategy has application up to 2021 and does not acknowledge net zero pathways as this concept was not in use.*<br>Residual removals:<br>*No mention.* |
| Blackburn with Derwent Local Transport Plan 3, 2011-21 (2011)<br>Link to policy document | The document sets out a strategy for transport in Blackburn with Derwent.<br>With regards to carbon, LTP3 sets out Goal 2: Tackle climate change - We will reduce carbon emissions from transport to help achieve a low-carbon and resilient transport system. And states that reducing carbon emissions is one of the LTP3 priorities.<br>The plan has limited relevance for this assessment since the updated plan (LTP4) is due imminently. | Net Zero Pathways assessment:<br>• *This strategy has application up to 2021 and does not acknowledge net zero pathways as this concept was not in use.*<br><br>Residual removals:<br>*No mention.* |
| Blackpool Local Transport Plan (Implementation Plan), 2018-2021<br>Link to policy document | Blackpool Council published its Local Transport Plan Strategy in April 2011, which covered the years 2011 to | Net Zero Pathways assessment:<br>• *This implementation plan has application up to 2021 and does not acknowledge net zero* |

| Document | Key Objectives / Targets / Policy | Implications for study |
|---|---|---|
| | 2016. The council has commenced work with Blackburn with Darwen Borough Council and Lancashire County Council to produce a new joint Local Transport Plan (LTP) Strategy. The implementation plan has been produced to reiterate Blackpool's transport policies; also referencing other key Blackpool Council policy documents that have been produced in recent years.<br><br>The LTP Implementation Plan Transport Vision sets out that [By 2021] Blackpool will have a well maintained and integrated transport network, which will be safer and more secure for all users. Journeys will be more reliable and less affected by congestion, which will contribute to sustained economic growth and a reduction in carbon emissions. | *pathways as this concept was not in use.*<br>Residual removals:<br>*No mention.* |
| Transport for the North, Transport Decarbonisation Strategy | Transport for the North's Decarbonisation Strategy for the North of England sets out a strategy for reaching near-zero emissions from surface transport by 2045, going beyond national policy targets.<br><br>It was released for consultation in June with views requested before 31st August.<br><br>It is the first regional strategy of its type, and highlights the importance of maximising clean growth opportunities; the need to ensure decarbonisation is at the heart of transport-related policy and investment decisions; and that coordination at a regional level will play an important role.<br><br>The strategy considers a range of potential actions and areas of focus including:<br><br>•Zero emission vehicles, including cars, HGVs and buses, with a comprehensive network of charging facilities to support their wider use<br><br>•The decarbonisation of the rail network through electrification<br><br>•The use of hydrogen and alternative fuel vehicles<br><br>•Encouraging modal shift towards more sustainable ways of travelling, such as public transport and active travel<br><br>•Opportunities for decarbonisation in the freight industry | The document is in draft and was only released for consultation towards the end of the study (June 2021) so has not directly impacted on the study. However, the content of the strategy is consistent with other documents reviewed in terms of highlighting the scale of challenge for transport decarbonisation and the range and pace of change by a range of stakeholders required to achieve it. |

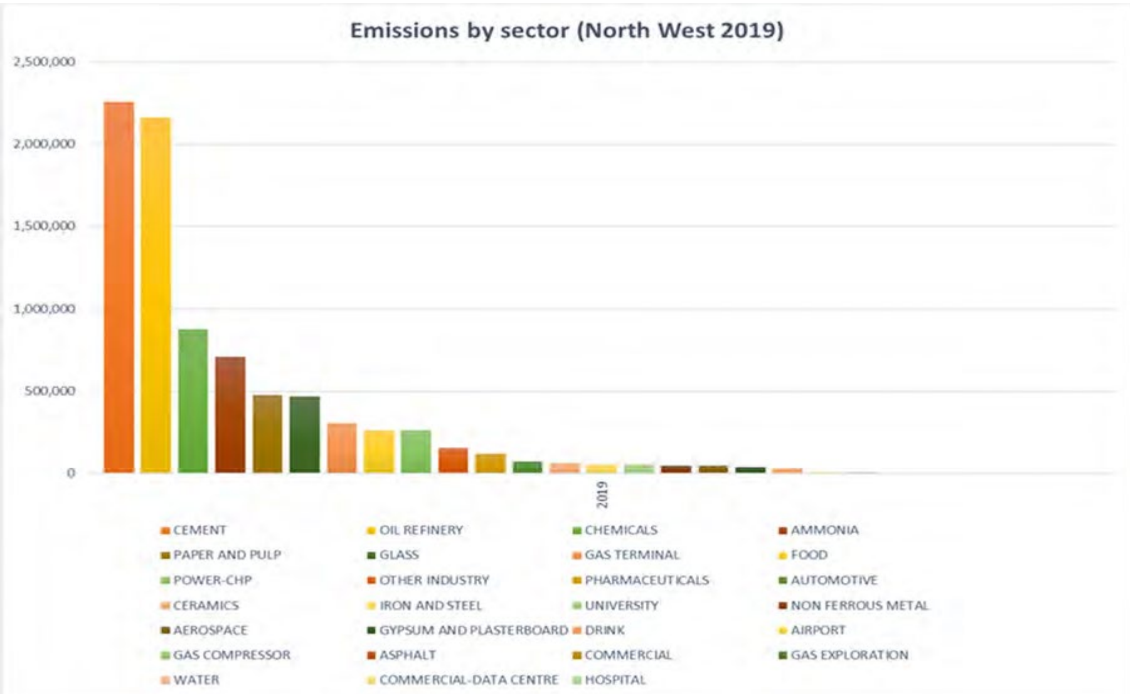
| Document | Key Objectives / Targets / Policy | Implications for study |
|---|---|---|
| | •Carbon reduction when projects are built, as well as carbon capture<br><br>•How Transport for the North's four Future Travel Scenarios could present challenges and opportunities for decarbonising transport<br><br>The final Decarbonisation Strategy will be adopted by the TfN Board in Autumn 2021 and will be submitted to the Government as statutory advice on behalf of the region. It will then form the blueprint for green transport investment in the North for the coming decades. | |
| **Industry reports** | | |
| Electricity North West – Net Zero Plan (2020)<br><br>Link to policy document | Proposed pathway to a decarbonised grid produced by ENWL, Cadent and Navigant, with a focus on centralised energy infrastructure.<br><br>Total energy demand is expected to fall in Lancashire from 34.5TWh in 2018 to 22TWh in 2050 on the back of expected improvements in energy efficiency.<br><br>Greater demand in electricity since road transport will be largely electrified (with a role for hydrogen and biomethane). Buildings will switch to new heating technologies including hybrid heating systems (54% of all dwellings), hydrogen boilers (24%) and all-electric heat pumps (18%).<br><br>Given significant renewable potential, Lancashire will be able to locally generate over half of the electricity it requires. The report claims that grid distribution level is the most appropriate scale for this generation. Onshore wind could generate 4.5TWh p.a. by 2050; it also claims there will need to be 5.9TWh of National Grid imports, which cuts against its claim. It does not mention potential for local scale renewable production.<br><br>Abundant low-carbon electricity can also be used for local production of green hydrogen.<br><br>The report concludes in its 'Balanced Scenario' that Lancashire will be a net importer of both electricity and hydrogen by 2050. See Figure A-2 below.<br><br>Call for the need for urgent coordinated action between multiple parties to deliver net zero energy systems, with a clear long-term strategy. | Business as Usual assessment:<br>• The projected growth rate of net dwellings in Lancashire is around 9% over the period 2018-2050<br>• The document refers to UK-wide changes in number of trips to 2050, and fleet composition, but nothing that couldn't be gleaned from BEIS/DfT.<br>• Total energy demand from industry is expected to fall from 4.1TWh in 2018 to 2.8TWh by 2050. Given the relatively low heat intensity of Lancashire industry, the role of electricity will increase substantially from 25% to 70% over this period.<br>• The regional economy (measured in GVA) is expected to increase by 0.8% per annum until 2033.<br>• *Note that the report was produced before the UK Government announcement in December to ban petrol/diesel vehicles by 2030.*<br>Net Zero Pathways assessment:<br>• To accommodate low-carbon heating technologies the energy efficiency of the existing building stock will have to be improved – 54% of buildings will need to undergo 'moderate' upgrades (e.g. install high-performance glazing or improve loft insulation), whilst 18% will have to see "extensive" upgrades (e.g. underfloor insulation and heating or solid wall insulation cladding).<br>Residual removals:<br>*No mention.* |

| Document | Key Objectives / Targets / Policy | Implications for study |
|---|---|---|
| | High-level roadmap included on page 11, which calls for detailed planning of hydrogen network by 2030 and expansion of the HyNet network to Lancashire within 2030-40. | |
| Electricity North West – Leading the North West to Zero Carbon<br>(year not stated)<br>Link to document | The document sets out ENWL's vision and its role as the District Network Operator (DNO) to the county/region. At a time when the distribution of electricity is becoming more complex – with storage, demand-side response and decentralised generation all factors to balance the grid – ENWL aims to achieve a 10% year-on-year emissions reduction target while investing in a smart grid that delivers reliably for the future.<br>The report claims that ENWL will invest £63.5m within four years towards achieving zero carbon emissions, including to reduce network emissions as far as possible by 2038. | Business as Usual assessment:<br>• ENWL currently emits 21ktCO2 per year.<br>Net Zero Pathways assessment:<br>• ENWL has a carbon budget of 148.5ktCO2 until 2038 and aims to achieve an annual 10% reduction.<br>• It has identified measures that will save 27.4ktCO2<br>• ENWL anticipates that renewable energy of 7.9GW will be connected to the grid by 2050 (triple today's supply) compared to a regional demand of up 4.4-7.7GW.<br>• ENWL anticipates over a third of domestic customers adopt a heat pump before 2040 to achieve the early decarbonisation of the heating sector<br>Residual removals:<br>As well as investigating how to reduce network losses, ENWL also refers to research into novel ways of off-setting these losses; this may refer to sequestering carbon, but no detail is provided. |
| Cadent Hydrogen Ten Point Plan<br>Link to document | This document outlines Cadent's long-term commitment to decarbonise homes and businesses and sets out 10 points and targets related to hydrogen | Net Zero Pathways:<br>• Hydrogen ready appliances to begin being installed by 2026 or earlier.<br>• Cadent aims to enable 5GW of hydrogen production in the region by 2030. |
| Cadent Gas Safety and Sustainability Strategy (2019/20)<br>Link to document | This is the full sustainability report for all of Cadent, operating across four regions in the UK. We have included nationwide commitments only where they might have relevance for the region, then analysed the northwest in detail.<br><br>In 2019/20 Cadent reduced its emissions by 5.5% year-on-year, and 17% from 2013/14. Cadent is switching its own HGV distribution fleet over to natural gas, which it claims will reduce its GHG emissions by 500 tonnes per year. It is also supporting greater adoption of low emissions/hybrid vehicles. | Business as Usual assessment:<br>• *No mention.*<br>Net Zero Pathways assessment:<br>• Cadent emphasises the opportunity of biomethane and hydrogen networks. It cannot effect change by itself, but is working in partnership with industry bodies to present its position to Government.<br>• It has progressed its bio-CNG refuelling infrastructure, adding nine public access stations connected to its national network with a further three under development. |

| Document | Key Objectives / Targets / Policy | Implications for study |
|---|---|---|
| | It has converted large portions of its delivery network over to polyethylene from metallic pipe since 2013/14 (over 11,000km), which has driven 295,000 tCO2 per year. | • Cadent states that its overarching goal is to reduce its emissions to net zero by 2050, but it doesn't explicitly state whether this applies to its business operations or to all of its network.<br>• It is working to decarbonise its First Call Operative fleet, (~1,100 vehicles), to deliver 4,000 tCO2e emissions savings per year by 2026.<br>• It refers to its most important emissions reduction activity as the mains replacement programme.<br>Residual removals:<br>*No mention.* |

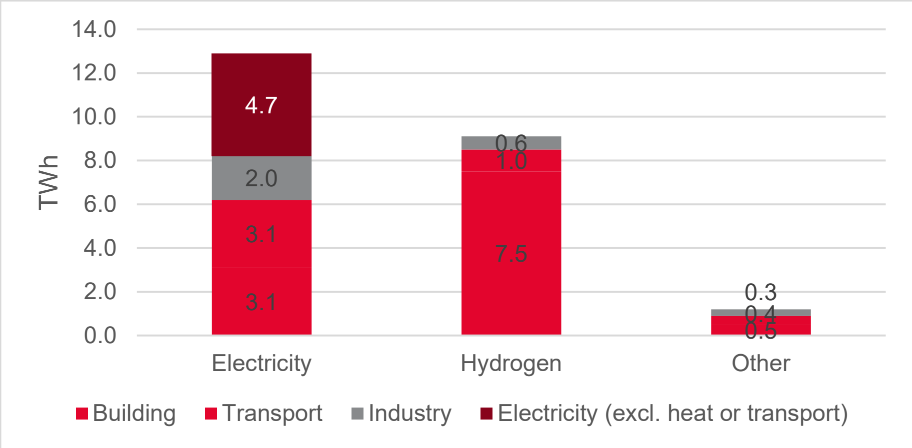
Supporting graphics referred to in the table are laid out below.

**Figure A-1 - Emissions by sector within NW Cluster, 2019**




Source: Industrial Cluster Research Phase 1 – Progressive Energy

**Figure A-2 - Projected energy demand in Lancashire, 2050**




Note: Other' includes biomass, bio-LPG, biomethane, etc.

Source: Adapted from Energy North West Limited, 2050 Lancashire Balanced Scenario.

**Table A-3 - Local Net Zero policy review**

| Authority | Net Zero Commitments | Work to Date |
|---|---|---|
| Burnley | • July 2019 – declared climate emergency<br>• "Make the Borough of Burnley carbon neutral by 2030, taking into account both production and consumption emissions (scope 1,2 and3)"<br>Link to commitment | • Encourage eco-friendly transport<br>• Park service vehicles replaced by electric from diesel<br>• Electric bikes for internal couriers<br>• Planted more than 1M trees over last 25 years<br>• Installing 8 EV charge points<br>Link to commitment |
| Chorley | • November 2019 – declared climate emergency<br>Link to commitment<br>• Intention to pursue NZ by 2030, awaiting roadmap and requested devolved powers from government to deliver this | Feb 20:<br>• Council building retrofit – LEDs, PIRs<br>• EV charge points in town centre<br>• Home energy efficiency service supporting resident with tariff switching and working with partners to provide boiler/insulation improvements<br>• Tree and wildflower planting<br>• Neighbourhood officers using EVs<br>• Sustainable travel incentives and recycling facilities for staff<br>• Committed to:<br>Quantify and reduce GHG emissions through own action. Then compensate remainder using certified emissions reductions.<br>Link to commitment |
| Hyndburn | • September 2019 – declared climate emergency<br>• Target for net zero by 2030 for council activities:<br>Link to commitment | • Green electricity tariff<br>• Zero carbon emission electric lifters on refuse vehicles<br>• Supporting greening of taxi fleet<br>• Working on Lancashire woodland campaign, woodland creation and other habitat enhancement |
| Lancaster | • Jan 2019 – declared climate emergency<br>• Target for NZ by 2030 for council activities<br>Link to commitment | • Gained funding for EV charge points for taxis<br>• Wildflower corridors<br>• Pledged 1M trees for Northern Forest project<br>• PV on sheltered housing schemes<br>• 14 EV vans procured for repairs and maintenance department<br>• Secured £6.8M funding for solar farm to power Salt Ayre leisure centre<br>• Approved action plan for NZ by 2030:<br>Link to commitment |
| Preston | • Declared climate emergency April 2019<br>• NZ of council activities by 2030<br>Link to commitment | • New building must be constructed to reach energy efficiency standards set out in Code for Sustainable Homes and BREEAM<br>• Lancashire County Council district renewable energy study – wind and micro-generation as main sources. 6% of county renewable capacity could be within Preston |
| Ribble Valley | • Carbon Neutral Borough by 2030<br>Link to commitment | • Increased plastic household waste collection to include pots, tubs and trays |

| Authority | Net Zero Commitments | Work to Date |
|---|---|---|
| | | • Shortly installing EV charge points in car parks and working to increase rail services to Clitheroe and Manchester<br>Link to source |
| South Ribble | • July 2019 declared climate emergency<br>• Carbon neutral borough by 2030<br>Link to commitment | • Climate Change Strategy, including carbon baseline and scenarios<br>Link to commitment |
| West Lancashire | • July 2019 declared climate emergency<br>• Council operations to be carbon neutral by 2030<br>Link to commitment | • EV trial in fleet, public EV charge points in council car parks<br>• LED retrofit in offices<br>• Energy efficiency measures on housing stock – insulation heating upgrades etc<br>• Renewable energy tariff<br>• Participation in Lancashire woodland connect project<br>• Waste and recycling promotions officer hired<br>Link to commitment |
| Fylde | No climate emergency or net zero target | • PIR-controlled LED lighting within the town hall as well as double glazing and insulation<br>• Stopped ordering single use plastic items and introduced office recycling bins<br>• Cycle to work scheme and bike facilities at town hall<br>Link to commitment |
| Pendle | • July 2019 declared climate emergency<br>• “Pendle council and its arms-length bodies carbon neutral by 2030 and for working for Pendle as a whole to be carbon neutral by 2030”<br><br>Policy and Resources Committee, 19th March 2020 | • Changing entire 44-vehicle fleet to lower emission equivalent<br>• PV on some buildings<br>• Reduced carbon emissions by 5%<br>• Renewable energy tariff<br>Link to commitment |
| Rossendale | • Declared climate emergency in September 2019<br>• Net-zero council activities by 2030<br><br>Rossendale Climate Change Strategy and Action Plan 2020-2030 | • PV on Futures Park offices<br>• Constructing EV charge points for taxis<br><br>Rossendale Climate Change Strategy and Action Plan 2020-2030 |
| Wyre | • Declared climate emergency July 2019<br>• Council’s activities net zero by 2050<br>Link to commitment | • Refused collection vehicles with electric bin lifts<br>• 2 hybrid vehicles to council’s fleet<br>• LED retrofit at Fleetwood Market<br>Link to source |
| Blackburn | • July 2019 declared climate emergency<br>• Borough carbon neutral by 2030<br>Link to commitment | • part of Cosy Homes in Lancashire<br>• EV charge points installed in 5 public car parks<br>• Insulation, central heating and new boilers have been installed at vulnerable residents’ properties through government Energy Company Obligation scheme.<br>• LED street lamp retrofit<br>Link to commitment |

| Authority | Net Zero Commitments | Work to Date |
|---|---|---|
| Blackpool | • June 2019 declared climate emergency<br>• Council activities net zero by 2030<br>Link to commitment | • LED retrofit<br>• Boiler replacement<br>• Advanced metering and management systems<br>• Renewables<br>• CHP<br>Link to commitment |

# A.2. Sectoral Net Zero Guidance

## A.2.1. Buildings Sector

### A.2.1.1. UK housing: Fit for the future? Committee on Climate Change, February 2019

The key message from the CCC report is that “UK homes are not fit for the future”. Greenhouse gas emission reductions from UK housing have stalled, and efforts to adapt the housing stock for higher temperatures, flooding and water scarcity are falling far behind the increase in risk from the changing climate. The quality, design and use of homes across the UK must be improved now to address the challenges of climate change. Doing so will also improve health, wellbeing and comfort, including for vulnerable groups such as the elderly and those living with chronic illnesses.

The report identified the following priorities for government action in relation to new homes:

#### Performance and compliance

The way new homes are built, and existing homes retrofitted often falls short of design standards. This is unacceptable. In the long run, consumers pay a heavy price for poor-quality build and retrofit. Greater levels of inspection and stricter enforcement of building standards are required, alongside stiffer penalties for non-compliance. The 'as-built' performance of homes, for example how thermally efficient they are, must also be better monitored. Closing the energy use performance gap in new homes (the difference between how they are designed and how they actually perform) could save between £70 and £260 in energy bills per household per year.

#### Skills gap

The chopping and changing of UK Government policy has inhibited skills development in housing design, construction and in the installation of new measures. Key steps for the UK in reducing emissions, like the wider deployment of heat pumps, require new skills. The UK Government should use initiatives under the Construction Sector Deal to tackle this low-carbon skills gap. New support to train designers, builders and installers is needed for low-carbon heating, energy and water efficiency, ventilation and thermal comfort, and property-level flood resilience.

#### Building new homes

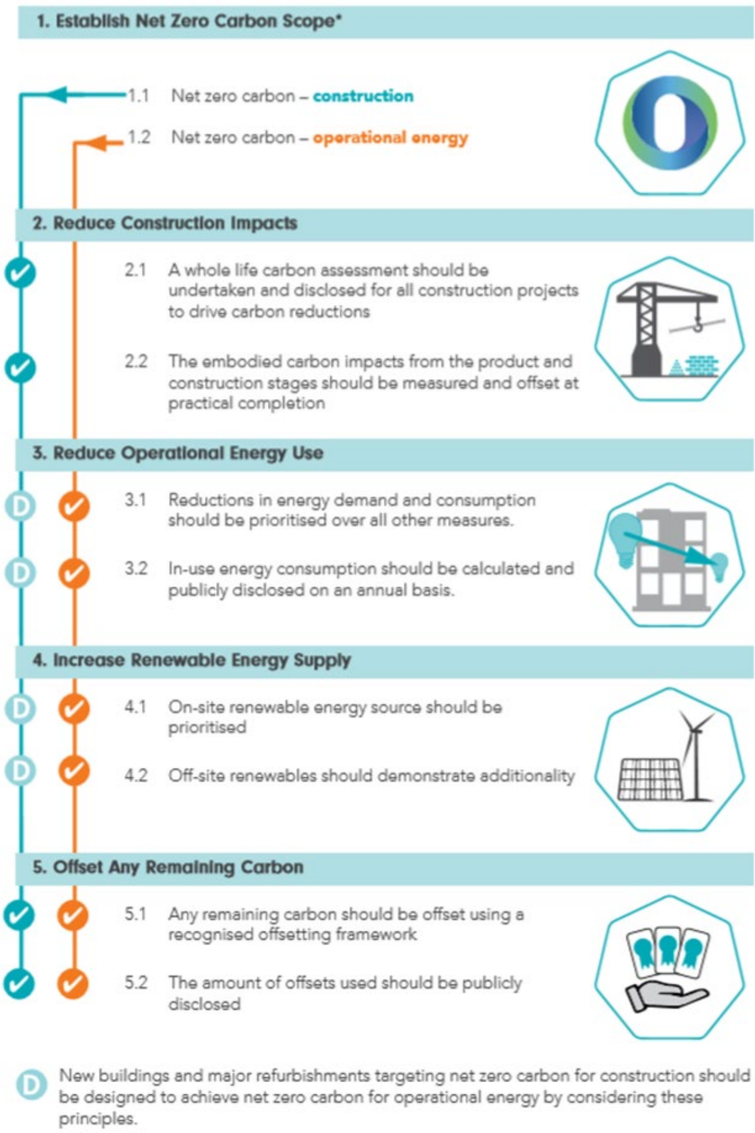
There are plans for 1.5 million new UK homes by 2022. These new homes must be built to be low-carbon, energy and water efficient and climate resilient. The costs of building to a specification that achieves the aims set out in this report are not prohibitive and getting design right from the outset is vastly cheaper than forcing retrofit later. From 2025 at the latest, no new homes should be connected to the gas grid. They should instead be heated through low carbon sources, have ultra-high levels of energy efficiency alongside appropriate ventilation and, where possible, be timber-framed. A statutory requirement for reducing overheating risks in new builds is needed, alongside more ambitious water efficiency standards, property-level flood protection in flood risk areas, and increasing requirements for greenspace and sustainable transport in planning and guidance.

#### Finance and funding

There are urgent funding needs which must be addressed now with the support of HM Treasury: low-carbon heating (only funded up to 2021), and resources for local authorities, in particular building control. The UK Government must implement the Green Finance Taskforce recommendations around green mortgages, green loans and fiscal incentives to help finance upfront costs, as well as improve consumer access to data and advice. It should widen the scope of these measures to include resilience.

### A.2.1.2. UK Green Building Council Framework for Net Zero Buildings, 2019

**Figure A-3 - Net Zero framework for Government Property Agency**




The UK Green Building Council (UKGBC) developed a framework definition for net zero carbon buildings in 2019. The primary focus of the framework is to set in place a path to achieve net zero carbon buildings in both construction and operation (in-use energy consumption) while also beginning to provide direction for addressing whole life carbon in the industry. The framework sets out definitions and principles around two approaches to net zero carbon which are of equal importance:

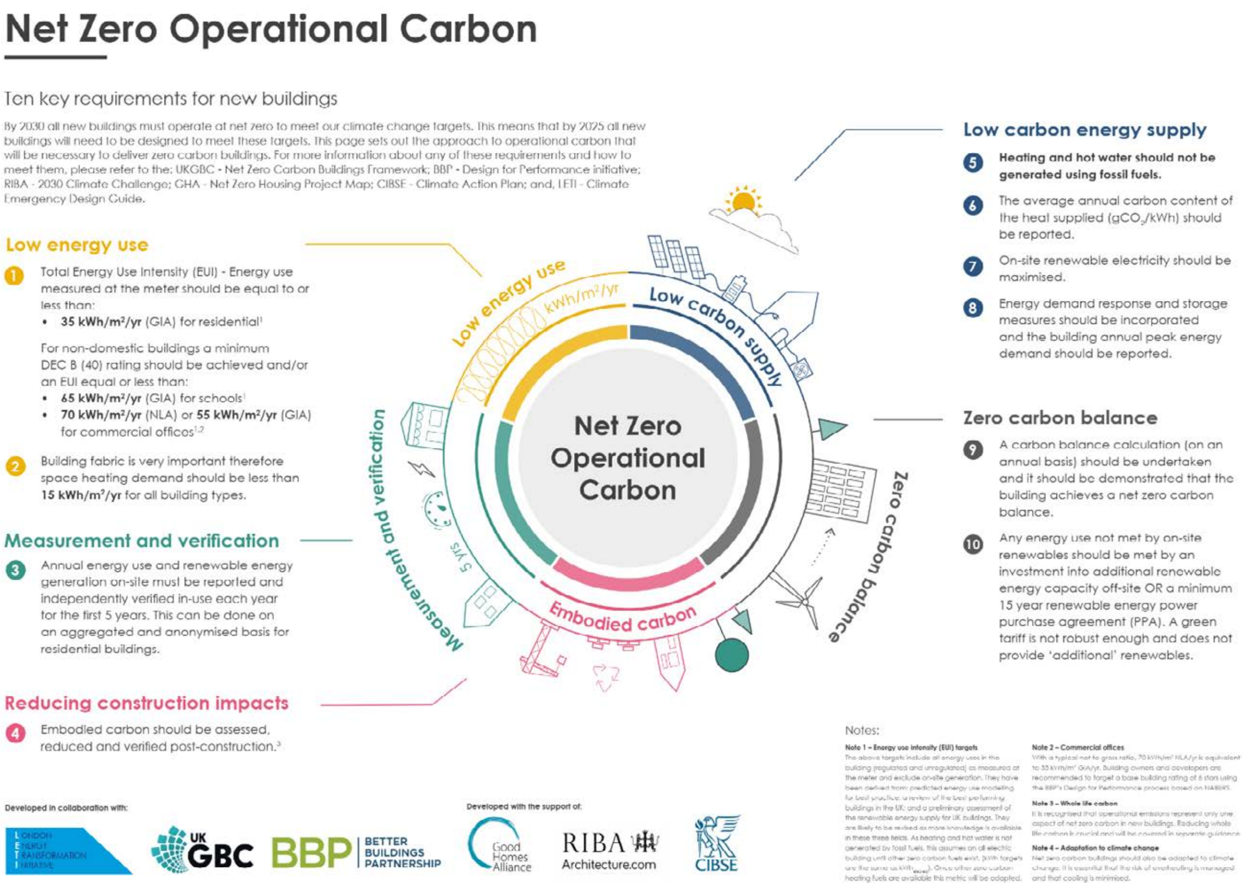
**Net zero carbon for construction** - “When the amount of carbon emissions associated with a building’s product and construction stages up to practical completion is zero or negative, through the use of offsets or the net export of on-site renewable energy.”

**Net zero carbon for operational energy** - “When the amount of carbon emissions associated with the building’s operational energy on an annual basis is zero or negative. A net zero carbon building is highly energy efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset.”

The framework outlines where the principles should be followed to demonstrate alignment with net zero carbon for both construction and operational energy across five key steps. All new buildings should target net zero carbon for both construction and operational energy by considering these principles and following the steps to achieve a net zero carbon building.

## A.2.1.3. London Energy Transformation Initiative – Net Zero 1-Pager, 2019

**Figure A-4 - LETI buildings requirements**




The Net Zero Operational Carbon one-pager, launched by the London Energy Transformation Initiative (LETI) in 2019 builds on the UKGBC's Net Zero Carbon Buildings framework definition to provide developers, designers and policy makers with a common reference point on the 10 key requirements for new buildings to achieve net zero carbon in operation. It addresses the operational energy of a building when in-use, including energy intensity targets for different building types and the requirement to demonstrate a net zero carbon balance. The one-pager is a result of a successful industry consultation with more than 330 responses and has been developed in collaboration with the London Energy Transformation Initiative (LETI) and the Better Building Partnership (BBP), and with support from the Good Homes Alliance (GHA), the Royal Institute of British Architects (RIBA) and the Chartered Institution of Building Services Engineers (CIBSE).

Building on this one-pager and the net zero framework, LETI has released two guidance documents to provide designers with practical guidance on how to design and deliver net zero new buildings:

- Climate Emergency Design Guide
- Embodied Carbon Primer

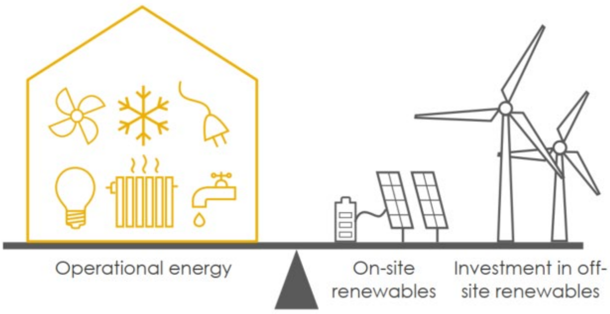
### A.2.1.4. LETI Climate Emergency Design Guide & LETI Embodied Carbon Primer, 2019

The Climate Emergency Design Guide (CEDG) notes that in the UK, 49% of annual carbon emissions are attributable to buildings. The ambition of the Design Guide is to help achieve a target of all new buildings operating at net zero carbon by 2030, while all buildings must operate at net zero carbon by 2050.

Net Zero carbon in buildings (homes and workplaces) needs to be considered in the context of whole life carbon. Whole life carbon includes operational and embodied carbon. The UKGBC is expected to publish further guidance related to whole life carbon to define the scope and requirements for this approach.

**Operational carbon** is directly linked to the energy consumed by a building associated with heating, hot water, cooling, ventilation, and lighting systems, as well as equipment such as fridges, washing machines, TVs, computers, lifts, and cooking (i.e. both regulated and unregulated energy uses). A new building with net zero operational carbon does not burn fossil fuels, is 100% powered by renewable energy and achieves a level of energy performance in-use in line with national climate change targets. This means that an operational carbon balance is met without the need for carbon offsets.

**Figure A-5 - Net Zero balance at a building level**




**Embodied carbon** refers to the 'upfront' emissions associated with building construction, including the extraction and processing of materials and the energy and water consumption in the production, assembly, and construction of the building. It also includes the 'in-use' stage (the maintenance, replacement, and emissions associated with refrigerant leakage) and the 'end of life' stage (demolition, disassembly, and disposal of any parts of product or building) and any transportation relating to the above. Embodied carbon is a topic that is becoming more relevant and important as operational carbon is reduced. A whole life zero carbon balance for embodied carbon can be achieved through carbon offsetting.

A building that is whole life Net Zero carbon meets the operational zero carbon balance and is 100% circular, this means that 100% of its materials and products are made up of re-used materials and the building is designed for disassembly such that 100% of its materials and products can be re-used in future buildings. When construction, transport and disassembly is carried out with renewable energy there will be zero carbon emissions associated with the embodied carbon. This should be the ultimate objective for any new building.

Reaching Net Zero targets will require setting out and following a zero-carbon trajectory. A Zero Carbon Trajectory is set out in the CEDG to illustrate the key milestones that must be achieved in order to ensure that the UK will have a zero-carbon built environment by 2050. Key milestones along such a trajectory would include consideration of elements such as:

**Table A-4 - Government intervention roadmap, 2020-30**

| Area of intervention | 2020-2025 | 2030 |
|---|---|---|
| **Operational energy** | Update UK Building Regulations to signpost transition to mandatory verification of in-use energy consumption and adoption of targets.<br>Introduction of regulatory performance framework<br>All new buildings designed to be net zero operational carbon | All new buildings to operate at net zero operational carbon |
| **Embodied carbon** | All buildings to conduct whole life carbon calculation and aim to achieve 40% CO2 reductions<br>Benchmarks and methodology to be establish and regulation introduced | All new buildings achieve a 65% reduction in embodied carbon emissions |

| Area of intervention | 2020-2025 | 2030 |
|---|---|---|
| **Future of heat** | All new buildings are fossil fuel free | |
| **Demand Response** | Metrics established<br>Policy to mandate minimum requirements for metrics | |
| **Data Disclosure** | All new buildings to disclose energy use data | |

Table A-4 above shows the urgency to take action within the next five years to ensure that the 2030 targets for operational energy and embodied carbon are achieved.

The Climate Emergency Design Guide focuses on four building archetypes of small-scale housing; medium and large-scale housing; commercial offices and schools. Indicative design measures and targets are set out for each type.

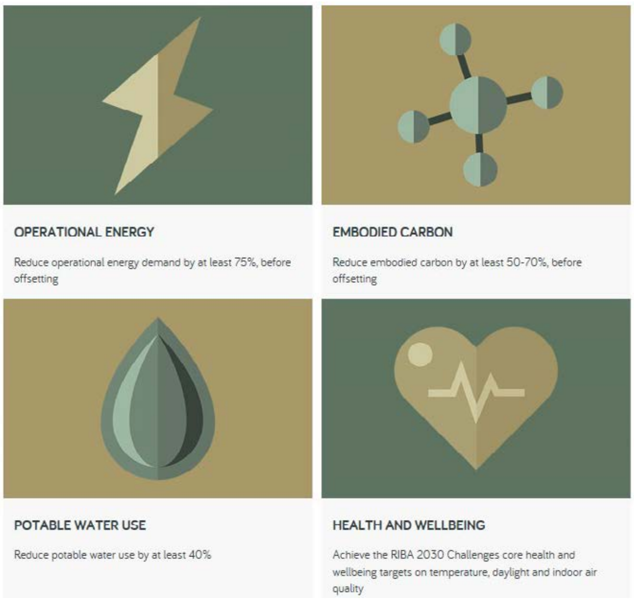
When considering these targets in context of the Welsh Building Regulations, the domestic U-values recommended by LETI are not too dissimilar to the 2020 proposed Part L, and almost identical to the 2025 proposed values. It's instructive to note the disparity in the airtightness target, although the SAP predicted heating consumption of a building to the Option 2 2020 standards is much the same as that proposed by LETI (15 kWh/m$^2$.annum). It should be noted that LETI considers a much wider scope of energy use than the traditional building regulations approach.

The LETI Embodied Carbon Primer provides supplementary guidance to the Climate Emergency Design Guide for those interested in exploring embodied carbon in more detail, including how to undertake Life Cycle Assessment (LCA) calculations. The document intends to provide designers with easy-to-follow, best practice and toolkits for reducing embodied carbon in buildings. It should be noted that emerging knowledge in the field of embodied carbon is rapidly evolving and therefore the guidance should always be read in conjunction with the latest guidance and technical toolkits including those available from the UKGBC, Royal Institution of Chartered Surveyors (RICS), Chartered Institution of Building Services Engineers (CIBSE) and the Royal Institute of British Architects (RIBA).

### A.2.1.5. RIBA 2030 Climate Challenge, 2019

In 2019, the RIBA Council voted to join the global declaration of an environment and climate emergency. To ensure that the declaration is matched by actions, RIBA has set Chartered Practices a challenge of achieving the following reductions as soon as possible:

**Figure A-6 - RIBA sustainable outcomes**




These reductions will also form the basis of RIBA's recommendations to the Government for future Building Regulations requirements. The targets have been developed for operational energy use, embodied carbon and water use reduction which take into account the latest recommendations from the Green Construction Board and have been developed by RIBA in consultation with other UK professional bodies. The targets are based on both domestic and commercial buildings and are set out over a trajectory from current benchmarks to 2030 targets as seen in the figure below.

**Figure A-7 - RIBA 2030 Climate Challenge target metrics for domestic and non-domestic buildings**

RIBA 2030 Climate Challenge target metrics for domestic buildings

| RIBA Sustainable Outcome Metrics | Current Benchmarks | 2020 Targets | 2025 Targets | 2030 Targets | Notes |
|---|---|---|---|---|---|
| Operational Energy $kWh/m^2/y$ | 146 $kWh/m^2/y$ (Ofgem benchmark) | < 105 $kWh/m^2/y$ | < 70 $kWh/m^2/y$ | < 0 to 35 $kWh/m^2/y$ | UKGBC Net Zero Framework 1. Fabric First 2. Efficient services, and low-carbon heat 3. Maximise onsite renewables 4. Minimum offsetting using UK schemes (CCC) |
| Embodied Carbon $kgCO_2e/m^2$ | 1000 $kgCO_2e/m^2$ (M4i benchmark) | < 600 $kgCO_2e/m^2$ | < 450 $kgCO_2e/m^2$ | < 300 $kgCO_2e/m^2$ | RICS Whole Life Carbon (A-C) 1. Whole Life Carbon Analysis 2. Using circular economy Strategies 3. Minimum offsetting using UK schemes (CCC) |
| Potable Water Use Litres/person/day | 125 l/p/day (Building Regulations England and Wales) | < 110 l/p/day | < 95 l/p/day | < 75 l/p/day | CIBSE Guide G |

RIBA 2030 Climate Challenge target metrics for non-domestic buildings

| RIBA Sustainable Outcome Metrics | Current Benchmarks | 2020 Targets | 2025 Targets | 2030 Targets | Notes |
|---|---|---|---|---|---|
| Operational Energy $kWh/m^2/y$ | 225 $kWh/m^2/y$ DEC D rated (CIBSE TM46 benchmark) | < 170 $kWh/m^2/y$ DEC C rating | < 110 $kWh/m^2/y$ DEC B rating | < 0 to 55 $kWh/m^2/y$ DEC A rating | UKGBC Net Zero Framework 1. Fabric First 2. Efficient services, and low-carbon heat 3. Maximise onsite renewables 4. Minimum offsetting using UK schemes (CCC) |
| Embodied Carbon $kgCO_2e/m^2$ | 1100 $kgCO_2e/m^2$ (M4i benchmark) | < 800 $kgCO_2e/m^2$ | < 650 $kgCO_2e/m^2$ | < 500 $kgCO_2e/m^2$ | RICS Whole Life Carbon (A-C) 1. Whole Life Carbon Analysis 2. Using circular economy Strategies 3. Minimum offsetting using UK schemes (CCC) |
| Potable Water Use Litres/person/day | >16 l/p/day (CIRA W11 benchmark) | < 16 l/p/day | < 13 l/p/day | < 10 l/p/day | CIBSE Guide G |

All new developments should seek to meet and where possible exceed these targets aligning with the interim targets to ensure that the 2030 net zero targets can be achieved.

## A.2.2. Transport Sector

### A.2.2.1. How to decarbonise European transport by 2050, Transport and Environment, 2018

By summarising a series of studies by Transport & Environment, the reports explains how the European transport sector can ("and must" decarbonise by 2050 to support climate and health challenges.

In 2017, transport accounted for 27% of Europe's greenhouse gas emissions, making it one of the continents largest climate issues and causing hundreds of thousands of premature deaths – all the while the EU spends over 200 billion per annum to import oil for transportation.

Well-documented policies for reducing the demand for transport are important in the journey to net zero, but for complete decarbonisation all transport vehicles will be required to run on zero emission energy. The report, "as well as many other reports", believes that electricity (through batteries and fuel cells)is the only energy vector capable of delivering this at scale. Thus, decarbonising the power sector is required too.

Unless the amount of low carbon electricity generation can be scaled up exponentially, the need to minimise energy demand and improve existing energy efficiency is essential.

Hydrogen and synthetic fuels are proposed to be used throughout shipping and aviation, but this cannot be rolled out across all other modes of transport due to the amount of clean electricity that would be required to deliver this. Initiatives such as carbon pricing can be used to drive the fuel switch. Synthetic kerosene for aviation will likely be more expensive in the short term, potentially reaching cost parity by 2050 and will likely lead to tickets being 23% more expensive. Battery powered ships offer an immediate option for short-haul voyages.

Accelerating action after 2030 makes achieving net zero by 2050 very challenging and risks raising global warming to 2C, instead of 1.5C.

By 2035, the last internal combustion engine needs to have been sold. Zero emission fleets can be achieved through the use of batteries and fuel cell cars, although the latter will require even greater amounts of zero emission electricity. To supplement a zero-emission fleet, higher fuel taxes and road charges, combined with car-sharing and using alternative transport modes will also reduce the number of cars on the road, aiding congestion and enhancing cities. Especially for trucks and buses, progressive policy will be required to make the change to zero emission vehicles.

Ambitious policies across the board and a holistic approach are essential to realise a decarbonised transport sector by 2050.

### A.2.2.2. Transport and Climate Change, Global Status Report, SLOCAT (Partnership on Sustainable, Low Carbon Transport)

In contribution to the Beyond 2C scenario target, the report considers transport emission trends, emission drivers, mitigation potential, policy responses and transport's overall contribution.

#### Transport and Climate Change Findings

Transport emissions are increasing in various regions and sub-sectors:

- Direct emissions from carbon dioxide in the transportation sector contributed 14% of global greenhouse gas emissions in 2014, having risen 29% (from 5.8 to 7.5 gigatonnes). Light duty vehicles contributed the most to this, at 45% of the total, followed by trucks at 21%.
- After power and industry, transport is the third-highest emitter of carbon dioxide.

Growth in Transport Activity and Demand is Driving an Increase in Transport Emissions:

- By 2017, the global population had reached 7.5 billion people, having frown by 1.4 billion from 2000 to 2017. 82% of the increase arose from middle and low-income countries, with China and India contributing 30% of this increase alone. Population growth is driving an increase in demand for transport;
- As global GDP and transport emissions have averaged 2.7% and 1.1% respectively since 2008, there are signs showing the potential to decouple transport emissions from rising income;
- Passenger transport energy intensity has fallen by 27% from 2005 to 2015;
- In OECD countries, public transport passenger activity has been stable (and not risen despite strategic policies and investment) since 2000;
- Global freight activity increased 108 trillion tonne-km in 2015;
- From 200 to 2015, air passenger-km increased 145% - the vast majority of this growth coming from Non-OECD countries.

Transport has the potential to make significant contribution to Paris Agreement Targets:

- IPCC reports show that 1.5C is possible, but with unprecedented changes;
- Transport emissions would be limited to 2-3 gigatonnes in 2050 to meet the Paris Agreement;
- Through stringent policy reducing the need for transport trips, encouraging modal shifts and improved vehicle efficiency with low carbon technologies, a 1.5C scenario pathway is possible.

Countries and cities are formulating initial plans to reduce transport emissions and to increase resilience of transport systems:

- Avoid-Shift-Improve Framework:
    - Avoid – passenger trips and freight movement (or reduce distance);
    - Shift – to more environmentally/social-friendly modes of transport e.g. public transport;
    - Improve – energy efficiency of transport modes through low carbon technologies.

Transport plans and actions to date are insufficient to make a proportional contribution to the well-below-2-degree Celsius scenario:

- The main shortfalls are:
    - Insufficient technological progress;
    - High proportion of private motorized private travel in OECD countries;
    - Rising urbanisation and motorisation across Asia and Africa;
    - Passenger travel in non-OECD countries.

## Transport and Climate Change Trends and Developments

Technology is Playing an increasing role in low carbon transport plans and targets from countries, states and provinces, cities and companies:

- Enhancing fuel economy and vehicle standards are crucial for reducing transport emissions;
- Improved battery capacity, reduced costs and supportive policies are accelerating electric mobility uptake;
- In 2017, e-bike sales outnumbered EV sales by 30:1 with approximately 32 million sold worldwide (majority share in Europe and China);
- Electric buses are playing an increasing role. In 2017, 375,000 e-buses were in operation, with 98% in China;
- Across non-electrified lines, fuel cell trains are beginning to replace diesels.

Transport is playing a more central role in global processes on climate change and sustainable development, but holistic solutions are still needed:

- In 2015, the UN adopted the 17 Sustainable Development Goals
- In 2017, launched Marrakech Partnership on Global Climate Action

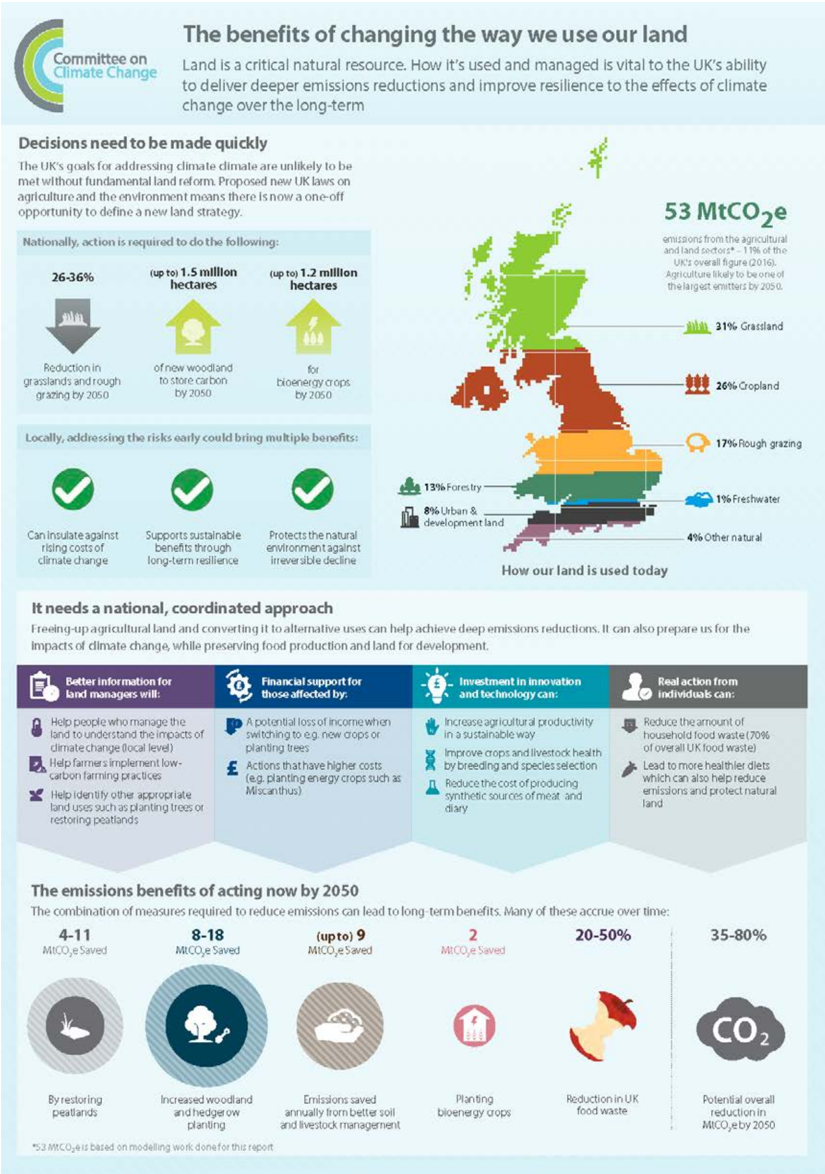
Political and corporate leadership on transport and climate change is growing in scope and intensity, within and outside of global agreements:

- No major breakthroughs in financing for low-carbon transport in 2017.
- Adaption in the transport sector continues to lag behind mitigation action.

# A.2.3. Agriculture and LULUCF Sector

## A.2.3.1. Land use: Reducing emissions and preparing for climate change, CCC 2018

**Figure A-8 - Committee on Climate Change land use decision framework**




The report by the Committee on Climate Change's 'Land use: Reducing emissions and preparing for climate change'[2], published in 2018, identifies areas where land-use and land management changes can enable land-owners to deliver climate change mitigation and adaptation objectives. The report also provides examples on how land can be used to deliver higher emissions reductions, covering greater use of low-carbon intensive farming practices and releasing agricultural land for carbon reduction by converting them to alternative uses.

[2] Land use: Reducing emissions and preparing for climate change - Climate Change Committee (theccc.org.uk).

# A.3. Selection of Case studies

## A.3.1. Net Zero development

### Parc Hadau (Pontardawe, Wales)

- One of the world's first net zero carbon neighbourhood by developer Sero Homes
- First scheme to meet UK Green Building Council definition of net zero by tracking the development's energy use and carbon emissions in real time
- 35 new sustainable homes (11 two-bed, 22 three-bed, 2 four-bed homes)
- Developer offering the properties on affordable long term index linked leases with no large deposits needed
- Residents will pay no energy bills because development will use a mixture of renewable technologies to power their homes over the year (solar panels and energy storing batteries, ground source heat pumps and innovative ventilation systems)
- To be completed April 2021

### Zero-carbon housing project in Oxfordshire

Springfield Meadows is a project of 25 zero-carbon homes by Greencore Construction, located in Southmoor, Oxfordshire.

They are high-performance and low-carbon living homes, using the Biond system which is an off-site manufactured, closed panel timber frame construction, insulated with Lime-Hemp and natural fibre insulation.

- Built to passivhaus standards.
- Zero embodied carbon.
- Net-zero energy and carbon in use.
- Second phase is 'Climate Positive' – locking up more carbon than emitted and generating more energy than used – thanks to bio-based materials, photovoltaic panels, and energy sourced from a green provider.
- Elimination of gas utilities to create an all electric development.

https://www.oxfordshirelep.com/news/article/zero-carbon-housing-project-named-oxfordshire%E2%80%99s-greenest

Deemed exemplary in the Built Environment & Communities category of Energy Pathfinders: 2050 (EP:50) a new competition run by Oxfordshire Greentech and the Oxfordshire Local Enterprise Partnership (OxLEP) to identify and showcase the county's leading carbon reduction initiatives.

## A.3.2. Housing

### A.3.2.1. Goldsmith Street, Norwich – Norwich City Council (council funded)

This development (approximately 100 residential units) is one of the largest Passivhaus schemes in the UK and comprises a design based on a traditional urban layout of a series of seven terrace blocks arranged in four lines. As noted by RIBA, the architects were able to convince the planners to accept a narrow 14m between blocks – effectively the street width – through a careful design of windows to minimise overlooking, and a very thoughtful asymmetric roof profile that allows good sunlight and daylight into the streets. The result is a very dense development, but one that is in no way oppressive. To be certified Passivhaus, the windows had to be smaller than the proportion in a Georgian or Victorian terrace, so the architects have used a set-back panel around the windows to give an enlarged feel, and panels of textured brick have been introduced into the main elevations.

Provision for parking has been pushed to the perimeter, so the streets feel safe and 'owned' by pedestrians rather than cars. Bin stores have been thoughtfully used in the front gardens to create buffer zones between the public footpath and the front doors, giving a humane gradation of public to private territory. The 'back street' has gardens and a pathway down the centre that has been fully landscaped, although the path takes a wavy course that stops the sense of a 'back alley' and gives a welcome curving foil to an otherwise rectilinear scheme.

Tenants get impressively high specification interiors – in both the end-of-terrace flats and the central terrace houses. Passivhaus detailing has nicely accommodated the mechanical ventilation Heat Recovery (MVHR) units in the interiors, and the services intakes have been intelligently controlled. Each dwelling has a range of providers' services pre-wired, so that they can be connected on demand, without the need for a service provider to come in later and drill through vital vapour barrier lines.

Bringing the reduced energy consumption associated with Passivhaus to mass housing was recognised as a great achievement, and one that has taken a large amount of effort and care by the architects, resulting in a number of national awards for this development including RIBA East Award 2019, RIBA East Client of the Year 2019 for Norwich City Council, RIBA East Sustainability Award 2019, RIBA National Award 2019, Neave Brown Award for Housing 2019 and RIBA Stirling Prize 2019.


### A.3.2.2. Agar Grove, London Borough of Camden

Agar Grove is the largest of Camden Council's community investment projects. Completed in April 2018, Phase 1a of the Agar Grove masterplan delivers 38 social rented homes, cross-subsidised by future private sale phases with the budget for the first phase at £9m.When finished, it will provide 493 affordable homes for new and existing tenants, and once complete will be Passivhaus accredited promoting a 'fabric-first' approach to energy performance and human comfort. The masterplan is based upon the traditional concept of 'streets and squares' with an emphasis on buildings which have front doors at street level, creating liveable spaces between them, and allowing people to move across, through and within the site. The overarching desire is to create a place where people want to live and contributes positively to the surrounding area.

The new build Agar Grove homes will be built to achieve Passivhaus certification. This will dramatically reduce the need for space heating and can reduce heating bills by 90% compared with conventional homes.

## Zero Energy Building Catalyst

Innovative programme demonstrating the retrofit of domestic and non-domestic buildings to achieve substantial reductions in energy consumption and carbon emissions. Ran 2017-2-

Project partners: Devon County Council (Lead), Regen, Energiesprong UK, Exeter City Council, North Devon Homes and Sanctuary Housing.

- whole-house retrofit of 15 homes in Devon using the innovative Energiesprong approach– a first for the south west

- support at least 80 enterprises in Devon to engage with new models of delivering whole-house retrofit at scale.

## A.3.3. Transport

### Go Ultra Low West

£7m project that aims to accelerate the purchase of electric vehicles across Bristol, South Gloucestershire, North Somerset and Bath & North East Somerset.

By 2021, there will be four Rapid Electric Vehicle Charging Hubs in the West of England region. These will work similar to petrol stations, but for electric cars. Drivers will be able to recharge their cars in minutes rather than hours.

Working with West of England car club providers to install charging points for electric car club vehicles

Each local authority in the West of England is converting a proportion of their diesel and petrol powered fleet to electric.

### itravelsmart

£4.6 million Local Sustainable Travel Fund (LSTF) programme designed to help Cheshire West and Chester Council target workplaces in the Chester and Ellesmere Port, Deeside, Wrexham, and Merseyside, areas to help attract new job opportunities and make journeys to existing workplaces easier to access.

Promote car sharing to connect people making the same journeys each day

Get more people cycling, walking and using bus and rail

Help the environment by cutting down on carbon emissions

Encourage job opportunities and transport to existing jobs

Improve health by promoting healthy ways to travel

Offer people advice, help, equipment and motivation

Make journeys to work cheaper, quicker, less stressful and easier than before.

### A.3.4. Local communities

## Chelwood Community Energy

Chelwood Solar Farm, a £2.5m and 5MW ground-mounted solar array. Became operational in December 2015.

The array is built on 22 acres of farmland near Chelwood, a village of around 150 residents, located approximately eight miles south of Bristol.

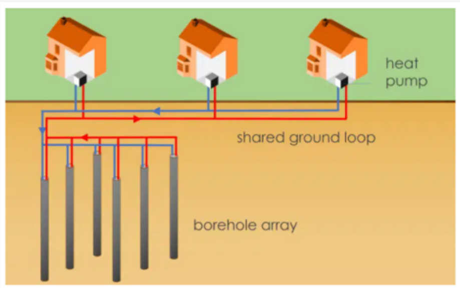
Sensitively sited on low grade agricultural land with no adverse amenity or visual impact.

Expected to generate 4,844MWh of renewable electricity each year – enough to power approximately 1,160 average UK homes.

Now exporting electricity to the grid. By June 2018 the site had generated about 11,000MWh of clean, green energy and received an income of over £1,228,000.

## Off gas houses/rural communities

**Innovative Low Carbon Heating For Firle Village**




Brighton and Hove Energy Services Co-operative (BHESCo) is working with the Firle Estate to create ground-source heat network for this village outside of Lewes in East Sussex.

At present, most properties in the village rely on fossil fuels as a source of heat, usually heating oil or LPG.

BHESCo, in partnership with RetrofitWorks, is pursuing a “fabric first” approach, improving the energy efficiency of each home, ideally to an EPC of C to deliver goal of clean, affordable heat.

## Low carbon heating in Barcombe

Residents in Barcombe, East Sussex, are helping their local electricity network operator to create a model roadmap for 'greener' home heating that will in time show the way for other communities to follow suit.

The project is a partnership between the people of Barcombe, local community energy group Ovesco, engineering practice Buro Happold and electricity network operator UK Power Networks.

Over 600 households are involved in the 'CommuniHeat' project.

# Appendix B. 'Bottom-up' baseline: methodology and calculations

Appendix B presents the 'bottom-up' baseline methodology and calculations for the four key sectors identified in the Lancashire region, based on the adopted study scope: Transport, Industry and Commercial Buildings, Domestic Buildings and LULUCF.

The work involved the development of a' bottom-up' carbon baseline spreadsheet model and calculations carried out by Atkins subject matter experts for each emission source category. Specific emissions source data from local authorities and the region were gathered and combined with carbon factor multipliers to create detailed 'bottom-up' analyses of current carbon emissions per source. The details of the input data into the 'bottom-up' calculations per emission source are described in the sections below.

It should be noted that, as set out in the study Options Report – Main Document, baseline emissions used for each of the Net Zero Pathway scenarios are those from the 'top-down' level analysis drawing on data from BEIS for the Lancashire region. The 'bottom-up' baseline information has been used primarily to inform development of interventions for each sector.

## B.1. Transport

The baseline transport emissions estimate accounts for well to wheel[3] emissions generated by road traffic and rail operations within the boundary of the 14 Lancashire authorities. It is primarily based on estimates of:

- Vehicle kilometres within the boundary of the authorities by vehicle type and speed band; and
- Emissions factors (in $gCO_2$ and $gCO_2e$ per kilometre) by vehicle type and speed band.

The calculations involved the following steps:

1) **Estimation of daily vehicle kilometres** in the Lancashire authorities on motorways, A roads, B roads and other roads, separately for cars, LGVs, HGVs and buses. These figures were derived from:
    a. Average traffic flow per day by vehicle type (cars, LGVS, HGVs and buses) and road type in the authorities, obtained from the DFT traffic count data site[4]
    b. DfT statistics on road length by type[5], using OS Open Roads[6] to cross check and to disaggregate minor roads between B roads, C roads and unclassified.

    The vehicle kilometre estimates produced were cross-checked against DfT estimates of 2018 vehicle kilometres by vehicle type in the authorities[7].
2) **Allocation of vehicle kilometres to three time periods** of AM, PM and Non Peak, on the basis of DfT statistics on travel by time period by vehicle type[8].
3) **Allocation of vehicle kilometres to 5mph speed bands** using DfT's free flow vehicle speed distributions by road type and vehicle type (cars, LGVs, HGVs and buses) by road type from the DfT's free flow vehicle speeds dataset[9], adjusted to represent real flow speeds on the basis of average speed by vehicle and road type in the DfT's Road Traffic Forecasts for the North West[10] (checked against 2018 DfT speed statistics for Lancashire)[11].
4) **Expansion from single day to a full year** of traffic to produce a summary of annual vehicle kilometres by time period, road type and vehicle type for 2018.
5) **Disaggregation of vehicle kilometres in each category by fuel/energy type** using fleet composition assumptions (i.e. the proportions of petrol, diesel and electric vehicles) from the DfT's Transport Appraisal

[3] Well to wheel emissions include emissions associated with extracting/generating and transporting the fuel or energy to the vehicle (well to tank) as well as the emissions generated in vehicle use (tank to wheel).
[4] DfT Road traffic statistics: Road traffic statistics - Local authority: Lancashire (dft.gov.uk)
[5] https://www.gov.uk/government/statistical-data-sets/road-length-statistics-rdl
[6] OS Open Roads: https://www.ordnancesurvey.co.uk/business-government/products/open-map-roads
[7] Tables TRA8904 to TRA8906: Traffic (www.gov.uk/government/organisations/department-for-transport/series/road-traffic-statistics)
[8]Table 0308 Traffic (www.gov.uk/government/organisations/department-for-transport/series/road-traffic-statistics).
[9] DfT Table SPE0111 - Free flow vehicle speeds GB (dft.gov.uk).
[10] Road traffic forecasts 2018 - GOV.UK (www.gov.uk).
[11] Tables CGN0401b, CGN0501b, CGN0501c, DfT Road Congestion Statistics.

Guidance databook[12], (also consistent with the assumptions used in the National Atmospheric Emissions Inventory).

6) **Calculation of fuel consumption/electricity use** for traffic in each speed band using functions from DfT TAG databook which relate fuel consumption or electricity use to vehicle type, fuel type, speed, year and distance of travel (also consistent with NAEI and drawn from the COPERT model).
7) **Conversion of fuel and electricity consumption estimates to estimated emissions** impacts using carbon intensity factors (kg $CO_2$e/ litre of fuel) from the DfT's TAG databook and kg $CO_2$e/ per kWh of electricity from the BEIS dataset[13],[14]
8) **Application of Well to Tank uplift factor** to Tank to Wheel emissions from petrol, diesel and electricity (calculated in steps 1 to 7) using the uplift factors from BEIS Greenhouse Gas Conversion Factors, 2020.[15]

Rail emissions estimates were taken directly from the BEIS 'top-down' figure as they account for just 1% of total emissions.

## B.2. Industrial and commercial buildings and large industrial installations

In order to develop pathways to Net Zero, it is important to understand the make-up of the industrial and commercial sub-sectors. The method for allocation within the BEIS data is complex. Details are provided within a technical report prepared for BEIS as part of the National Atmospheric Emissions Inventory (NAEI)[16]. A high-level summary is provided below.

- **Industrial and commercial electricity:** Data on electricity consumption at local authority level are used to map to $CO_2$ emissions from electricity generation to the point of consumption. Allocated to the Industrial / Commercial sector based on a combination of consumption profiles and address data.
- **Industrial and commercial gas:** Gas consumption data mapped to local authority areas. Allocated to business consumers using consumption thresholds. Non-disclosure agreements result in some suppression of data for the largest gas consumers, approximately 40 power stations and 110 large industrial, commercial or public sector users across the country, where the local authority areas are known. Data from the NAEI point source database[17] has been used to map these emissions, combining public domains emissions data with EU Emissions Trading System (EU ETS) reports to regulators. All emissions used in these calculations are 'end user' emissions and include emissions from the production and transportation of gas. Power stations' emissions are not included in any of these calculations as they are distributed by electricity consumption.
- **Large industrial installations:** Emissions are mapped using the NAEI database of point sources. For the Local Authority $CO_2$ End User dataset, an additional calculation is made to account for the $CO_2$ emitted during the processing of fuels used in industrial installations. Estimates of emissions have been compiled from a number of data sources, including: information on fuels burnt (in England, held by the Environment Agency (EA)); information on emissions of $CO_2$ from combustion processes regulated under Integrated Pollution Prevention and Control (IPPC) and reported to the EA for inclusion in the Pollution Inventory[18]; and additional data supplied by trade associations or individual process operators, to inform point source estimates. Note, the NAEI point source database (and the Pollution Inventory) are 'by source' emissions, rather than by end user. Therefore, where appropriate (only for fuel combustion emissions) an end user increment representing $CO_2$ emissions arising from fuel production (e.g. refineries) is also allocated to that end user.
- **Industrial and Commercial 'Other Fuels'** (e.g. oils, solid fuels, wastes and biofuels)**:** Derived as a combination of point and area sources from the EA's Pollution Inventory, EU ETS, employment and energy statistics.
- **Agriculture:** Consumption of solid and liquid fuels calculated using employment data. Off road mobile machinery emissions associated with agriculture are distributed using land use data, weighted to the land use type. Also

[12] DfT Transport Appraisal Guidance Databook: Transport analysis guidance - GOV.UK (www.gov.uk).
[13] BEIS data tables to support the Treasury Green Book supplementary appraisal guidance on valuing energy use and greenhouse gas (GHG) emissions. https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal.
[14] Using domestic grid average intensity for the baseline rather than marginal intensity which is recommended in the TAG databook to appraise changes in energy use.
[15] Greenhouse gas reporting: conversion factors 2020 - GOV.UK (www.gov.uk).
[16] National Atmospheric Emissions Inventory (2020) Local and Regional Carbon Dioxide Emissions Estimates for 2005-2018 for the UK. Technical Report. Prepared by Ricardo Energy and Environment for BAIS. Reference GA0216. 12 June 2020. Available online at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/894790/local-authority-co2-emissions-technical-report-2018.pdf. Accessed May 2021.
[17] National Atmospheric Emissions Inventory. Emissions from NAEI large point sources. Available online at: https://naei.beis.gov.uk/data/map-large-source. Accessed May 2021.
[18] Environment Agency. Pollution Inventory. Available online at: https://data.gov.uk/dataset/cfd94301-a2f2-48a2-9915-e477ca6d8b7e/pollution-inventory. Accessed May 2021.

includes $CO_2$ emissions from urea application and liming of soils using data provided by the UK Centre for Ecology and Hydrology and Rothamsted Research.

This 'bottom-up' Industrial and Commercial sector baseline focuses on the BEIS 'large industrial installations' category, excluding commercial / industrial gas, electricity and other fuels[19], relating to consumption by site users, since it is not possible to fully disaggregate these sources or assign them to sectors without access to the BEIS database. These are therefore taken as a given, and the assessment centres on point source emissions from industrial sites for which we can identify the emissions in the inventories below.

Both the EA and NAEI datasets provide eastings and northings for individual sites, which allows for entering them into a GIS map and associate each point source of emissions with local authority boundaries. Once site, sector, local authority and quantity of emissions were compiled, an amalgamated list was produced which compares the EA and NAEI point source data given. In comparing across these two sources and the BEIS dataset, we undertook a line-by-line comparison, matching emissions to number of sites to correct for anomalies and avoid double-counting. The full line-by-line comparison is contained with Appendix B.

The EA's Pollution Inventory lists annual mass emissions from Part A industrial activities regulated under IPPC. In 2018, there were 45 operators listed within Lancashire County Council, of which 15 reported $CO_2$ emissions above the EA's annual reporting threshold (10,000 tonnes), totalling 888,622 tonnes. Details are provided in Table C-2 and Figure C-11, which present both the total reported emissions, and the theoretical maximum emissions, which assumes those facilities below the reporting threshold are responsible for emissions equal to the reporting threshold (10,000 tonnes per annum). Note, caution must be taken in comparing with the BEIS data, as the EA's Pollution Inventory includes emissions from power stations, which are specifically removed from the BEIS data and spread across end users as Industrial/Commercial Electricity, Gas or Other. One Cement and Minerals site (Hanson Cement, previously Castle Cement in Ribble Valley) accounted for 65% of reported $CO_2$ emissions in 2018, with Chemicals, Landfill and Combustion (Power) accounting for 10%, 8% and 7% respectively. Nuclear and Paper / Textiles each at 4%, with the remaining 2% from the water industry.

In contrast to the EA's Pollution Inventory, the NAEI includes a slightly different range of sources, e.g. Public Administration (hospitals in Lancaster, Blackpool, Preston, Burnley and Blackburn, and HM Prisons Garth and Wymott), emissions from vehicles at Warton and Samlesbury Aerodromes and Rolls Royce, oil and gas exploration and production and other mineral industries. Nonetheless, the overall picture is very similar, with emissions from Hanson Cement dominating (57%), and other industries each contributing 10% or less.

## B.3. Buildings (residential and non-residential)

To understand the pathway to Net Zero it is very important to measure the impact of buildings, specifically the breakdown of residential and non-residential stocks. To provide an accurate calculation, it is essential to understand the problem at a granular level, ideally at a property level wherever possible.

To do this, a methodology has been developed that prioritises property level data from EPCs (Energy Performance Certificates) wherever possible, and where this is not possible, accurate assumptions have been created using building typologies recorded in Council Tax Records for residential and Non-domestic National Energy Efficiency Data for non-residential.

Due to the size and density of the data (see Table B-1 below), this has resulted in a complex methodology, which is summarised below, with its limitations and next steps outlined in more detail in Building heat grant schemes (Appendix E).

**Table B-1 - Residential Data Summary**

| Local Authority | Total Number of EPCs | Total Unique Properties from EPC Data | Total Properties from Council Tax Data | Difference |
|---|---|---|---|---|
| Blackburn with Darwen | 53,330 | 35,717 | 60,740 | 41% |
| Blackpool | 68,498 | 45,619 | 70,900 | 36% |
| Burnley | 38,365 | 25,547 | 41,420 | 38% |
| Chorley | 37,048 | 23,895 | 50,870 | 53% |
| Fylde | 33,087 | 21,239 | 38,410 | 45% |
| Hyndburn | 30,247 | 21,060 | 36,610 | 42% |
| Lancaster | 49,826 | 36,185 | 64,280 | 44% |

[19] 'Commercial', i.e. non-residential, buildings emissions are dealt with in the Buildings (domestic and non-domestic) section below.

| Local Authority | Total Number of EPCs | Total Unique Properties from EPC Data | Total Properties from Council Tax Data | Difference |
|---|---|---|---|---|
| Pendle | 35,249 | 23,758 | 39,900 | 40% |
| Preston | 55,305 | 37,963 | 63,720 | 40% |
| Ribble Valley | 19,151 | 12,058 | 26,810 | 55% |
| Rossendale | 23,558 | 17,188 | 31,480 | 45% |
| South Ribble | 32,911 | 24,177 | 49,360 | 51% |
| West Lancashire | 33,713 | 23,791 | 48,970 | 51% |
| Wyre | 37,775 | 26,657 | 51,170 | 48% |
| Total | 548,063 | 374,854 | 674,640 | 44% |

By prioritising property level data, an accurate pathway to net-zero can be produced for residential buildings in Lancashire that provides a much more granular picture that standard aggregated data. However, by focussing on property level data, this means a certain proportion (44%) of residential buildings have been missed from the more accurate analysis. Nevertheless, because EPCs are regularly required for all rental properties in the UK, this means rented properties have been more accurately picked up (29.4%) than home owned properties (70.6%). Especially true for social rent properties, directly managed by the local authority or housing associations, this could mean interventions in these properties are potentially easier to implement and furthermore could have greater social value, by reducing energy costs to those that most need it. Our methodology provides the ability to filter down to social rent properties and could be further interrogated in the future to flag specific buildings, or groups of buildings for specific interventions.

While there are limitations in our methodology, a very accurate dataset of buildings at a property level for a very large proportion of Lancashire has been created which allows for precise interventions to be developed to create a pathway to Net Zero.

## B.3.1. Domestic buildings methodology

To create an accurate picture of the different residential building typologies across Lancashire, data from Domestic EPC was first analysed and then compared to similar aggregated data from council tax records. This is to take into consideration the limitations of the EPC data. The following steps were then undertaken:

1. **Extract, transform, load:** Downloading the raw data from MHLCG data repository for each Local Authority and housing in an appropriate file location for compiling, we removed outliers from the data, followed by duplicate certificates (where multiple historic EPC certificates were associated with listings) to create the set of unique property listings with the most recent data attached.
2. **Data validation**: The variables within specific data field were cleaned to make the analysis manageable and relatable to Council Tax records. This included removing duplicate entries to create a single (latest) EPC entry for each property; tidying up floor description, walls description, windows descriptions, and roof description to be consistent. Then the main building typologies were modified to be consistent with council tax records, this included property type and construction age bands[20].
3. **Extra data fields were added** to provide mappable geographies, such as LSOA codes using a ONS postcode lookup file. This also allowed secondary data source to be joined, including the council tax data which is aggregated at the LSOA level. This allows the results to be analysed spatially across Lancashire to highlight potential areas of interest.
4. **Accuracy testing:** With the EPC data processed and cleaned, it was then analysed to test its level of accuracy. Correlations were observed on various levels, further informing our assumptions and methods. This included correlations with the council tax data using the follow data points:
    a. Age bands.
    b. Bedrooms and habitable rooms.
    c. Floor area and number of bedrooms.
    d. Property types.
    e. EPC rating.
5. **Evaluation of energy demand**: A summary of energy required across different building typologies was compiled, for thermal and electrical demand.

[20] An analysis of the age band, property type and built form variables highlighted that older properties, especially detached/semi-detached houses were more impacted by these cut-off values.

6. **Conversion to carbon dioxide emissions**: Conversion factors were applied for each of the energy categories, and these were aggregated.
7. **Presentation**: The data were visualised dynamically in the tools Tableau and PowerBI so that visual summaries could be produced and presented depending on the analysis needed. These will also serve for the later stages where analysis by measures and intervention opportunities will be required.

## B.3.2. Non-residential buildings methodology

A similar approach has been taken for the non-residential energy performance certificates and the Display Energy Certificates (DEC):

1. Download the raw data from MHLCG data repository (see Data Sources) as a CSV file for each Local Authority and then merge each into one file store in a local Atkins database.
2. Duplicated certificates were removed. Due to the data including all EPC issued, as well as legal reasons, many properties had multiple historic EPC associated to them, therefore it was important to only capture the most recent certificate to gain an accurate picture of what is there. This removal of certificate was based on the unique building reference number used to record each property and the latest inspection date. This reduced the number of certificates from 23,661 to 22,083.
3. More certificates were removed due to an overlap between the non-residential dataset and the DEC dataset. The number of certificates went from 22,083 to 21,751.
4. Data variables cleaned to make analysis manageable and relatable to council tax records. This included extracting the use classes.
5. Extra data fields were added to provide mappable geographics, such as Lat/Lon values using ONS postcode lookup data. This allows the results can be analysed spatially across Lancashire to highlight potential geographics areas of interest. However, because of the smaller distribution of data point (22,083 non-domestic compared to 374,795 for domestic) is it not possible to aggregate this to LSOAs since there would be too few to make an accurate representation of the data.
6. Lat/Lon values were added to the EPC postcodes using ONS lookup file (see data source).
7. Finally, the data is visualised dynamically in Tableau and PowerBI to allow the results to be interrogated by the end user. This means specific geographies and interventions can be view individually without the need to produce multiple pdfs or reports.

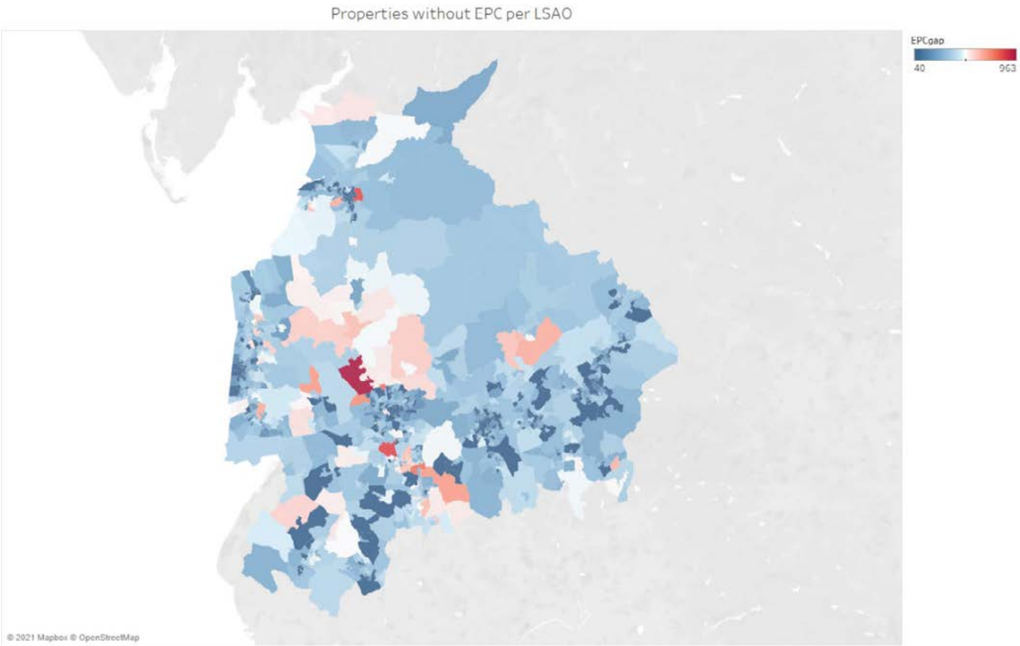
## B.3.3. Domestic buildings methodology limitations

In our efforts to create as accurate and new methodology for recording a pathway to Net Zero for buildings, the prioritisation of property level data over aggregated data was paramount. This has meant there are certain limitations which are set out below.

### B.3.3.1. Domestic EPC Data Coverage

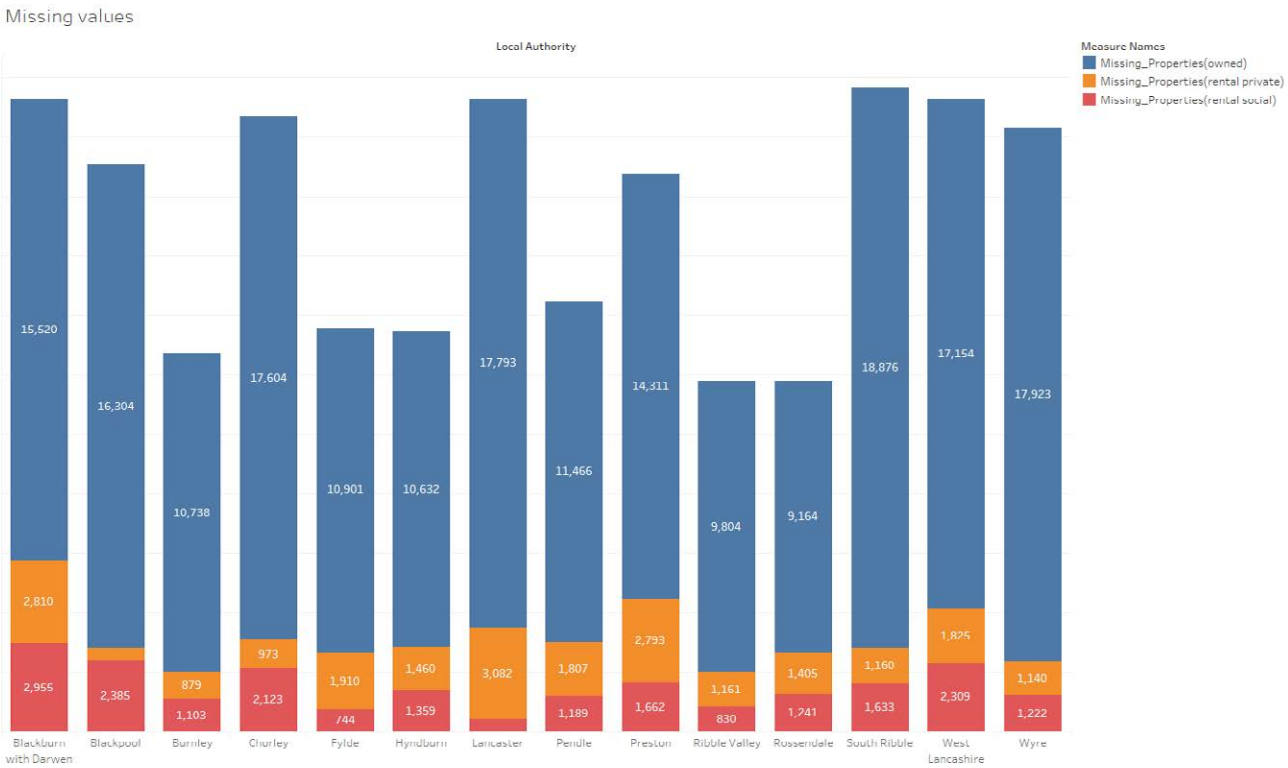
While the data within the EPCs provide a very granular understanding of existing residential buildings it does not provide a blanket coverage of all residential buildings in the Lancashire region. This is mainly because EPCs are only regularly required for rental and newly developed properties and owners have the option to withhold data from being publicly recorded and the data only goes as far back as 13/01/2000.

**Figure B-1 - Residential properties without an associated EPC, mapped against LSOA**




The residential buildings that have the most accurate coverage within the EPC mainly fall within the rent tenures and are mostly located in urban locations. This is especially important for social rent properties, as it these homes that local authorities are most likely to have control over to develop interventions and where the impact of interventions could also have the greatest social impact for local communities.

**Figure B-2 - Number of missing EPCs per tenure and Local Authority**




### B.3.3.2. Domestic EPC data inputting

While the data within the EPC provide 90 variables for each property recorded, allowing for the most accurate building typology possible in the UK, this data is sometime inputted inaccurately. This includes typos, inconsistencies in variable names, multiple certificates for a single property and incomplete addresses. This requires a longer initial stage to process the data to get it to point that it can be analysis to develop interventions.

However, with the sample size being very large and the granularity of the data incredibly detailed for each individual property, once processed this provides a very accurate picture of residential buildings so that high quality interventions can be developed. This is significantly more so than what would be possible with aggregated data.

### B.3.3.3. Council tax data

While the coverage of the EPC data is limited, the council tax data records the number of each residential property in England and Wales and aggregates this to a LSOA level. Similarly, to the EPC data, this data also records property types and constructions age and additionally includes the number of bedrooms, which could be used to assume size. Yet, these two datasets do not perfectly align, as property types and construction ages are slightly different, and while bedroom numbers are recorded in the council tax data in the EPC data property sizes are recorded more accurately as floor areas (sq.m.) and habitable rooms. This has meant modifications to the EPC data were required to correlate the two datasets, specifically the age band and the property types needed to be re-aligned to allow a more accurate comparison. However, the biggest difficulty was aligning property size, since there was no direct correlation immediately possible here.

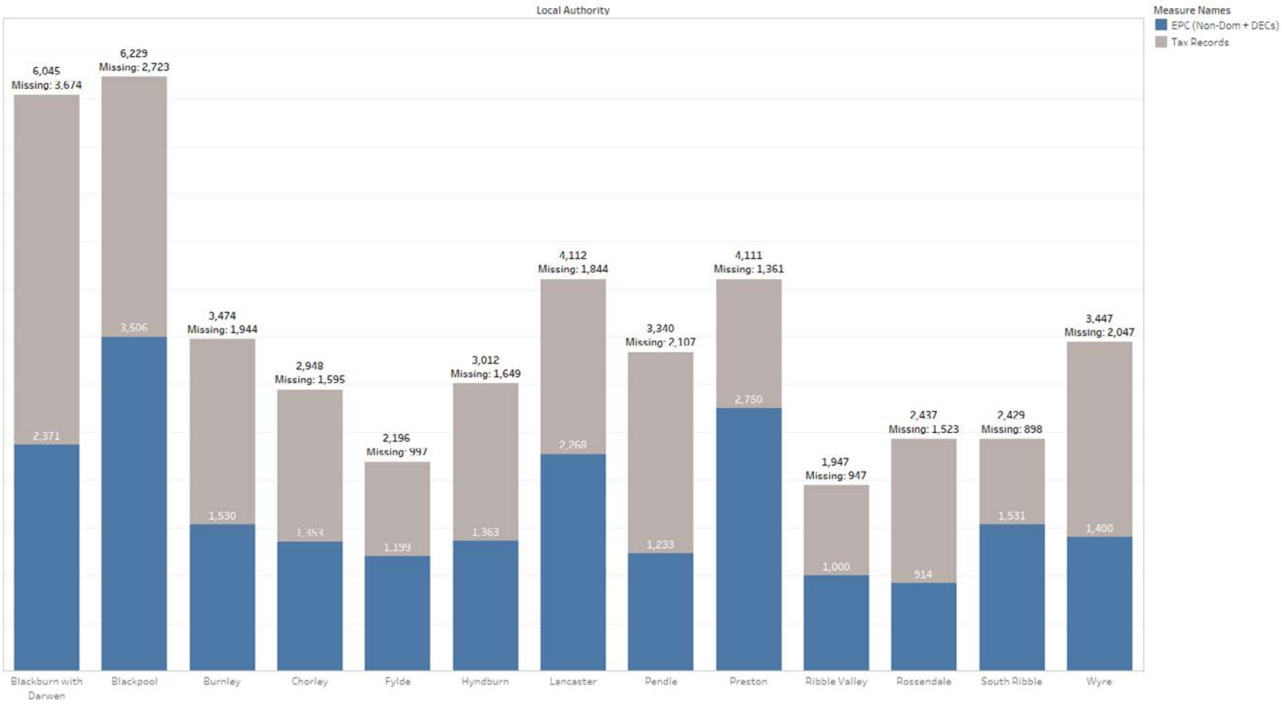
Nonetheless, the council tax data provided an accurate picture of all the residential buildings and typologies in Lancashire so that the modification made to the EPC data could be aligned correctly with a comparative dataset.

## B.3.4. Non-residential buildings methodology limitations

### B.3.4.1. Non-domestic EPC/ DEC data coverage

Like the domestic EPC data, the non-domestic EPC and DEC data does not provide a blanket coverage of all non-residential buildings in the Lancashire region. Non-domestic EPC are only required when premises are rented or sold, or when there are changes to the number of parts used for separate occupation, whilst DEC are only necessary for public buildings above 250 $m^2$.[21]

**Figure B-3 - The number of non-domestic buildings missing per Local Authority**




However, these datasets do provide a consolidate account of all non-residential buildings in Lancashire and importantly the DEC provide accurate and regular measurements of energy consumption for public buildings. It is these public buildings, such as libraries, museums, prisons, education buildings, hospitals, that the local authority are likely to have the control over to implement interventions and the where the impact could have the largest social impact.

### B.3.4.2. Non-Domestic EPC/ DEC Data Field

Unlike the domestic data, the non-domestic EPC and DEC data do not have regular property types or construction ages to assume accurate interventions. This has meant use types and floor areas have been the most reliable datasets to model interventions against.

Also, like the domestic data multiple certificates are published for the same property and this require the data to be further processed to remove duplicates before analysis.

### B.3.4.3. Non-Domestic EPC / DEC data geographies

With there being significantly fewer data points for non-residential buildings (over 70% of the UK building stock is residential) this has meant that the data cannot be visualised in the same way. This is because the residential buildings are visualised using LSOAs, but there are not enough Non-Domestic buildings to make this an accurate representation, therefore the data have been visualised at the local authority level.

### B.3.4.4. NEED Data

While the coverage of the Non-Domestic EPC and DEC data is limited, the Non-domestic National Energy Efficiency Data-Framework (NEED) data records an accurate coverage of all non-domestic buildings and aggregates this to a Local Authority level. Again, these two datasets do not perfectly align, as use types are slightly different, and floor area are recorded at a regional level instead of Local Authority.

[21] https://www.gov.uk/check-energy-performance-public-building

Nonetheless, this data type provides an accurate picture of all non-residential buildings in Lancashire so that the data could be aligned correctly for comparative purposes.

## B.3.5. Data sources and benchmarks

Table B-2 and Table B-3 contain supporting information for how baseline emissions data were arrived at.

**Table B-2 - Buildings data sources and links**

| Data Title | Source | URL | Date Accessed |
|---|---|---|---|
| **Domestic Energy Performance Certificates** | MHLCG | Energy Performance of Buildings Data England and Wales (opendatacommunities.org) | May-21 |
| **Non-Domestic Energy Performance Certificates** | MHLCG | Energy Performance of Buildings Data England and Wales (opendatacommunities.org) | May-21 |
| **Display Energy Certificates** | MHLCG | Energy Performance of Buildings Data England and Wales (opendatacommunities.org) | May-21 |
| **Electricity consumption statistics are available at an MSOA/LSOA level** | BEIS | Lower and Middle Super Output Areas electricity consumption - GOV.UK (www.gov.uk) | May-21 |
| **Electricity consumption statistics are available at an MSOA/LSOA level** | BEIS | Lower and Middle Super Output Areas electricity consumption - GOV.UK (www.gov.uk) | May-21 |
| **ND-National Energy Efficiency Data-Framework (NEED)** | BEIS | Non-domestic National Energy Efficiency Data-Framework (ND-NEED), 2020 - GOV.UK (www.gov.uk) | May-21 |
| **National Statistics Postcode Lookup** | ONS | Open Geography Portal : National Statistics Postcode Lookup (May 2021) | May-21 |
| **Council Tax: stock of properties, 2019** | VOA | Council Tax: stock of properties, 2019 - GOV.UK (www.gov.uk) | May-21 |
| **Housing Tenure, 2011 Census** | NOMIS | QS405EW (Tenure - Households) - Nomis - Official Labour Market Statistics (nomisweb.co.uk) | May-21 |
| **English indices of deprivation 2019** | MHLCG | English indices of deprivation 2019 - GOV.UK (www.gov.uk) | May-21 |
| **Lower Layer Super Output Areas (December 2011) Boundaries Full Clipped (BFC) EW V3** | ONS | Open Geography Portal : Lower Layer Super Output Areas (December 2011) Boundaries Full Clipped (BFC) EW V3 : Lower Layer Super Output Areas (December 2011) Boundaries Full Clipped (BFC) EW V3 (statistics.gov.uk) | May-21 |

**Table B-3 - Industrial & commercial buildings benchmarks**

| USE_CLASS | Assumed no. floors | Benchmark Type | Lighting kWh/m2 | | Heating kWh/m2 | | Total Elec | | Peak Heating |
|---|---|---|---|---|---|---|---|---|---|
| | | | Typical | Good Practice | Typical | Good Practice | Typical | Good Practice | Wp/m2 |
| A1/A2 | 1 | Offices Type 3 | 54 | 27 | 178 | 97 | 226 | 178 | 100 |
| A3/A4/A5 | 1 | Offices Type 3 | 54 | 27 | 178 | 97 | 226 | 178 | 100 |
| Airport | 2 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 70 |
| B1 | 3 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 70 |
| B2 | 2 | Mix-use Type 8 | 45 | 20 | 325 | 125 | 85 | 50 | 70 |
| B8 | 1 | Mix-use Type 5 | 25 | 5 | 185 | 80 | 43 | 20 | 70 |
| Bus | 1 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 70 |
| C1 | 3 | Hotels Type 2 | 65 | 35 | 230 | 160 | 140 | 80 | 60 |
| C2 | 1 | Hotels Type 2 | 65 | 35 | 230 | 160 | 140 | 80 | 60 |
| C2A | 1 | Hotels Type 2 | 65 | 35 | 230 | 160 | 140 | 80 | 60 |
| Community/day | 1 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 70 |
| Crown | 1 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 70 |
| D1 | 1 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 70 |
| D2 | 1 | Sports and recreation buildings - spectator areas | 46 | 30 | 355 | 168 | 102 | 62 | 70 |
| Dwelling | 1 | Hotels Type 2 | 65 | 35 | 230 | 160 | 140 | 80 | 60 |
| Emergency | 1 | Hospital Teaching | 40 | 20 | 249 | 215 | 122 | 86 | 87 |
| Further | 5 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 87 |
| Hospital | 4 | Hospital Teaching | 40 | 20 | 249 | 215 | 122 | 86 | 87 |
| Hotel | 3 | Hotels Type 2 | 65 | 35 | 230 | 160 | 140 | 80 | 60 |
| Industrial | 2 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 70 |
| Launderette | 1 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 70 |
| Libraries/museums/galleries | 1 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 70 |
| Miscellaneous | 1 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 70 |
| Nursing | 2 | Hotels Type 2 | 65 | 35 | 230 | 160 | 140 | 80 | 60 |
| Office | 3 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 70 |
| Others | 1 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 70 |
| Primary | 1 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 87 |
| Prisons | 2 | Hotels Type 2 | 65 | 35 | 230 | 160 | 140 | 80 | 60 |
| Residential | 2 | Hotels Type 2 | 65 | 35 | 230 | 160 | 140 | 80 | 60 |
| Restaurant/public | 1 | Offices Type 3 | 54 | 27 | 178 | 97 | 226 | 178 | 100 |
| Retail | 1 | Offices Type 3 | 54 | 27 | 178 | 97 | 226 | 178 | 100 |
| Secondary | 2 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 87 |
| Social | 1 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 70 |
| Sports | 1 | Sports and recreation buildings - spectator areas | 46 | 30 | 355 | 168 | 102 | 62 | 70 |
| Theatres/cinemas/music | 2 | Sports and recreation buildings - spectator areas | 46 | 30 | 355 | 168 | 102 | 62 | 70 |

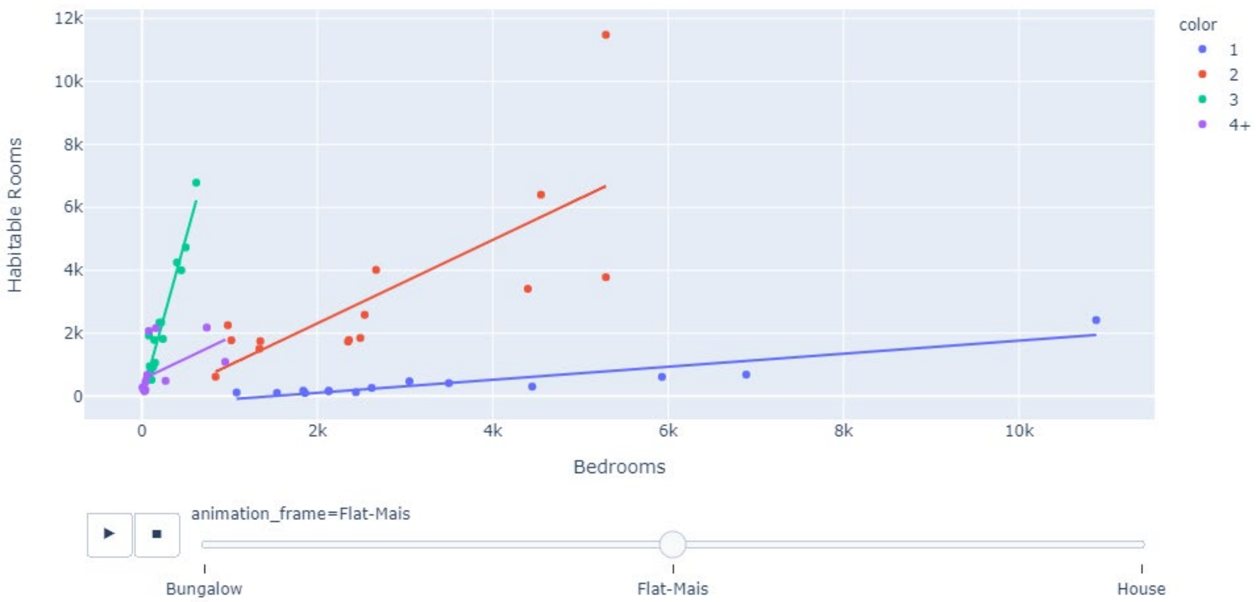
| USE_CLASS | Assumed no. floors | Benchmark Type | Lighting kWh/m2 | | Heating kWh/m2 | | Total Elec | | Peak Heating |
|---|---|---|---|---|---|---|---|---|---|
| | | | Typical | Good Practice | Typical | Good Practice | Typical | Good Practice | Wp/m2 |
| Warehouse | 1 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 70 |
| Workshops/maintenance | 1 | Offices Type 2 | 38 | 22 | 151 | 79 | 85 | 54 | 70 |

## B.3.6. Methodology next steps

### B.3.6.1. Improving Accuracy

While it is acknowledged that there are limitations in the initial comparative studies between the EPC data and Council Tax Property data undertaken as part of this study, this analysis has started to show correlations in the data that could be developed further to fill the gap in the buildings missed in the EPC data at a later stage.

**Figure B-4 - Correlations between EPC and tax records for flats-maisonettes**




Note:
Correlations per number of bedrooms: 1: R2= 0.853; 2: R2= 0.574; 3: R2= 0.924), 4+ (R2= 0.25)

This is because in the council data property types, construction ages and bedrooms are recorded, and while this is not perfectly represented in the EPC our initial modifications started to show that similar property types and construction ages could be formed. So, if floor areas can be accurately correlated from the EPC data onto the council tax data, more precise interventions could be modelled onto the missing building.

This would require the development of a multilevel regression model to understand the missing values and a margin of error calculation for the specific geographies to understand the lowest level of spatial accuracy possible.

## B.3.7. Summary

While there are limitations in the methodology that has been derived, a very accurate dataset of buildings at a property level for a very large proportion of Lancashire has been created which allows for precise interventions to be developed to create a pathway to Net Zero.

# B.4. LULUCF

- The LULUCF sector reflects the impact of land use, land use changes and land management processes on emissions and removals of carbon dioxide ($CO_2$). This impact may cause a pool to increase or decrease, determining whether land parcels act as sinks or sources, for example where forests or peatland are removed to make way for agriculture, or infrastructure. The biosphere is an important reservoir of carbon, and LULUCF processes are a net carbon sink in the UK, although in Lancashire they are a net emitter (5%) as discussed in the Main Report.
- This baseline exercise for Lancashire considers only stocks of carbon and emissions and removals of $CO_2$. Stocks of carbon are considered as tonnes of carbon (tC) stored in biomass (vegetation and dead organic matter) or soil.

The methodology for estimating carbon stocks is based on the principle of dividing the total land area of Lancashire into its different land-use categories and multiplying these areas by emission factors that account for the potential carbon stored in biomass and soil stocks.

The key sources of methodological guidance have been:

- the IPCC's 2006 guidelines22
- Defra's Enabling a Natural Capital Approach (ENCA) guidance[23].

The IPCC guidelines provide a comprehensive and detailed approach to preparing national greenhouse gas inventories in the Agriculture, Forestry and Other Land Uses (AFOLU) sector. Much of the technical content of the guidelines – such as classifying land-uses and the calculations for estimation – can be readily applied at a regional or local level.
The guidelines have also been adapted by DEFRA to the UK context and are used in the UK National GHG Inventory for its LULUCF emissions and removals. The ENCA guidelines provide a complementary set of tools and datasets, including Natural England's latest review of carbon storage and sequestration factors for different habitats[24].

Combining natural capital tools and datasets with the LULUCF methodology allows Lancashire to make use of the most up to date, publicly available, peer-reviewed and technically rigorous evidence for establishing the LULUCF baseline for the study region.

## B.4.1. Study boundary, temporal and technical scope

The geographic study area has been set to include all 14 local authorities within the study region, an area of 307,306 hectares (ha) based on the analysis carried out as part of this study.

The temporal scope for the baseline assessment is a single 'snapshot' of carbon stocks across all land use types within a year. The baseline year is set as 2018 to align with the wider Pathway Options study, however the land use data that informs this analysis is based on the most up to date data available (ranging between 2013 and 2018, with the exception of one data source from 2019; see section Generating Land Use Maps and Calculating Areas below on data prioritisation for rationale).

The study is concerned with carbon stocks and carbon emissions and removals as follows:

### B.4.1.1. Carbon stocks

A carbon 'pool' is a reservoir with the capacity to store, capture and release carbon. The quantity of carbon within a pool is referred to as the carbon 'stock'. Within each land-use area, there are carbon stocks within the following two aggregate carbon pools:

- biomass (vegetation above and below ground, including dead organic matter); and
- soils (soil organic matter in the top 30cm of mineral and in organic soils).

The carbon content per carbon pool differs from one land-use to another and within the sub-categories of a land-use. For example, in Grassland most of the carbon is within soil, whereas Forest Land has significant above-ground biomass present. The baseline includes estimates of carbon stocks in all pools within each identified land use.

[22] Intergovernmental Panel on Climate Change (IPCC), "Guidelines for National Greenhouse Gas" Inventories, Volume IV: Agriculture, Forestry and Other Land use," 2006 https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html.
[23] Defra (2021) Enabling a Natural Capital Approach (ENCA) https://www.gov.uk/guidance/enabling-a-natural-capital-approach-enca
[24] Natural England Research Report. NERR094. Carbon storage and sequestration by habitat: a review of the evidence (second edition).

### B.4.1.2. Emissions and removals

Emission and removal rates associated with land uses vary depending on its level of establishment. Once a land-use conversion or change in management practices has taken place, it takes several years to a few decades for the new land-use to reach equilibrium status[25].

Specific information has not been made available on the age of the land uses within Lancashire or the level of land use management that is currently being undertaken. Therefore, when selecting emissions and removal factors, these were chosen to represent land uses which are being maintained, not having undergone land use change in the recent past, and not being managed intensively. To gain an in-depth understanding of annual emissions and removals across Lancashire's land uses would require a much more extensive and in-depth assessment.

For the purpose of the Pathway Options study, the baseline emissions assessment is based on the total carbon stocks of land use types, representing the total quantity of carbon that could be both stored or emitted. Emissions and removals rates have also been provided but should only be treated as indicative.

### B.4.1.3. Generating land use maps and calculating areas

All land within the study area has been categorised as one of six broad land-use categories: Forest Land; Cropland; Grassland; Wetlands; Settlements; and Other Land. The categories used were developed by the IPCC to be robust, comprehensive and implementable in any setting. They form the basis of all land representation for LULUCF emissions and removals estimations, internationally. The IPCC definitions of different land-use types are provided in Table B-4, as well as the total land area of that land use type identified in Lancashire. Definitions are sourced from the IPCC guidelines, with specifics around the definition of forest in the UK sourced from Annex II of Regulation 2018/841[26].

Each overall land use category has been subdivided further into high-level subcategories to ensure greater alignment with the biomass and soil carbon factors reported by habitat in the Natural England (2021) dataset.

Based on the Office for National Statistics 2019 Natural Capital Accounts[27] for designated peatland sites in England, 13% of peatland is assumed to be in a 'good' condition, and the remaining 87% not to be in a 'good' condition.

**Table B-4 - Land Use categories, subcategories and total areas in Lancashire**

| Land use category | IPCC 2006 definition | Subcategory | Total area (ha) |
|---|---|---|---|
| Forest Land | In the UK, a wood or forest is defined as an area of trees 0.1 hectares or greater, with a canopy cover of 20% and a height of 2m. Areas of less than 0.5 hectares of open space within a woodland are included within the woodland area. However, open spaces of greater than 0.5 ha within a woodland are excluded. | Broad-leaved, mixed and yew semi-natural woodland | 14,845 |
| | | Broad-leaved, mixed and yew plantation[28] | 1,777 |
| | | Coniferous plantation | 3,420 |
| Cropland | Cropland includes arable and tillable land, and agroforestry systems which do not meet the definition of Forest Land. Annual and perennial crops are included, as are herbaceous or woody crops. Land which is temporarily fallow is also included, as is land which is normally used for the cultivation of crops but is temporarily used for grazing as part of an annual crop-pasture rotation. | Arable fields | 40,993 |

[25] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_01_Ch1_Introduction.pdf.
[26] http://www.legislation.gov.uk/eur/2018/841/2018-05-30.
[27] Table 6.1 UK natural capital - Office for National Statistics (ons.gov.uk) We have had to make assumptions that i) conditions for designated peatlands sites in England are representative of the distribution of peatland condition in Lancashire which will include designated and non-designated areas, ii) that a favourable site condition translates to a "near natural bog (undrained)" condition in the Natural England 2021 database of carbon factors the client and stakeholders want us to use.
[28] Plantation refers to woodland that has been felled and replanted with non-native species. https://www.woodlandtrust.org.uk/trees-woods-and-wildlife/habitats/ancient-woodland/.

| Land use category | IPCC 2006 definition | Subcategory | Total area (ha) |
|---|---|---|---|
| Grassland | Grassland is non-forested land where crops are not grown. This includes continuous pasture, hay land, moorland and areas of scrub and trees not reaching the threshold required for 'Forest Land'. | Grassland | 130,662 |
| | | Dense scrub | 4,665 |
| Settlements | This includes all developed land; residential, commercial, manufacturing, and transportation, or land which is functionally or administratively associated with public or private land in cities, towns or villages. It incorporates infrastructure of any size. Settlements can include soils, trees, grass, golf courses and parks (typically referred to as 'green areas'). | Urban - Built environment | 39,271 |
| Wetland | This category includes areas of peat extraction and land that is covered or saturated by water for all or parts of the year (which does not fall into the Forest Land, Cropland, Grassland or Settlements categories). It includes peat bogs and marshes, as well as reservoirs and natural rivers and lakes. | Peatland / Bog | 69,200<br>Of which:<br>• 8,996 (13%) in 'good' condition<br>• 60,204 (87%) not in 'good' condition |
| | | Freshwater | 1,341 |
| Other Land | This includes all land areas which do not fall into any of the other five categories. | Dwarf shrub heath | 1,132 |

Note: all figures are indicative estimates only.

The spatial data in GIS format used for the preparation of the land use map used in this assessment are set out in Table B-5, coming from three main sources:

- Crop Map of England (CROME) 2019 – Lancashire[29]
- National Forest Inventory Woodland 2018[30]
- Natural England Peaty Soils Location Map 2013[31]

The various subcategories of land use that were included within these sources are also listed against the land use category under which they were grouped for use in the baseline assessment. Grouping was carried out based on descriptions provided in the sources of the individual subcategory and assigning subcategories to the most appropriate carbon factor value.

We acknowledge that other opensource geospatial datasets are available that would enable landcover to be mapped with a greater level of resolution and thus offer greater nuance in the LULUCF baseline and quantification of removals potential. The objective of the analysis at this stage was to provide a high-level estimate of carbon emissions and removals, and to indicate a theoretical maximum removals potential for interventions that have established standards i.e. woodland creation via the Woodland Carbon Code and peatland restoration via the Peatland Code. It is recommended that this analysis be built upon in follow-on stages of work to take a habitats-based approach using datasets such as the Priority Habitat Inventory and SSSI condition data. This would enhance the accuracy of the LULUCF baseline and quantification of the carbon removals' potential.

[29] https://environment.data.gov.uk/DefraDataDownload/?mapService=RPA/CropMapOfEngland2019LAN&Mode=spatial.
[30] Forestry Commission : National Forest Inventory Woodland England 2018 (arcgis.com).
[31] https://data.gov.uk/dataset/c9eb1cd9-c254-4128-a18d-d368fbe6acf0/peaty-soils-location.

**Table B-5 - Land use categories and sources of spatial data**

| Land use types | Sub-categories | Source |
|---|---|---|
| Broad-leaved, mixed and yew semi-natural woodland | Broadleaved woodland | National Forest Inventory |
| | Mixed mainly broadleaved | |
| | Assumed woodland | |
| | Trees and Scrubs, short Woody plants, hedgerows | Crop Map of England |
| Broad-leaved, mixed and yew plantation | Young trees | National Forest Inventory |
| | Low density trees | |
| | Shrubs | |
| | Windblown | |
| Coniferous plantation | Conifer | National Forest Inventory |
| | Mixed mainly conifer | |
| Dense scrub | Trees and Scrubs, short Woody plants, hedgerows | Crop Map of England |
| Arable fields | Agriculture Land | National Forest Inventory |
| | Fallow Land | Crop Map of England |
| | Beet | |
| | Maize | |
| | Mixed Crop-Group 1 | |
| | Onions | |
| | Perennial Crops and Isolated Trees | |
| | Potato | |
| | Soya | |
| | Spring Barley | |
| | Spring Cabbage | |
| | Spring Field beans | |
| | Spring Linseed | |
| | Spring Oats | |
| | Spring Peas | |
| | Spring Wheat | |
| | Winter Barley | |
| | Winter Field beans | |
| | Winter Oats | |
| | Winter Oilseed | |
| | Winter Rye | |
| | Winter Triticale | |
| | Winter Wheat | |
| Semi-natural grassland | Grassland | National Forest Inventory |
| | Failed forest | |
| | Uncertain | |
| | Felled forest | |
| | Ground preparation | |
| | Grass | Crop Map of England |

| Land use types | Sub-categories | Source |
|---|---|---|
| Urban – Built environment | Road | National Forest Inventory |
| | Urban | |
| | Bare area | |
| | Quarry | |
| | Non-vegetated or sparsely vegetated Land | Crop Map of England |
| Peatland / Bog | Peatland | Natural England Peaty Soils |
| Dwarf shrub heath | Bracken | National Forest Inventory |
| | Heathland and Bracken | Crop Map of England |
| | Heather | |
| Freshwater | Open water | National Forest Inventory |
| | Water | Crop Map of England |

It is noted that in a number of cases, datasets overlapped spatially, and therefore some layers needed to be prioritised over others in the GIS analysis. The order in which datasets were prioritised is set out below (from highest priority to lowest) with a short rationale for the prioritisation:

1. National Forest Inventory – Greatest level of detail of varying woodland types
2. Natural England Peaty Soils – An important carbon stock not separated from other land use types (such as grassland) within CROME data
3. Crop Map of England – Provided full spatial coverage of land use types across Lancashire at a resolution of 0.41ha but lacks subcategory detail of some land use types such as woodland and peatland.

## B.4.2. Estimating soil carbon stocks

Soil carbon stocks were estimated based on the landcover type using soil carbon factors from Natural England's (2021) review, normalised to a depth of 30cm. These values were compared with soil carbon data sourced from the UK Soil Observatory (UKSO)[32] for the County, and these broadly align with the habitat carbon factors reported by Natural England.

## B.4.3. Selecting carbon factors

Carbon densities and emission factors, for each pool within each land use type, were taken from various sources from a widespread literature review carried out by Atkins to develop the LULUCF Carbon Calculator tool applied in this project. Biomass stocks account for both biomass and dead organic matter carbon. The various sources used for both carbon stocks and estimates of emissions and removals are listed in Table B-6. To ensure the use of the most authoritative and up-to-date sources of carbon factors have been used, where multiple factors were available from different sources, data from the Natural England (2021) carbon storage and sequestration by habitat was used preferentially.

- It should be noted that differences in land quality, habitat condition, maturity and management practices can cause emissions and removal rates to vary dramatically, such that the same categories of landcover may be sinks or sources depending on these factors. Where a range of estimates were available, the central (medium, or middle ground between the highest and lowest values identified in the literature review) emissions and removals factors were selected to provide an indication of potential annual emissions and/or removals from land use types across Lancashire.
- Natural England (2021) summarises and reports these central values, such as by providing averages across different scientific studies. Condition is particularly important in the case of peatland because this can determine whether peatland represents a net sink or a net source for carbon. In this case assumptions were made about the proportion of peatland in Lancashire in a 'good' versus not 'good' condition. Different emission factors were used for these two condition categories. A more comprehensive analysis of landcover and habitat condition would be required to provide an accurate representation of LULUCF carbon stocks and annual emissions and removals across Lancashire.
- Where stocks in a particular pool are noted to be zero, this assumption is based on guidance in the 2006 IPCC guidelines[33].

[32] http://mapapps2.bgs.ac.uk/ukso/home.html?layer=mySoil&_sm_au_=iVVPNfqT6r6240W7.
[33] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_01_Ch1_Introduction.pdf.

**Table B-6 - Carbon stock density and potential emissions / removals data**

| Land use category | Subcategory | Carbon pool | Carbon stock density (tonnes C $ha^{-1}$) | Source | Medium Estimate of Annual Emission (+) or removals rate ($tCO_2$ $ha^{-1}$ $yr^{-1}$)[34] | Source |
|---|---|---|---|---|---|---|
| Forest Land | Broad-leaved, mixed and yew semi-natural woodland | Biomass | 203.00 | Natural England 2021[35] - 100 year old mixed native broadleaved woodland on mineral soil | -7.00 | Natural England 2021 - 100 year old mixed native broadleaved woodland on mineral soil |
| | | Soil | 110.00 | Natural England 2021 - 100 year old mixed native broadleaved woodland on mineral soil | | |
| | Broad-leaved, mixed and yew plantation | Biomass | 203.00 | Natural England 2021 - 100 year old mixed native broadleaved woodland on mineral soil | -7.00 | Natural England 2021 - 100 year old mixed native broadleaved woodland on mineral soil |
| | | Soil | 110.00 | Natural England 2021 - 100 year old mixed native broadleaved woodland on mineral soil | | |
| | Coniferous plantation | Biomass | 111.30 | Natural England 2021 – coniferous woodland | -15.77 | Natural England 2021 – coniferous woodland |
| | | Soil | 162.80 | Natural England 2021 – coniferous woodland | | |
| Grassland | Grassland | Biomass | 0.00 | Natural England 2021 – improved grassland | -0.36 | Natural England 2021 – improved grassland |
| | | Soil | 39.00 | Natural England 2021 – improved grassland | | |
| | Dense scrub | Biomass | 48.40 | Natural England 2021 – 70 year old scrub vegetation | -1.90 | KWT Woodland Scrub[13] (area adjusted to 1 ha) |
| | | Soil | 61.50 | Natural England 2021 Natural England 2021 – 70 year old scrub vegetation | | |
| Cropland | Arable fields | Biomass | 0.00 | Natural England 2021 – arable/cultivated land | 0.29 | Natural England 2021 0 – arable/cultivated land |

[34] While this study focuses on CO2 emissions only, LULUCF bottom up calculations covered CO2 equivalent emissions due to the available resources and literature in this topic, however, as majority of emissions/removals are CO2, this approach has been found to have a negligible impact on the analysis.
[35] Natural England Research Report NERR094 (2021) Carbon storage and sequestration by habitat: a review of the evidence (second edition)

| Land use category | Subcategory | Carbon pool | Carbon stock density (tonnes C $ha^{-1}$) | Source | Medium Estimate of Annual Emission (+) or removals rate ($tCO2\ ha^{-1}\ yr^{-1}$)[34] | Source |
|---|---|---|---|---|---|---|
| | | Soil | 57.85 | Natural England 2021 – arable/cultivated land | | |
| Wetland | Peatland / Bog – 'good' condition | Biomass | 45.50 | Natural England 2021 – blanket bog | -0.02 | Natural England 2021 – natural bog (undrained) |
| | | Soil | 155.40 | Natural England 2021 – blanket bog | | |
| | Peatland / Bog – not in a 'good' condition | Biomass | 45.50 | Natural England 2021 – blanket bog | 12.73 | Natural England 2021 – eroding modified bog (bare peat) |
| | | Soil | 155.40 | Natural England 2021 – blanket bog | | |
| | Freshwater | Biomass | 0.00 | Natural England 2021 – rivers and streams | 0.00 | Natural England (2021) report low confidence in all values with very large ranges. Freshwater atmosphere flux is generally net emissions while carbon accumulation is generally net removals. Therefore, assumed a neutral balance overall until better data is available. |
| | | Soil | 109.40 | Natural England 2021 – floodplain sediment | | |
| Settlements | Urban - Built Environment | Biomass | 0 | IPCC 2006 | 0.0 | Assumed |
| | | Soil | 0 | IPCC 2006 | | |
| Other | Dwarf shrub heath | Biomass | 16.78 | Natural England 2021 – dwarf shrub heath | 0.05 | Natural England 2021 – lowland heathlands and upland heathlands |
| | | Soil | 57.00 | Natural England 2021 – dwarf shrub heath | | |

# Appendix C. 'Bottom-up' carbon baseline results per key sector

The application of the methodology and calculations described in Appendix B have been used to generate 'bottom-up baseline estimates[36] for each key sector, as set out in the sections below.

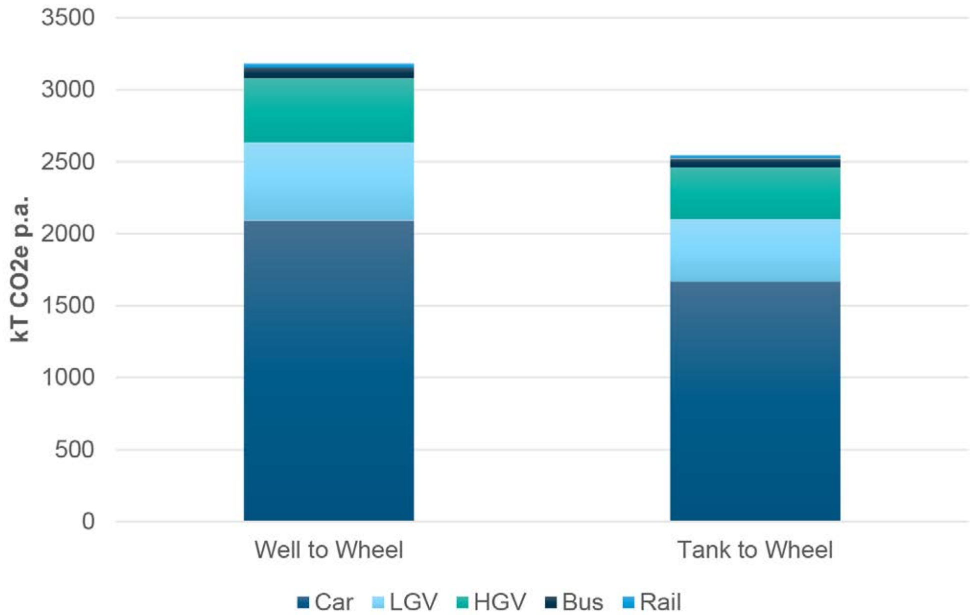
## C.1. Transport

The 'bottom-up' baseline estimate suggests surface transport emissions within the Lancashire region of 3,200 kt$CO_2$e (well to wheel) in 2018. $CO_2$ accounts for the large majority of greenhouse emissions from transport and so the total emissions of $CO_2$ only are approximately 1% lower at 3,120 kt$CO_2$ (well to wheel). Figure C-1 shows the baseline emissions estimate, disaggregated by vehicle type and shown separately for Tank to Wheel and Well to Wheel emissions.

Well to Tank emissions account for around 20% of the total Well to Wheel emissions for transport. Of the total, approximately 66% of emissions are estimated to have been generated by car travel, 17% by LGVs, 15% by HGVs, 2% by bus and 1% by rail. Road transport is therefore the key priority for targeted emissions reductions.

The 'bottom-up' baseline transport $CO_2$ emissions estimate was compared against the BEIS local authority transport emissions estimate for Lancashire local authorities for 2018. The calculated figure is within 12.5% of the BEIS estimate. The difference can be explained by minor differences in approach to speed and traffic by road type and the Well to Tank uplift applied. It is thus considered that the 'bottom-up' baseline model will allow for a meaningful assessment of pathway options for emissions reductions for the Transport sector in Lancashire.

**Figure C-1 - Baseline (2018) surface transport emissions, Lancashire, kt$CO_2$e p.a.**




Note: all figures are indicative estimates only.

Further Transport sector results are contained in Section D.7.1 with Business as Usual projections.

[36] All figures, both for carbon and financial, in this chapter are indicative estimates only.

# C.2. Buildings

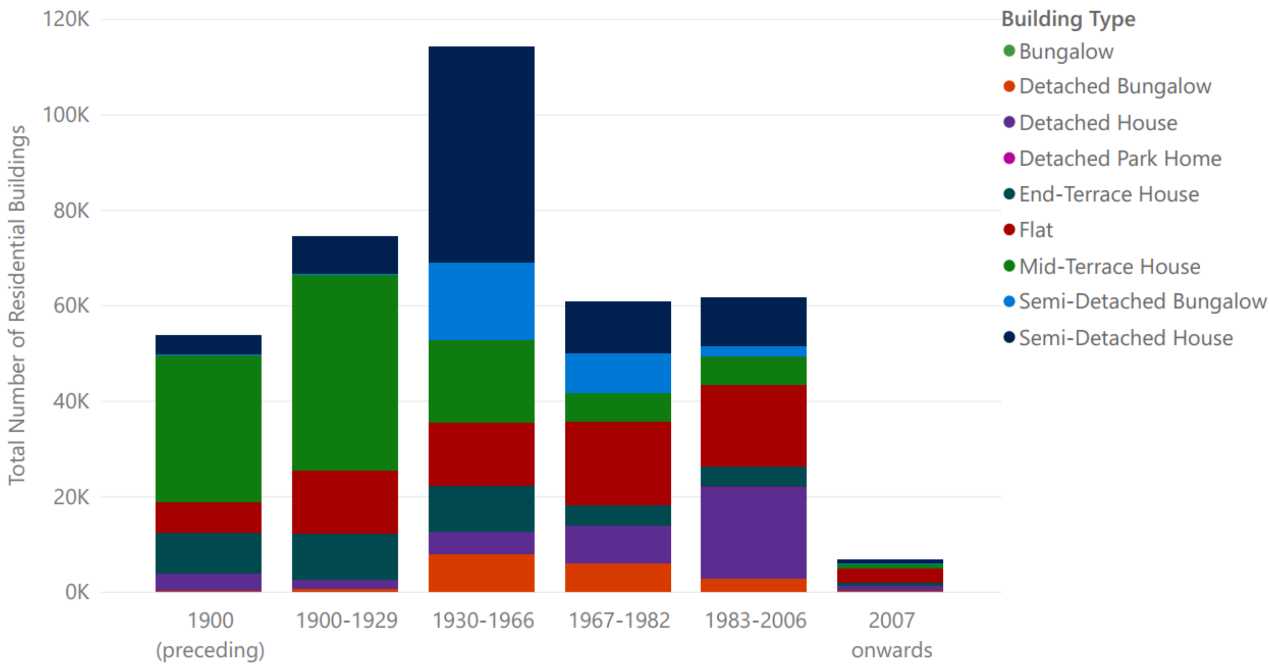
## C.2.1. Residential Building Stock Analysis

Using data from EPC certificates, the current domestic building stock in Lancashire has been analysed. This baseline calculation has been developed using the latest available EPC per domestic building. The following analysis does not consider any improvements that might have been made to the energy efficiency of the building since the latest EPC was issued.

It can be seen from the graphs below that the largest proportion of buildings were built between 1930 and 1966 and that the most common building types are mid-terrace and semi-detached. Only 6.5% of domestic dwellings in Lancashire were built after 2007 which means there is an ageing building stock which will benefit from retrofitting. The majority of dwellings are either owner occupied or privately rented, less than 15% of residential buildings in Lancashire are socially rented.

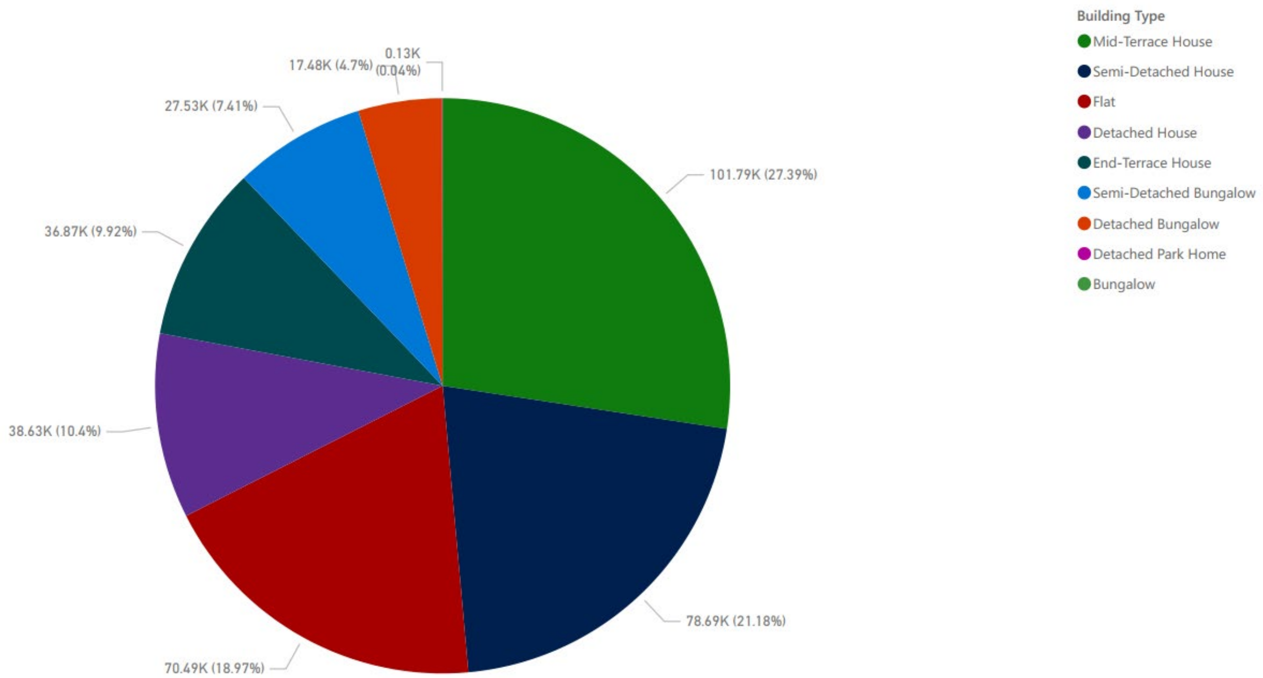
Of the EPC certificates available 132 were for detached park homes which have been discounted for the purpose of this study. This is due to their unique characteristics which would make them unsuited to the majority of interventions under investigation.

**Figure C-2 - Number of residential buildings by type and age**



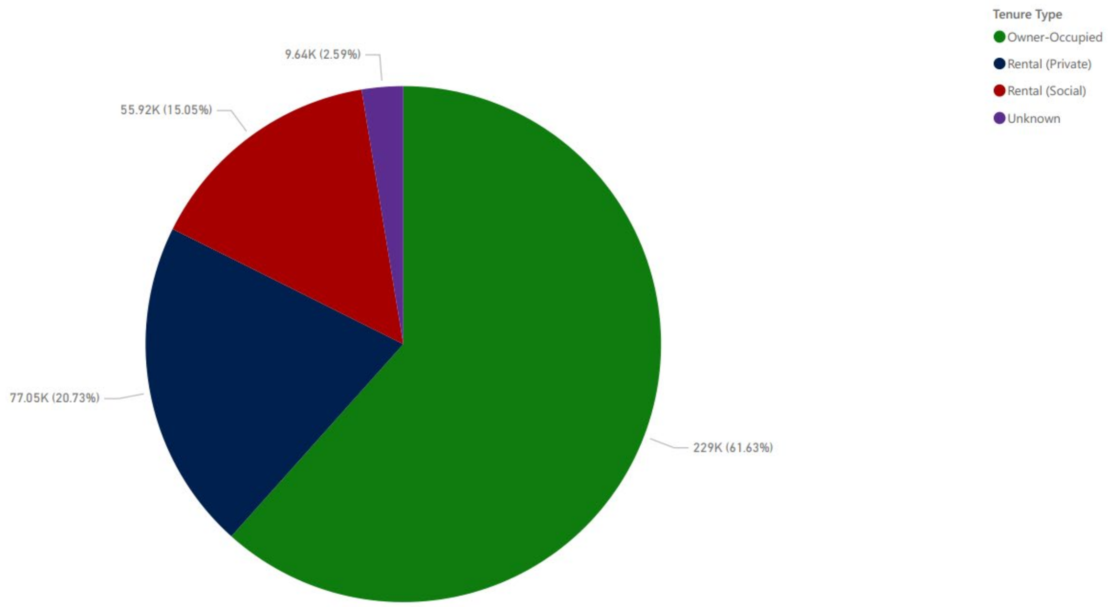

Note: all figures are indicative estimates only.

**Figure C-3 - Residential Building by % Building Type**



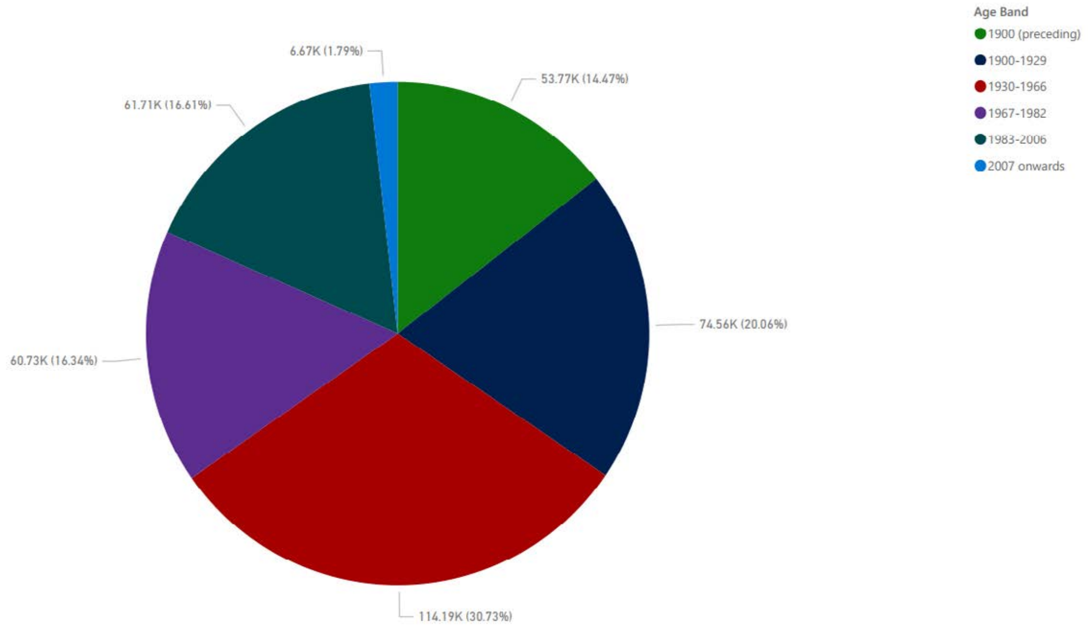

Note: all figures are indicative estimates only.

**Figure C-4 - Residential Building by % Tenure**




Note: all figures are indicative estimates only.

**Figure C-5 - Residential Buildings by % Age Band**

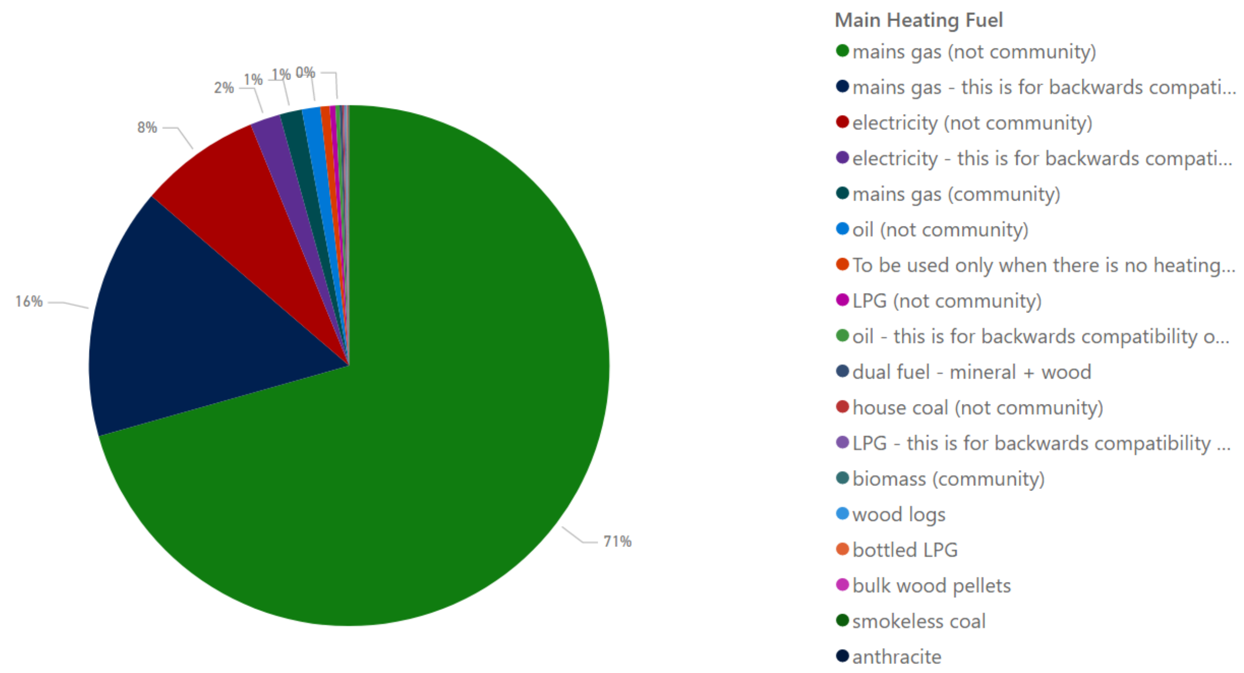



Note: all figures are indicative estimates only.

## C.3. Residential Baseline Emissions

Baseline emissions have been calculated for heating and hot water using data from the most recent EPC certificate available for each building. For all buildings with a mains gas connection, it has been assumed that gas is the fuel source, for all other buildings an electrical heat source has been assumed. Other fuel sources make up ~3% and so have not been considered in this analysis.

**Figure C-6 - Analysis of heating fuels**




Note: all figures are indicative estimates only.

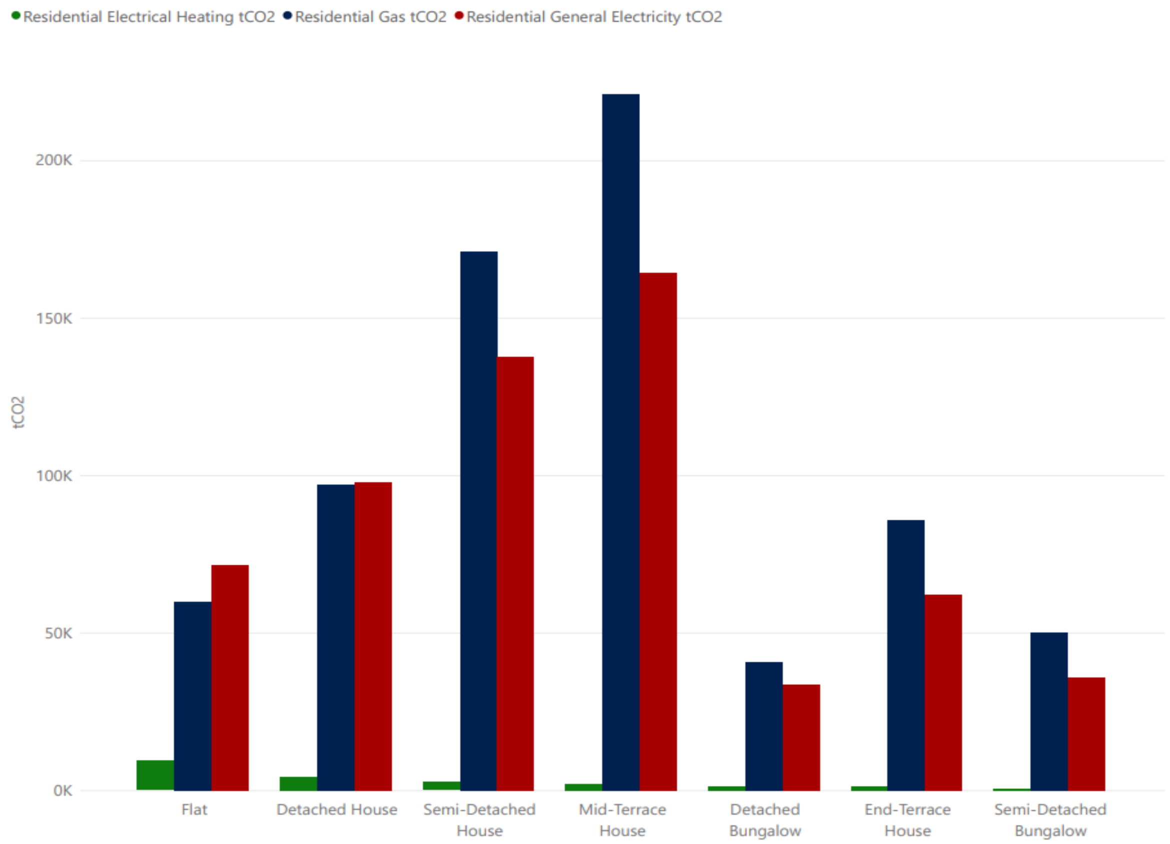
The electrical demand baseline has been estimated using the total floor area from the EPC certificates and benchmark data from CIBSE Guide F. The gas and electric kWh values have then been multiplied by the current carbon factors for each fuel shown in Table C-1.

**Table C-1 - Baseline Carbon Factors**

| Energy source | Carbon Factor (KgCO2e/kWh) |
|---|---|
| Electricity | 0.233 |
| Gas | 0.203 |

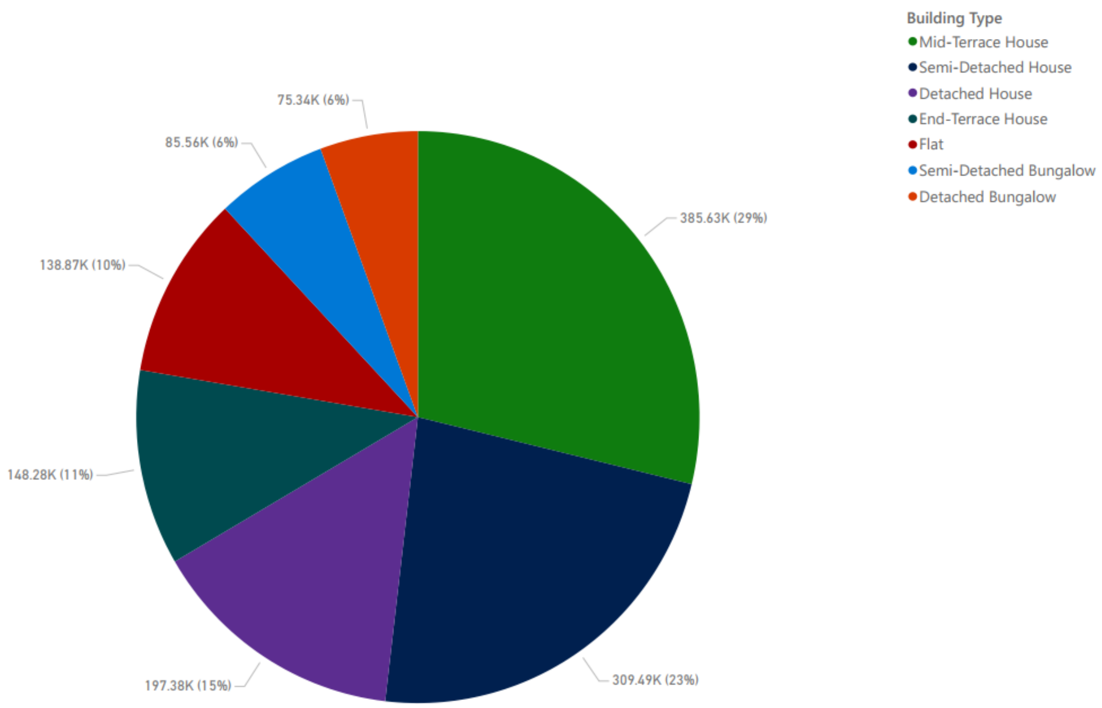
Figure C-7 and Figure C-8 show the total estimated baseline carbon emissions for residential buildings.

**Figure C-7 - Tonnes CO2 per energy source and residential building typology**




Note: all figures are indicative estimates only.

**Figure C-8 - Proportion (%) of tonnes $CO_2$ emissions by residential building typology**

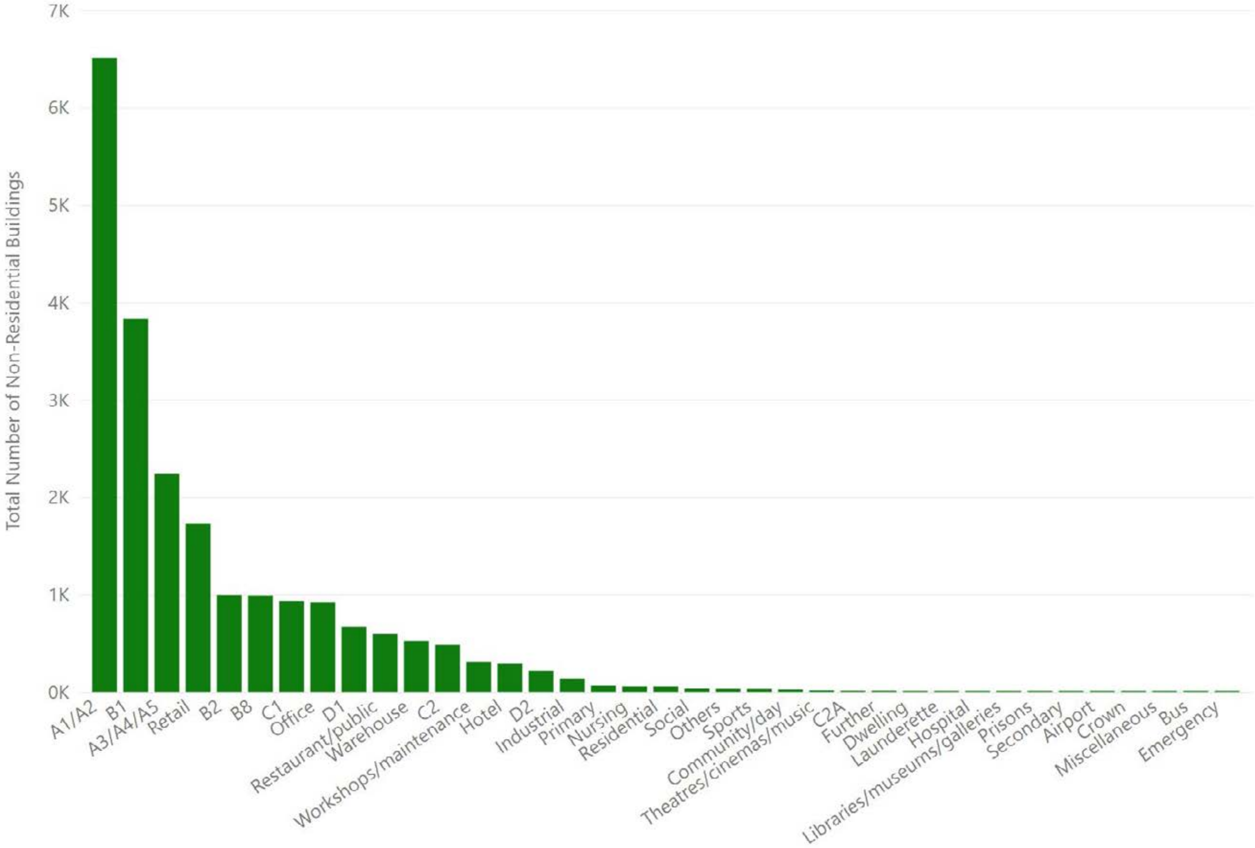



Note: all figures are indicative estimates only.

## C.4. Non-residential building analysis

Using data from council tax records and available DECC certificates for buildings occupied by a public service organisation, we have analysed the current non-residential building stock in Lancashire. The DECC certificates account for 8% of non-residential buildings. Figure C-9 shows the number of non-residential buildings per typology.

**Figure C-9 - Number of non-residential buildings, by typology**




Note: all figures are indicative estimates only.

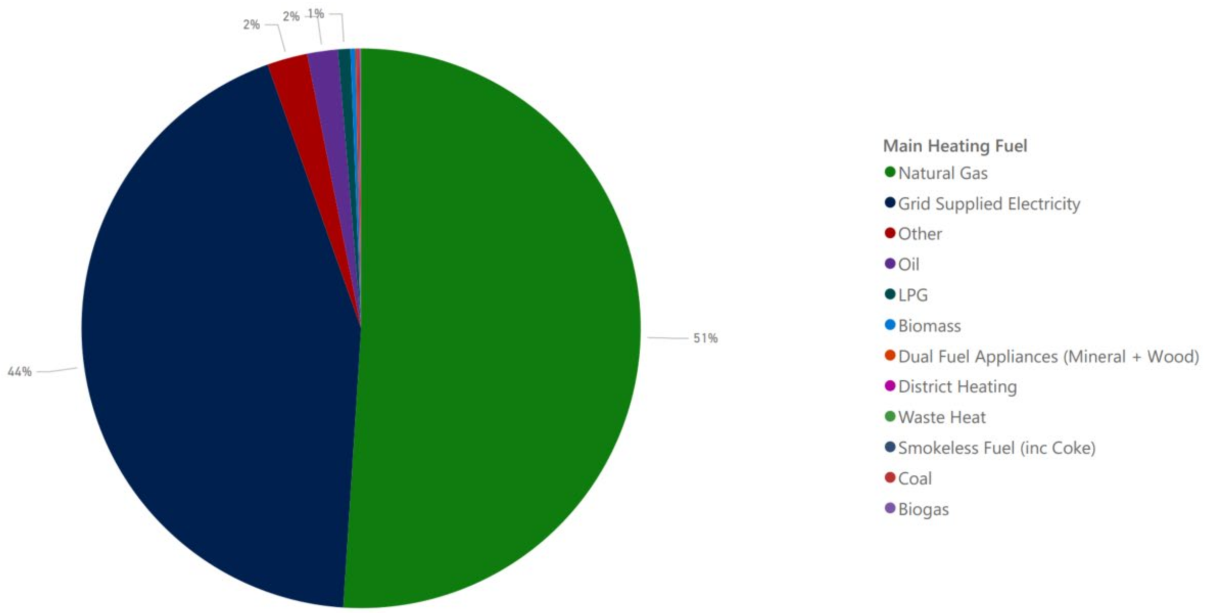
## C.5. Non-residential buildings baseline emissions

Total baseline emissions for non-residential buildings were calculated using the available information from DECC certificates and council tax information. For heating, gas and electrical heating has been considered as this makes up 95% of the demand.

For electricity baseline emissions, benchmarks have been taken from CIBSE Guide F.

Figure C-10 shows the non-residential heating fuel sources breakdown.

**Figure C-10 – Breakdown of Non-Residential Heating Fuel Sources**




Note: all figures are indicative estimates only.

## C.6. Large industrial installations

A pairing exercise was undertaken, comparing the 2018 BEIS 'Large Industrial Installations' $CO_2$ emissions for each local authority, with the list of sites with known locations as recorded within both the EA's Pollution Inventory and the NAEI. By going down to a site level, discrepancies were identified within some of the BEIS data, and a revised list produced (Table C-2), which is comparable to the BEIS 'large industrial installations', but with improved granularity at a sectoral and site by site level. Total emissions from these sites were 675,375 tonnes in 2018, 11% higher than the 607,000 tonnes reported in BEIS.

It is not possible to directly match the BEIS 'top-down' figures with the source data, without access to all of the underlying databases and assumptions used in the generation of the BEIS estimates. This is due to the crossovers between the Industrial and Commercial sector, and the split of point source emissions between the other BEIS categories of Electricity, Gas and Other Fuels. However, information from both the EA's Pollution Inventory and the NAEI can be compared with the BEIS category 'Large Industrial Installations', as split by local authority, to identify the particular sites (and sectors) that are included within the BEIS data, and to refine the national top-down figures where possible.

**Table C-2 – Compiled list of large industrial sites in Lancashire, comparable with the BEIS 'large industrial installations'**

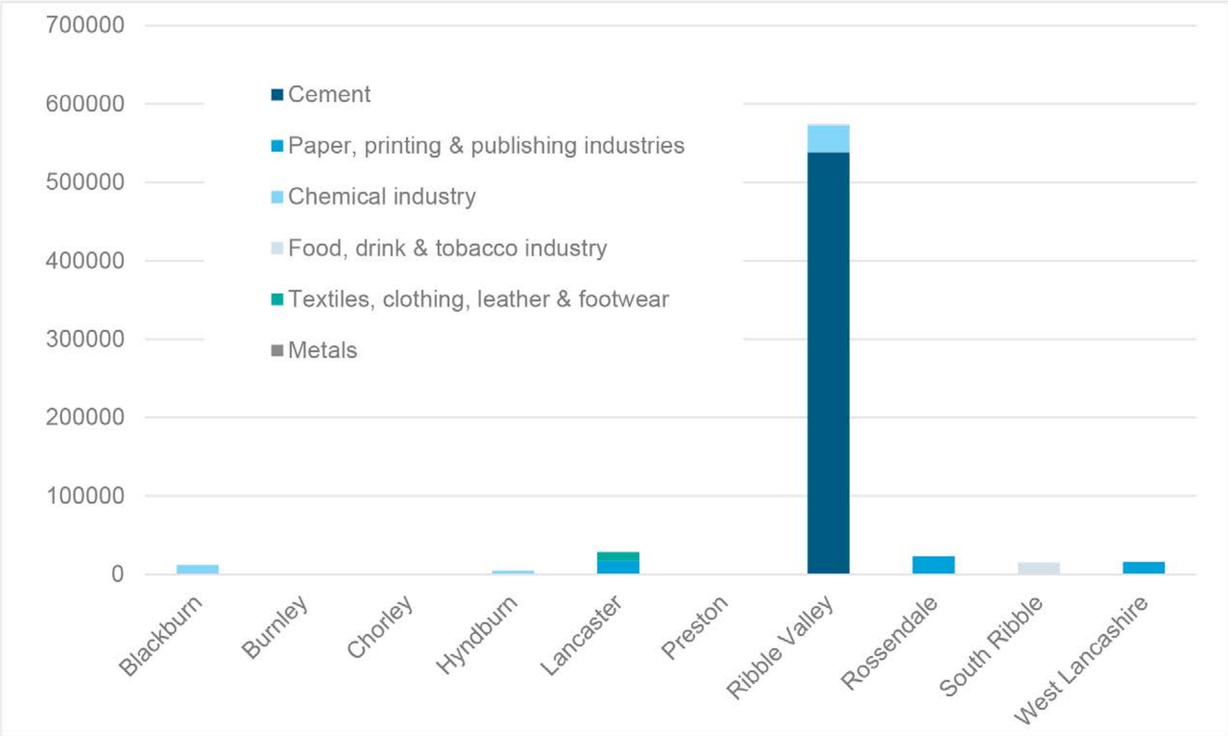
| Authority | Sector | Site | 2018 $CO_2$ emissions (t) |
|---|---|---|---|
| Blackburn | Chemical industry | Lucite International UK Limited | 2,412 |
| Blackburn | Chemical industry | Perspex International Ltd | 9,744 |
| Burnley | Metals | Heasandford Surface Treatments Hycrome (Europe) Ltd | 822 |
| Chorley | Textiles, clothing, leather & footwear | Pincroft Dyeing and Printing Co. Ltd | 123 |
| Hyndburn | Chemical industry | William Blythe Limited | 4,787 |

| Authority | Sector | Site | 2018 $CO_2$ emissions (t) |
|---|---|---|---|
| Lancaster | Textiles, clothing, leather & footwear | Abaris Holdings Ltd | 11,354 |
| Lancaster | Paper, printing & publishing industries | Northwood Tissue (Lancaster) Ltd | 5,222 |
| Lancaster | Paper, printing & publishing industries | Sofidel UK Ltd | 12,086 |
| Preston | Chemical industry | Incorez Limited | 45 |
| Ribble Valley | Chemical industry | JOHNSON MATTHEY PLC | 34,549 |
| Ribble Valley | Food, drink & tobacco industry | Dunbia (England) | 2,030 |
| Ribble Valley | Cement | Hanson Cement Ltd. (formerly Castle Cement) | 538,296 |
| Rossendale | Paper, printing & publishing industries | Essity UK Ltd (Stubbins Mill) | 22,923 |
| South Ribble | Food, drink & tobacco industry | AB InBev UK Ltd (Samlesbury Brewery) | 14,821 |
| West Lancashire | Paper, printing & publishing industries | Essity UK Ltd (Tawd Mill) | 16,163 |
| | | **TOTAL** | **675,375** |

Note: all figures are indicative estimates only.

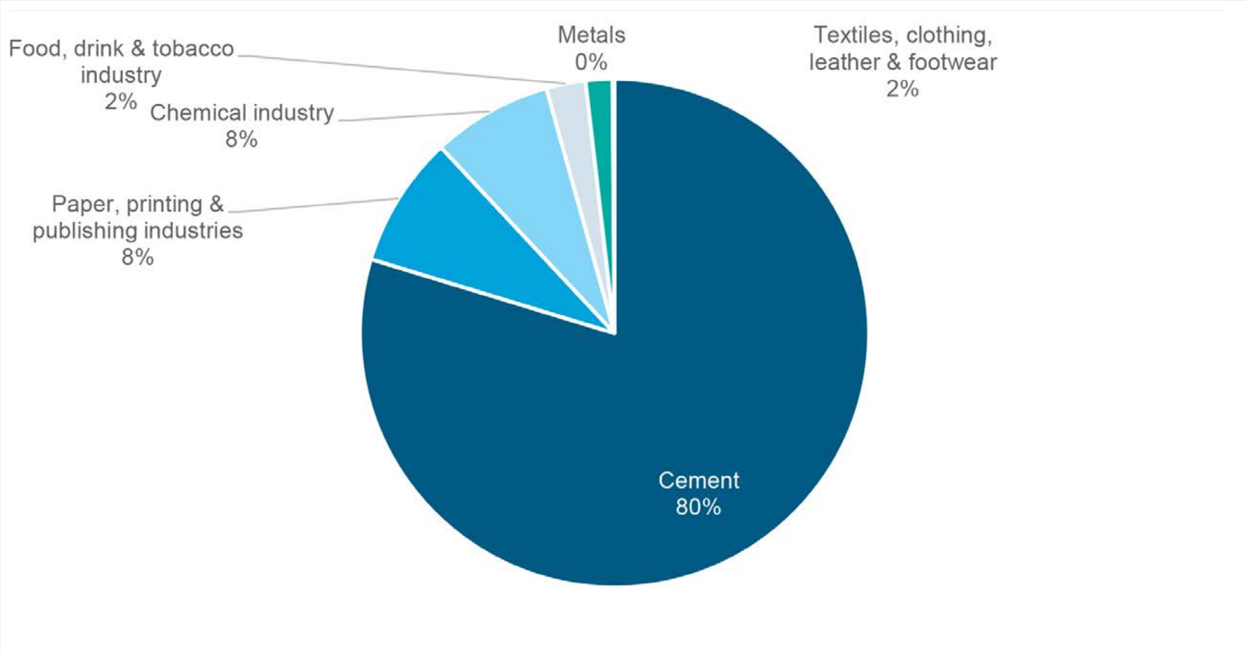
Emissions from the Hanson Cement in Ribble Valley account for 80% of total emissions (Figure C-11), with emissions from Paper (four sites) and Chemical (five sites) sites accounting for 8% each. The remaining 4% of emissions are split between Food and Drink, Textiles and Metal industries (Figure C-12).

**Figure C-11 – $CO_2$ emissions from large industrial installations in Lancashire in 2018 by sector and by local authority**



Note: all figures are indicative estimates only.

**Figure C-12 – Proportion of $CO_2$ emissions from large industrial installations in Lancashire in 2018 by sector**




Note: all figures are indicative estimates only.

The main contributing emissions source from large industrial installations in Lancashire is the Hanson Cement site, which suggests that direct engagement with Hanson Cement is required to target emissions reduction opportunities and interventions. Other large industrial emissions sources include Paper, Printing and Publishing as well as the Chemical industry. Direct action should also be taken to reduce emission from these key sources.

Food, Drink & Tobacco and Textiles, Clothing, Leather and Footwear are relatively minor emissions source when compared to cement, paper or textiles but opportunities to reduce carbon emissions from these sources should not be overlooked as reductions from all sources will be required to align with target pathways.

Table C-3 below shows a comparison between the Lancashire specific 'bottom-up' industrial baseline and the BEIS 'top-down' baseline for large industrial installations. The calculated figure for Lancashire is within 11% of the BEIS estimate. The Lancashire specific baseline is equivalent to the 'Large Industrial Installations' category within the BEIS data but provides emissions detail at a site by site level. It is thus considered that the 'bottom-up' baseline model will allow for a meaningful extrapolation of pathway options for the emissions reduction by the Industry sector in Lancashire.

**Table C-3 – Comparison between NAEI and EA PI industrial emissions data with BEIS top down data**

| Local Authority | Emissions ($tCO_2$) | | Reasons for difference |
|---|---|---|---|
| | BEIS: Large Industrial Installations | Lancashire Detailed Industrial Baseline | |
| Blackburn with Darwen | 31,318 | 12,155 | BEIS appears to include a CHP facility (Blackburn Paper Mill CHP Facility, operated by Scottish Power), which should be categorised separately. It does not include two Chemical sites which are included within the NAEI. |
| Blackpool | - | - | No difference |
| Burnley | 71 | 822 | Differences not significant. NAEI detailed information |
| Chorley | 123 | 123 | No difference |
| Fylde | 732 | - | Differences not significant. No information on specific sources within NAEI or EA PI. |

| Local Authority | Emissions ($tCO_2$) | | Reasons for difference |
|---|---|---|---|
| | BEIS: Large Industrial Installations | Lancashire Detailed Industrial Baseline | |
| Hyndburn | 5,898 | 4,787 | Differences not significant. NAEI detailed information |
| Lancaster | 5,660 | 28,662 | BEIS doesn't appear to include Textiles and Paper plant listed in the NAEI. |
| Pendle | - | - | No difference |
| Preston | 45 | 45 | No difference |
| Ribble Valley | 541,415 | 574,875 | NAEI and EA PI include emissions from Chemical site |
| Rossendale | 12 | 22,923 | NAEI includes detailed information on Paper site |
| South Ribble | 3 | 14,821 | NAEI includes detailed information on Food/Drink site |
| West Lancashire | 21,751 | 16,163 | NAEI includes detailed information on Paper site |
| Wyre | 7 | - | No significant difference |
| **Total** | **607,032** | **675,375** | **+68,342 (+11%)** |

Note: all figures are indicative estimates only.

## C.7. Land use, land use change and forestry (LULUCF)

The various land use types identified across Lancashire are displayed in Figure C-13.

**Figure C-13 - Land use map of Lancashire**

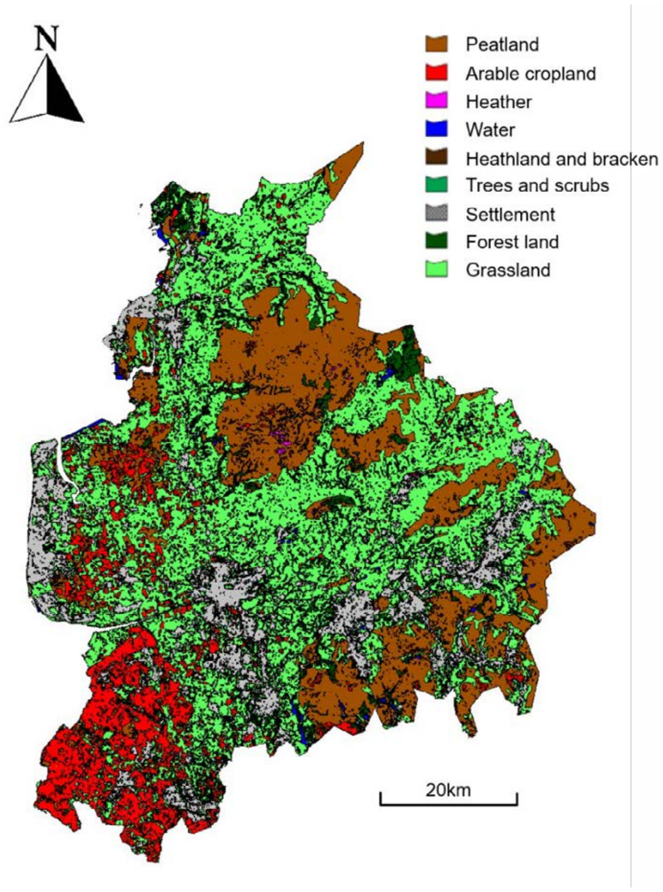


Table C-4 shows the total areas of the different land use types in Lancashire and presents the estimated carbon stock in each, accounting for both biomass stocks and soil stocks. All literature values in Table C-4 originate from the Natural England 2021 report[37].

The total estimated baseline carbon stock is approximately 43,923,285 tonnes C. Important land uses for carbon storage in the study area are Grassland (which holds around 47% of total carbon, as a result of occupying 43% of total land area), Peatland (32% of stored carbon and 23% of the land area) and Broadleaved Woodland (storing 12% of total carbon across all woodland types, covering 8% of land area). The urban built environment is the lowest store, (assumed zero as guided by the IPPC methodology).

In terms of annual removals, Broad-leaved semi-natural woodland is estimated to be providing the largest annual removal of carbon of -103,915 $tCO_2$ per year, followed by coniferous plantation at -53,992 $tCO_2$ per year and grassland -47,038 $tCO_2$ per year. Peatland has the potential to either be a net source or net sink of carbon depending on its condition. Lancashire's peatland which is estimated to be a 'good' i.e. near natural and undrained condition (13%) may sequester -180 $tCO_2$ per year whereas that which is estimated to be not in a 'good' i.e. a degraded condition (87%) may be a net emitter of 766,096 $tCO_2$ per year. This estimate is based on national distribution of peatland condition based on designated site data. Establishing Lancashire's peatland condition will be essential to enhancing the accuracy of these estimates, and is especially important because Peatland stores approximately 32% of Lancashire's total carbon stocks. Arable fields also have the potential to be a substantial net emitter, estimated at +11,888 $tCO_2$ per year. This is an important factor, considering that cropland may hold up to 5% of Lancashire's carbon stocks.

It should be noted however, that all land use types may be sources or sinks, depending on their age, quality and the management practices used, however for this baseline assessment we do not have sight of the land management practices across land use types in Lancashire; studies of much greater detail would be required to gain a full understanding of the annual balance of emissions and removals from land use.

The total estimated LULUCF baseline of +551,689 $tCO_2e$/year emitted is within an acceptable margin of error compared to the BEIS baseline for LULUCF for Lancashire of +408,630 $tCO_2$/year. The difference is considered likely to be the result of subtle differences in methodologies and the datasets consulted in landcover mapping This means that potential emission reduction and removals for LULUCF based interventions can be explored, at a high level, using the landcover mapping data and emission factors collated in the baseline. The emissions and removals baseline should, therefore, be taken as a guide for the purposes of calibration for the exploration of LULUCF interventions only. It is recommended that this analysis be built upon in follow-on stages of work to take a habitats-based approach using datasets such as the Priority Habitat Inventory and SSSI condition data. This would enhance the accuracy of the LULUCF baseline and quantification of the removals potential.

[37] Natural England Research Report. NERR094. Carbon storage and sequestration by habitat: a review of the evidence (second edition)

Table **C**-4 - Lancashire estimated **LULUCF** baseline

| High level habitat | Habitat list | Literature Values | | | | Baseline values | | |
|---|---|---|---|---|---|---|---|---|
| | | Estimate of net annual emissions (+) or removals (-) rate ($tCO2e\ ha^{-1}\ yr^{-1}$) | Biomass stocks tC/ha | Soil stocks tC/ha | Combined stocks tC/ha | Land use Extent (ha) | Estimate of net annual emissions (+) or removals (-) rate ($tCO2e\ yr^{-1}$) | Total stock tC - baseline whole area |
| Woodland | Broad-leaved, mixed and yew semi-natural woodland | -7.0000 | 203 | 110 | 313 | 14,845 | -103,915 | 4,646,485 |
| | Broad-leaved, mixed and yew plantation | -7.0000 | 203 | 110 | 313 | 1,777 | -12,439 | 556,201 |
| | Coniferous plantation | -15.7667 | 111 | 163 | 274 | 3,420 | -53,922 | 937,422 |
| | Dense scrub | -1.8995 | 48 | 62 | 110 | 4,665 | -8,861 | 512,684 |
| Semi-natural grassland | Improved grassland* | -0.3600 | 14 | 145 | 159 | 130,662 | -47,038 | 20,766,547 |
| Enclosed farmland | Arable fields | 0.2900 | 0 | 58 | 58 | 40,993 | 11,888 | 2,371,445 |
| Mountains, moors and heaths | Peatland (overall i.e. a sum of both conditions) | N/A | N/A | N/A | N/A | 69,200 | 765,916 | 13,902,280 |
| | Peatland / Bog - good condition | -0.0200 | 46 | 155 | 201 | 8,996 | -180 | 1,807,296 |
| | Peatland / Bog - NOT in good condition | 12.7250 | 46 | 155 | 201 | 60,204 | 766,096 | 12,094,984 |
| | Dwarf shrub heath | 0.0540 | 17 | 57 | 74 | 1,132 | 61 | 83,516 |
| Freshwater, open water, wetlands and floodplains | Freshwater( Rivers and Streams) | 0.0000 | 0 | 109 | 109 | 1,341 | 0 | 146,705 |
| Urban | Urban - Built Environment | 0.0000 | 0 | 0 | 0 | 39,271 | 0 | 0 |
| | **Total**** | N/A | N/A | N/A | N/A | 307,306 | **551,689** | 43,923,285 |

- * Note all grassland detected classified as "improved grassland
- ** Note totals only considers peatland overall as a sum of the two conditions (avoids double counting)

# Appendix D. Deriving the Business as Usual scenario

When considering a route map to achieve Net Zero carbon in Lancashire, the first step is to predict future carbon emissions of the area as if no external intervention was taken over a specified timeframe, i.e. the business-as-usual scenario (BAU). This may be the result of already committed activities, construction of new projects, changes in building occupancy, as well as external impacts such as electrical grid decarbonisation. Working with Lancashire, an understanding of the current pipeline of committed activities has been developed to ensure that any associated emissions fluctuations are included in the BAU scenario. A broad overview of any macro changes that will impact the baseline data when projecting these emissions into the future has also been considered.

The BAU scenario to 2050 has been established with the core sectors as a focus; this also captured the carbon sequestration potential from land use, land use change and forestry (LULUCF). This allows for an accurate comparison against any potential carbon reductions to be calculated for other scenarios.

The modulation from the baseline 2018 data will result from the following factors:

- Expected growth in housing, population or economic activity (GVA);
- Policy at a national or regional level which are likely to stimulate a major change in activity;
- Further committed major projects or schemes in the county, which will result in emissions in future years which have not been captured within the baseline; and
- Any other considerations relating to individual sectors.

Note that in most cases, broad-based growth factors will already have been captured in the projections provided by sectors; furthermore, there may be additional policy changes which apply only one sector.

Aside from these modulating factors, the baseline data has been assumed as constant from 2018 to 2050, and the BAU projections have been extrapolated in this way to give a comprehensive understanding of the trends if no action were taken at a county level.

## D.1. Broad-based macro-trends

In the event that no change is made at a county level, Lancashire in 2050 will nevertheless have different characteristics to today. External changes to the way that energy is supplied and consumed, as well as a range of societal changes, will impact upon how many emissions are produced to fulfil the county's needs across sectors. This BAU scenario acknowledges and considers the following trends:

- Growth factors;
- Energy supply and its carbon intensity; and
- Impact of the COVID-19 pandemic.

### D.1.1. Growth factors

The factors that could be used to capture likely changes to future activity in the county at a broad level are given below, including how they are incorporated into our BAU assessment:

- **Population growth**: The change in population over time will have an impact at a county level on the growth in trips (transportation) and demand for housing and associated usage. The growth in trips associated to population change has been factored into the transport methodology.
- **Housing growth**: The change in housing has been captured within the assessment for buildings.
- **Gross value-added (GVA) growth**: The change in economic activity has been captured in the industry sector only, to avoid any potential double-counting with other macro-trends already captured in other sectors. Our evidence review has identified a growth in economic activity of 0.8% per annum as far as 2033. In the absence of further data, we have assumed a constant from 2033 to 2050. Energy supply & consumption. For the transport sector forecasts, the Department for Transport's estimates account for the impact of economic growth on forecast income and therefore levels of trip making and car ownership.

### D.1.2. Energy supply

The supply of electricity is likely to reduce in its 'carbon intensity' in years to come – that is, the quantity of embodied emissions per unit of electricity arriving to domestic, commercial and industrial sites. The opportunities for renewable energy sources to supply electricity in the local region will likely improve the availability of green electricity. The power sector as a whole reduced its annual emissions from 1990 to 2017 by over 60%38; and National Grid ESO predicts in one of its scenarios that 76.5% of the required electricity across the UK will come from renewable sources by 2050 (in the Customer Transformation scenario), or 53% in the Steady Progression scenario[39].

The baseline data have been modulated in line with the carbon intensity projections for electricity drawn from BEIS (2019) Commercial / Public sector grid emissions factor projection trends used to estimate and applied to the domestic and commercial / industrial electricity categories. BEIS provides annual grid carbon intensity figures to capture activity between 2018-50; it assumes that there will be a further 81% reduction in emissions for each unit of electricity consumed over this period.

Note that the methodology has drawn from BEIS (2020) electricity usage projections to estimate changes in electricity demand and emissions factors. These projections are based on policies and measures[40] including increased smart metering, energy performance standards improvements and increased use of renewables.

For gas, a constant carbon intensity per unit of gas supplied has been assumed.

The key project that stands to displace the current rate of gas consumption available to the region before 2050 is HyNet North West (see Section D.3.1 below). This development could make a moderate impact on the energy supply to the county by itself, depending on how much energy can be made available from the Cheshire-based facility. Moderate assumptions have been made about how much will be supplied in the long term, based on the current direct of travel for the facility.

See also Section D.3 below for further evidence on energy supply.

### D.1.3. COVID-19 considerations

While the COVID-19 pandemic has created a range of large-scale shifts in behaviour which were not captured within the 2018 baseline, it is too soon to tell whether these shifts will become permanent in a way that has a meaningful impact at county level on carbon emissions. Indeed, we are not currently able to obtain reliable data for reporting relating to 2020, the first year of the pandemic, or to subsequent years.

We have therefore not sought to capture the impact of the COVID-19 pandemic within the BAU projections. The dramatic changes it has brought forward nevertheless represent opportunities to embed permanent shifts, which we highlight as we identify and assess potential interventions that could be taken by the county.

## D.2. Impacts of policy

### D.2.1. National and regional

The following key national and regional documents as well as documents from the private sector have been highlighted as potentially significant to the Business as Usual scenario. These are summarised in Appendix A – Evidence Review.

- Energy White Paper (December 2020)
- Industrial Decarbonisation Plan (March 2021)
- the Transport for the North Transport Decarbonisation Strategy
- Net Zero NW Cluster Plan (2020)
- National Grid, Future Energy Scenarios
- Energy North West Limited documents
- Renewable Energy evidence project in support of Greater Lancashire Plan: Lancashire County Council has commissioned a Renewable Energy report separately, in parallel with this study. There are 96MW of grid-scale renewable energy power production capacity that have been approved with planning permission in Lancashire, which will come onstream in coming years, but which have not been captured within the baseline. There are applications submitted that if approved, would bring a further 37.5MW of capacity in the region. These installs would be supported by 175MW (approved) and 75MW (application) of battery storage capacity.

[38] Net Zero - The UK's contribution to stopping global warming - Climate Change Committee (theccc.org.uk)
[39] Future Energy Scenarios | National Grid ESO.

[40] BEIS (2020) Updated 2019 Energy & Emissions Projections v1.0 (Annex D: Policy savings in the projections).

Finally, there are 170MW of additional renewable power capacity at mid-scale or micro-generation expected between now and 2030. This breaks down as 74% solar PV, and 26% on-shore wind (primarily large capacity wind farms). While wind power has recently been introduced into 'contracts for difference' auctions by the UK Government following their removal in 2015, there is a lack of focus on solar in recent UK government strategies, which implies that there will be only a modest uptake in the short to medium term[41].

The total potential capacity that could be present by 2030, which was not present in the baseline, is 303.5MW of power generation supported by battery storage representing 82% of additional capacity. The 2.65MWh that this would provide is equivalent to 7.7% of the total energy demand in Lancashire in 2018, and 12% of the expected energy demand in 2050 (according to the Balanced Scenario set out by ENWL and Cadent).

## D.2.2. Major committed projects

The following projects have been advised as confirmed to progress in the intervening years beyond 2018 – i.e. having already received planning permission – which will not have been captured within the 2018 baseline data.

### Central Lancashire

The multi-purpose development scheme was approved for construction in 2017, to be completed no later than five years forward. The result will be an increase of 210 residential units, 10,800m$^2$ commercial, 36,000m$^2$ office space and 12,000m$^2$ other non-domestic (hotel, gym, creche/nursery, uses). In addition, there will be a parking provision of 3,218 new spaces for cars, 304 spaces for bicycles and 90 spaces for motorbikes[42]. Only 10 electric vehicle charging points are explicitly enumerated in the planning application; the application refers to a sustainable transport plan, and emphasises journeys via different modes, such as cycling.

From a traffic perspective, the majority of trips generated to the site can be assumed to be drawn from in-county, serving as a central location for trips of different kinds which would have otherwise been fulfilled elsewhere within the county, albeit in a more distributed way. Our assessment methodology is based on data for interior and county border trips; given this, we can assume that any additional trips from out of county will be negligible.

### West Preston Distributor road

This scheme secured planning permission and a compulsory purchase order for the land was issued in 2019. The supporting information for the scheme lists the distributor road as providing a reduction in traffic emissions, except for the M55 J1, which will experience an increase in peak traffic volumes of 12-18% in both directions[43]. For the purposes of carbon emissions, we regard this as a small reduction of a scale that will not affect the broader BAU projections.

The Distributor road forms part of the Northwest Preston Masterplan and will enable more efficient journeys for an increased number of people in the new development. The detailed emissions data are not available across the whole scheme, so any increased emissions due to housing will be included within the housing growth factor.

In a similar way to the Central Lancashire development, this scheme can be assumed to rebalance traffic internally within the Preston area, and by extension within the county. Although the scheme will result in a moderate alleviation of congestion at a local level, the extent of this benefit will be very limited when evaluated at a county level. Therefore, this scheme will have a negligible impact on emissions.

### Blackpool Central

This is a £300m scheme which, when complete would aim to attract an additional 600,000 visitors per year. The initial phase involves the re-location of the existing court building and construction of a multi-storey car park. For our calculation, we will assume that Phase 4 of this scheme will be complete by 2030, and that the number of visitors is equivalent to the number of trips or 'people days' to the town centre. We further assume that 80% of these visits will be via private car.

The leisure and attraction nature of the scheme means that a meaningful number of visitors will come from out of county in future. Compared with our baseline of 540m single destination car trips per annum (including visitors from outside of county)[1], this additional number of visitors would only register as a 0.11% increase in the number of cross county border trips that currently take place on a daily basis, so is also negligible in relation to the broad number of trips on which we have based our assessment.

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[41] Jacobs (2021), separate commission by Lancashire County Council in support of the Greater Lancashire Plan.
[42] 07/2017/0211/ORM | Hybrid planning application for the South Ribble area; assumes all office space is at ground floor so that one parking space is required for all 36,000m2 approved.
[43] https://www.lancashire.gov.uk/media/896806/environmental-impacts-and-mitigation-3-landscape-traffic-and-transport.pdf.
[1] According to the DfT's National Trip End Model (NTEM) approximately 680 million trips p.a., of which approximately 300 million were car trip, with destination in Lancashire, drawn from both within and outside the county. Converting to single-direction trips, this would result in approximately 540 million trips in and out.

### HyNet North West

In addition to these, it is also worth considering the HyNet development based in Cheshire. This is an experimental 'cluster' of new low-carbon alternative technologies, including carbon capture and storage and hydrogen production. It is currently being taken forward for permitting, with investment from BEIS co-funded by private industry. However, it is one of seven clusters in competition for full backing by central Government. As part of its Industrial Decarbonisation Plan, Government has committed to support two such clusters by 2025 and two further clusters by the early 2030s.

If taken forward, HyNet's first phase is expected to open in 2026 and run for 25 years; but it would expand in a second phase, due to open the following year (and also to run for 25 years). If the infrastructure and resulting energy supply are to be extended to Lancashire, as is in view, this could result in a change in the energy mix available to Lancashire, which could have an impact on industry through direct carbon capture or through natural gas displaced by hydrogen for space heating.

It is too soon to quantify the impact of this development in terms of carbon capture implications, not least because it has yet to be approved, and a number of national clusters are competing for funding from Government announced in the Energy White Paper.

By 2026, the HyNet development is expected to produce approximately 5.3TWh of hydrogen per annum, which could displace 200,000$Nm^3$ of natural gas. If all of that energy were to be diverted to Lancashire from its home in Cheshire, this would serve 37.5% of the total Lancashire energy demand across industry, transport and buildings. Although not all this energy will be supplied to Lancashire, any portion being made available to the county could have a moderate impact on the carbon emissions embedded within the energy system. We have assumed that 5% of the hydrogen energy from HyNet will become available to industry in Lancashire from 2030, rising to 10% by 2040. This will have the effect of displacing approximately 88% of the natural gas currently utilised by industry across high-temperature processes and space heating, according to the Lancashire 2050 Balanced Scenario produced by ENWL and Cadent.

### Other non-committed schemes

Finally, we note the following projects which are in the pipeline of planning development, and so do not form part of the BAU scenario – or for which there are not enough data to make a quantified assessment.

- **South Ribble Western Distributor (A582 Dualling)**: This scheme is due to progress to Outline Business Case in 2021. It will upgrade lengths of three roads in the district to dual carriageway.
- **Blackpool 'Multiversity' campus**: This £100m development aims to offer high-quality reskilling opportunities with a technical and professional curriculum, co-created with local employers and in partnership with Lancaster University. It will support skills growth in Lancashire, and is supported up to £10m by the Town Deal, with the remainder co-funded through Blackpool Council capital budgets. The Multiversity is soon to enter Master planning stage, and is not considered as part of the Business as Usual since planning permission has not yet been granted.
- **Local transport developments in Blackburn**: The extension of the Tramway Extension, along with a new bus hub on Corporation Street and increase in the number of bus stops, will have a minor negative impact on traffic-based emissions in Blackburn. The Local Transport Plan 2018-21 estimates £800,000 of costs of these two schemes taken together. While this infrastructure will support mode shift at a local level within Blackburn, its impact at a county level is likely to be minimal as far as reducing quantity of car trips is concerned.
- **M6 Lune Gorge**: This scheme is currently in outline design and will be a like-for-like replacement of seven bridges in Lune Gorge. This is not expected to make any long-term differences to traffic patterns, and the replacements will mostly take place in Cumbria, so are likely to have minimal impact on emissions from traffic or construction activity during the replacement period.

## D.3. Other considerations at a sector level

### D.3.1. Transport

Our estimates of future BAU transport emissions have taken account of three key influences through time:

- Change in traffic levels, accounting for influences such as population growth and changes in income and car ownership;
- Change in emissions factors by vehicle type; and
- Change in vehicle fleet composition.

Future traffic levels were estimated from the 2018 estimates using growth factors by road type and vehicle type from the DfT's Road traffic forecasts 2018 for the North West. The DfT's Reference Scenario assumptions on population, income and car ownership changes for the North West were used, producing traffic estimates by road type and vehicle type for the years 2025, 2030, 2035, 2040, 2045 and 2050.[44]

Future year emissions factors by vehicle type were derived from the base year emissions factors (based on fuel/energy consumption by vehicle type and speed), adjusted for assumed improvement in vehicle efficiency through time (based on DfT TAG assumptions) and BEIS national estimates of decarbonisation of electricity generation.

## D.3.2. Large Industrial Installations

We anticipate that a proportion of industrial processes currently fulfilled through natural gas will in future transfer to electricity. The 'Balanced Scenario' for Net Zero emissions provided by ENWL states that use of electricity in these processes will increase from 25% today to 70% in 2050. However, this presents a view in which some interventions have been taken at a national and regional level to push industry away from natural gas usage. It is also not possible to map the allocation of emissions from the BEIS baseline data onto this leveraged scenario provided by ENWL.

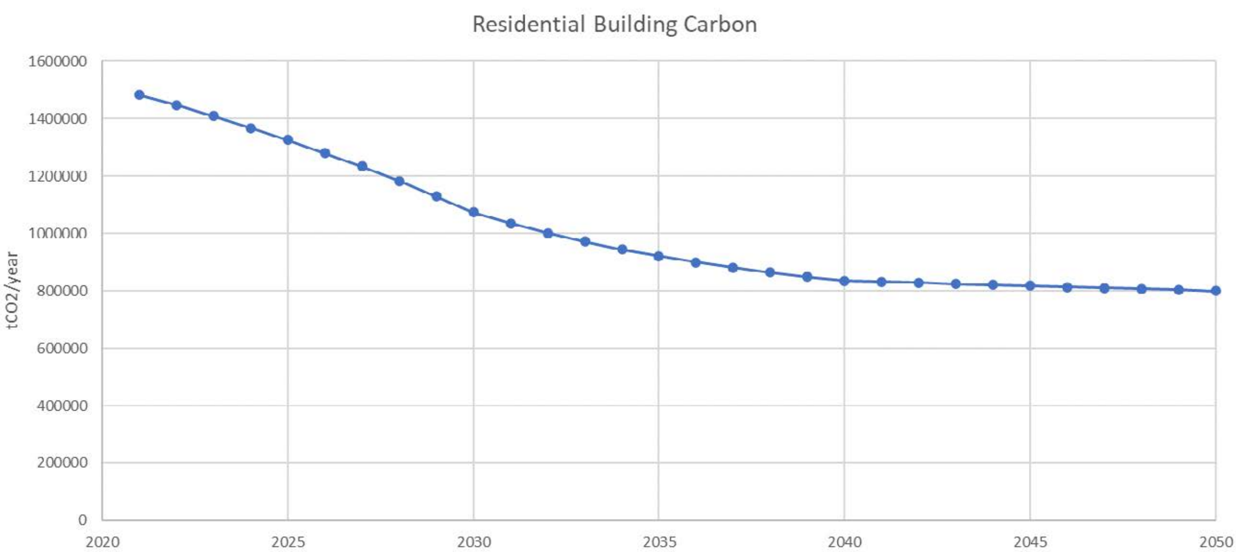
In the BAU scenario, it has been assumed that there will be a gentle 30% 'transfer' of energy demand away from natural gas towards electricity by 2050, which will progress at a constant rate throughout the period.

The Committee on Climate Change (CCC) projections have been used to assess the decline in emissions by industrial sector capture all current climate policy committed by UK Government. It has been assumed that CCC will have been apprised of any legislation due to be announced in the Industrial Decarbonisation Strategy published in March 2021, when it published its sixth carbon budget in December 2020, where we have drawn our BAU carbon factors from.

## D.3.3. Buildings

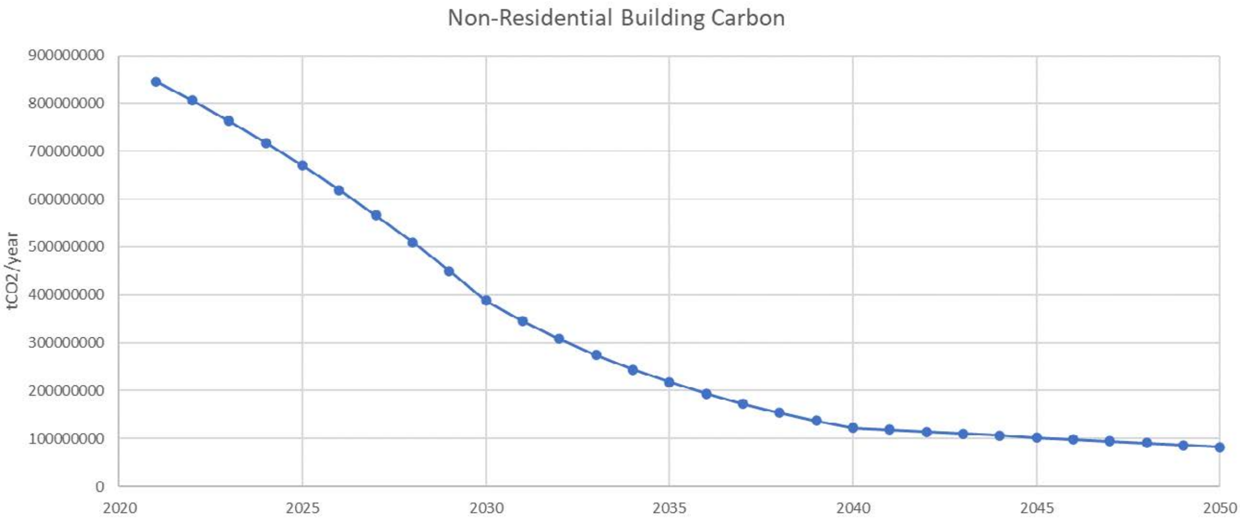
It is anticipated that the National Grid rapid decarbonisation in the UK due to an increase in renewable energy sources including offshore wind and solar energy will have an impact on the carbon emissions related to both residential and non-residential buildings within Lancashire. Figure D-1 and Figure D-2 show how this will impact the total emissions calculated in the Baseline section of this report using the BEIS 2019 grid carbon predictions. The graphs show the reduction of emissions over time due to grid decarbonisation assuming no other changes.

**Figure D-1 - Residential building decarbonisation due to decreasing grid carbon intensity**




[44] Road traffic forecasts 2018 - GOV.UK (www.gov.uk).

**Figure D-2 - Residential building decarbonisation due to decreasing grid carbon intensity**




In addition to decarbonisation of the grid, a continuing trend of increased energy efficiency of appliances is also expected. This trend has been observed over time and has been responsible for some of reduced energy demand that has been seen to date.

## D.4. Climate change adaptation

Lancashire County Council has commissioned a Climate Adaptation report separately, in parallel with this study. Checking the information available that would be applicable to Net Zero pathways, the following findings have been considered pertinent for the analysis:

- **Changes in heating/cooling patterns**: The 'degree-days' where heating is likely to be required are expected to decrease as the climate warms. The number of days are likely to decrease from the current 2,220 degree-days by approximately 8-12% by 2050, under low-medium climate change scenarios[45]. The number of degree-days likely to be required for cooling is expected to increase tenfold, but from a low base, such that the worst-case increase will be +100 compared with the -250 expected for heating. Given that cooling is drawn from electrical power, whereas heating is largely gas based, this will mean a net decline in emissions, due to the decarbonisation of the electricity grid.
- **Impacts of 'hard' flood defences**: embodied carbon in building extra sea defences (see Section 4.4.2 of the climate resilience report).
- **Impacts of 'soft' flood defences**: extra land area given over to flood management may have a co-benefit in terms of sequestration of $CO_2$, such as additional grasslands

[45] UKCP RCP 2.6 is taken as the 'low' scenario, RCP 6.0 is medium; RCP 8.5 is high.

# D.5. Summary

To provide an overview of how future years are assumed to change relative to 2018, should no action be taken at a regional/local level, Table D-1 below captures how any modulating factors have been applied across each sector.

**Table D-1 - Summary of BAU factors applied by sector**

| Factor | Transport | Industry | Buildings | LULUCF |
|---|---|---|---|---|
| Population growth | Yes | No | No | No |
| Gross value-added | Yes (via income) | Yes | No | No |
| Housing growth | No | No | Yes | No |
| Electricity carbon intensity | Yes | Yes | Yes | No |
| Gas carbon intensity | No | No | No | No |
| Energy supply | Yes | Yes | Yes | No |
| Energy demand | No | Yes | Yes | No |
| Evidence review* | No | Yes | Yes | Yes |
| Major committed projects | Yes | No | Yes | No |
| Early-stage pipeline projects | No | No | No | No |
| Impact of COVID-19 pandemic | No | No | No | No |

Note:

* Key findings have been drawn through into other factors.

# D.6. Business as Usual projections

## D.6.1. Transport

The largest influence on future vehicle fleet composition will be the rate of electrification of the fleet. The Government's announcement in November 2020 of a ban on petrol and diesel car and van sales from 2030 will have an important influence on the rate of change. However, it is not yet clear how the change will feed through the fleet, particularly in individual counties, as petrol and diesel vehicles will remain on the road until well into the 2040s. The impact of the subsequent announcement of a ban on diesel HGV sales in 2035 (for vehicles <26 tonnes) and 2040 (>26 tonnes) is even less clear.

Two alternative business as usual estimates have been produced, using two sets of fleet composition assumptions, as follows:

- The DfT TAG databook projection of fleet composition change through time which pre-dates the ban on petrol and diesel car and van sales and assumes a slow rate of electrification and steady improvement in vehicle efficiency; and
- An estimate of the national average fleet composition change, assuming the ban on petrol and diesel car and van sales in 2030, based on analysis by UKERC[46].

[46] UK Energy Research Centre: Response to DfT consultation on ending the sales of new petrol, diesel and hybrid cars and vans, August 2020.

The first option (without ban) has been taken as the business as usual scenario in the analysis that follows. This option was adopted because it provides the opportunity to highlight the impact and importance of the national action on fleet and the importance of increased support to achieve it, including local support.

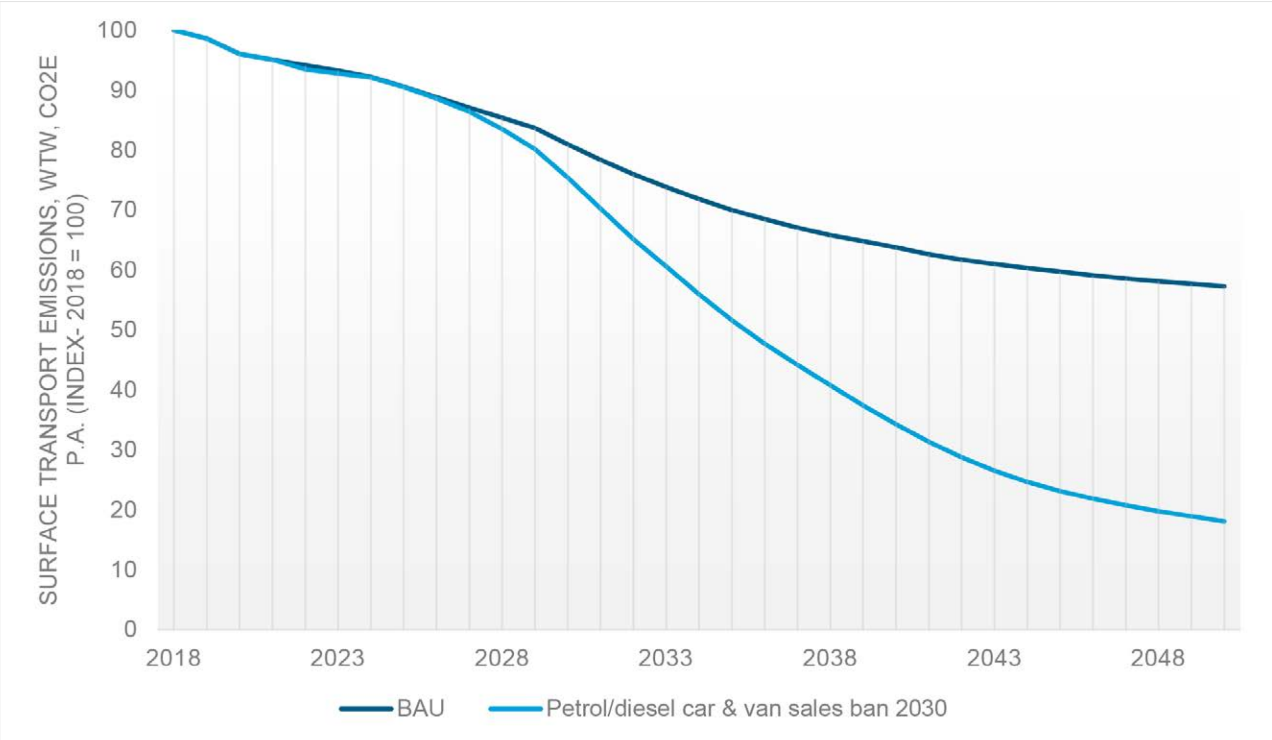
The mechanisms for delivering the ban are not yet fully in place, although they took a step forward with the publication of the Transport Decarbonisation Plan in July 2021 and the launch of a consultation on a regulatory framework to accelerate car and van fleet change.

However the ban is delivered, there will be a need for substantial support at a county level to bring about the emissions savings, due to the need for extensive charging infrastructure at a local level. Without the right support from the county, emissions may not reduce at the rate forecast as a national average following the sales ban. Thus the 'without ban' is the most representative scenario to take forward as 'business as usual'.

Achieving the assumed 'with ban' fleet composition implies a requirement for electric vehicle charging infrastructure, financial and technical support and awareness raising beyond currently committed levels. Without those measures, it is plausible that those driving in Lancashire would continue to use petrol and diesel vehicles sold before the ban well into the 2030s. Car and van owners may continue to use older/second hand petrol and diesel vehicles, if they perceive electric vehicles are not affordable or suitable for their needs and/or that there is not enough supporting infrastructure to support their recharging needs.

Figure D-3 shows the estimated business as usual trajectory for Lancashire transport emissions. The blue line shows emissions assuming fleet composition change as forecast before the ban on petrol/diesel car and van sales. The green line shows the trajectory with the ban on petrol/diesel car and van sales assumed to be in place from 2030. Without the ban, emissions reduce slowly through time, as the savings resulting from the slow electrification of the car and van fleet and improved efficiency of all vehicle types more than offset the forecast traffic growth. The introduction of the ban considerably accelerates the rate of emissions reduction through time, particularly from 2030 onwards. The implications of the ban on the sales of diesel HGVS from 2035 and 2040 will significantly reduce the remaining emissions in the 2040s.

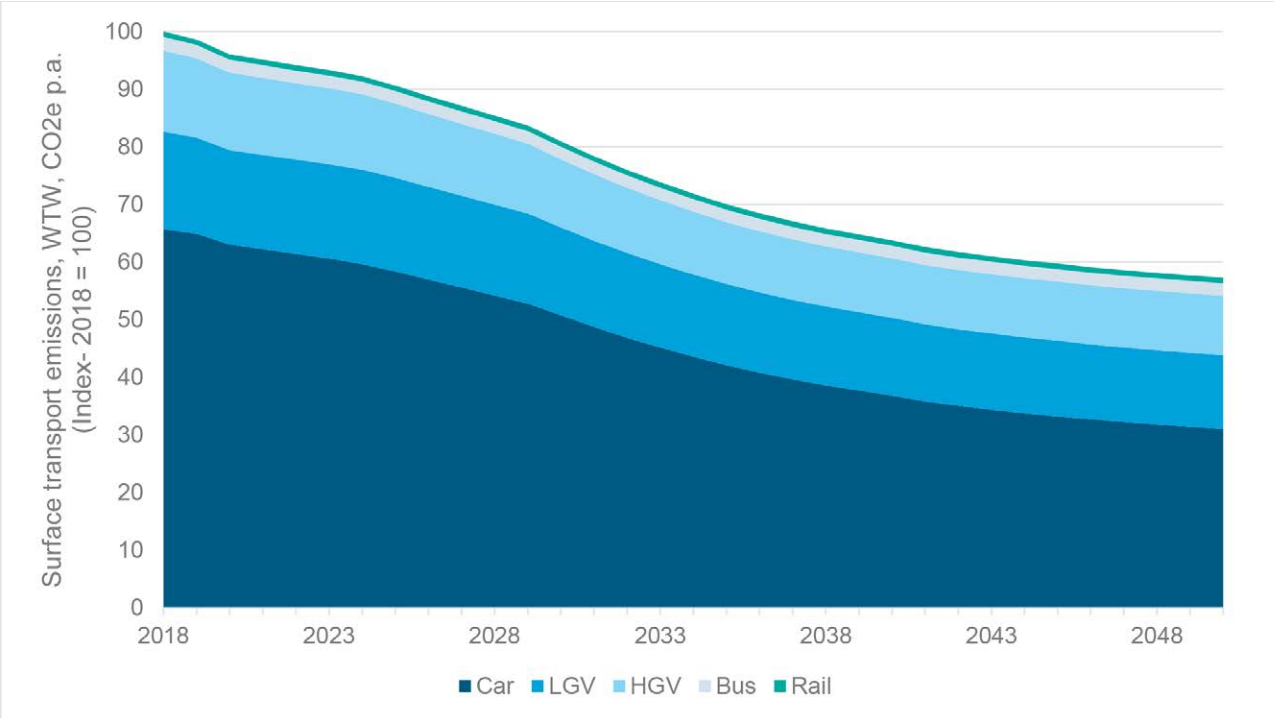
**Figure D-3 - Business as usual surface transport emissions, Lancashire, Well to Wheel $CO_2$e p.a.**




Note: all figures are initial indicative estimates only.

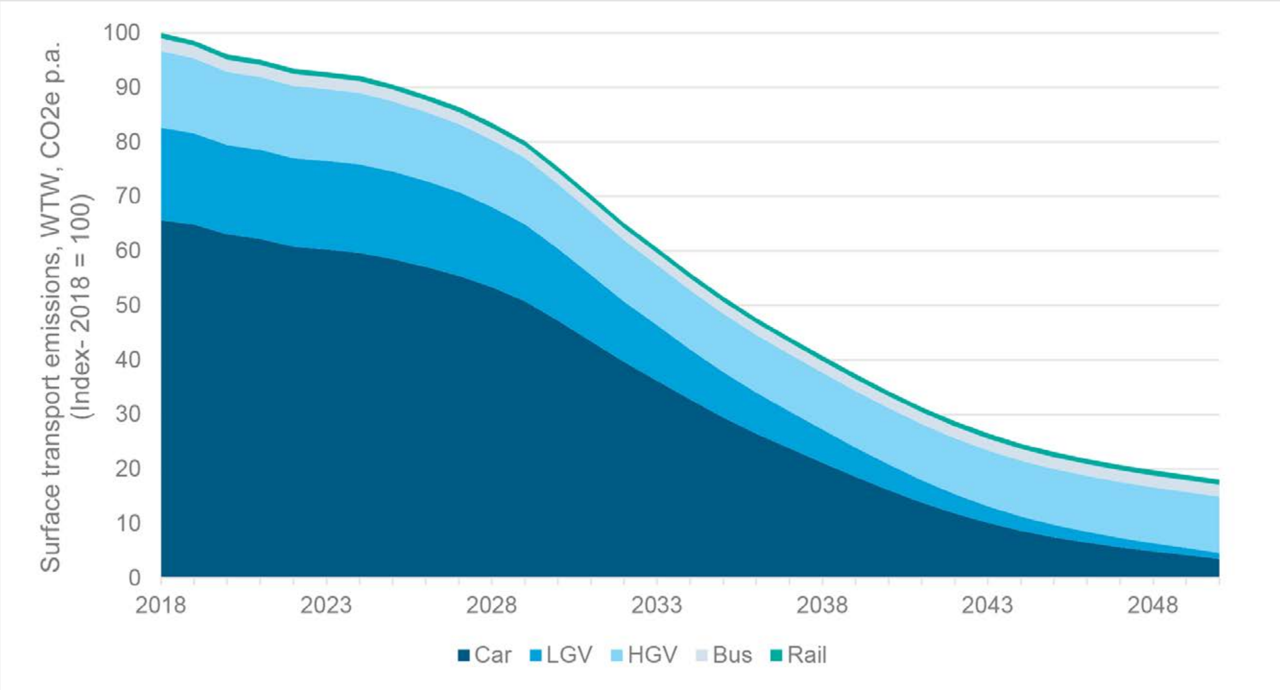
Figure D-4 and Figure D-5 show the disaggregation of the emissions in each scenario by vehicle type. In both cases car and van emissions account for a decreasing proportion of the total through time as the emissions intensity for these vehicle types decreases more rapidly than it does for the HGV and bus fleet. In the scenario including the ban on petrol/diesel sales in 2030, the proportion of emissions from the car and van fleet is very limited by the mid-2040s as the fleet is assumed to have fully converted to electric vehicles and the electricity supply is assumed to be very low carbon intensity, based on BEIS assumptions.

**Figure D-4 - Business as usual surface transport emissions by vehicle type for Lancashire, Well to Wheel $CO_2e$ p.a. – assuming no ban on petrol or diesel car and van sales**




Note: all figures are indicative estimates only.

**Figure D-5 - Business as usual surface transport emissions by vehicle type, Lancashire, Well to Wheel CO2e p.a. – assuming 2030 ban on petrol/diesel car and van sales**



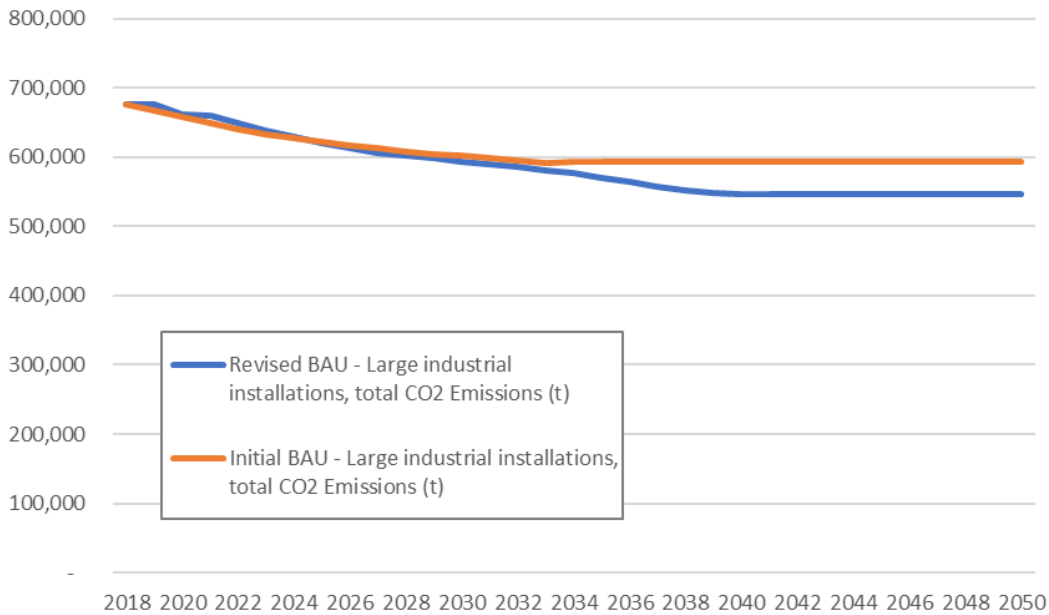

Note: all figures are indicative estimates only.

## D.6.2. Large Industrial Installations

The BAU projection was calculated with reference to the Climate Change Committee methodology used to project a baseline for the UK's Sixth Carbon Budget. Since the working draft Baseline and BAU paper was produced, additional data has been identified[47] and used to update the BAU industrial projection. The difference between the initial BAU projection and the revised figures is presented in Figure D-6 below. The projected emissions are matched to 2032, when the revised projections are slightly lower. This revised BAU (Figure D-7**)** has been used within the subsequent analysis.

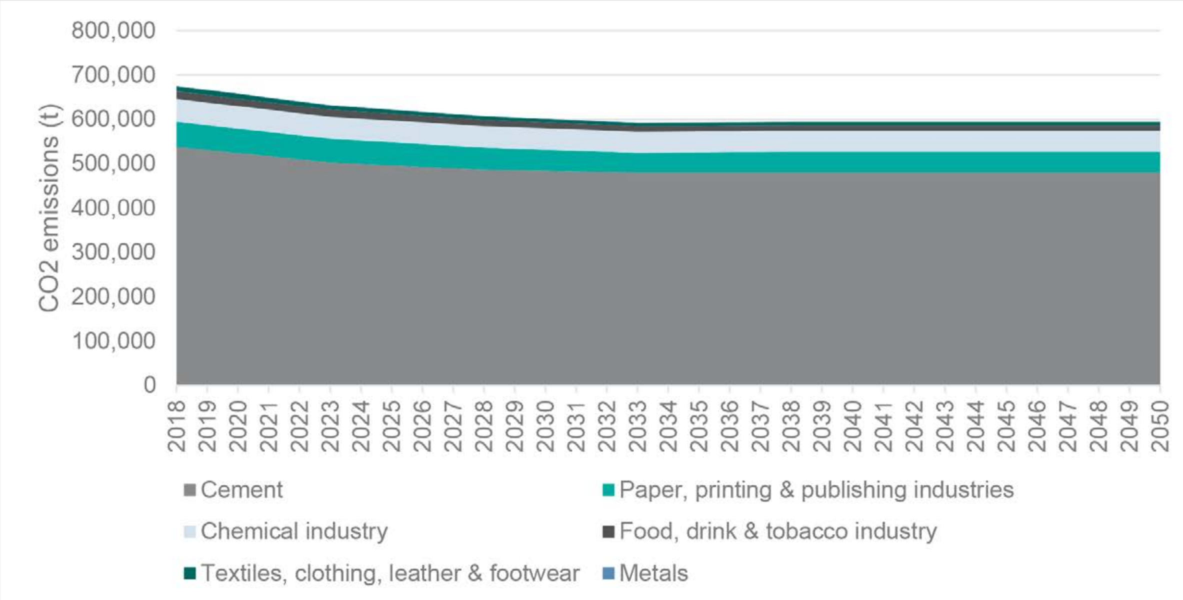
**Figure D-6 - Comparison of initial BAU projection for large industrial installations, with the revised figures based on underlying data from Element Energy (2020)**

[47] As part of the Sixth Carbon Budget, the Climate Change Committee (CCC) commissioned Element Energy to improve the evidence base on the potential of industrial deep-carbonisation measures. The report and underlying data have been published. They include full details of the baseline used to create CCC projections.
Element Energy (2020) Deep-Decarbonisation Pathways for UK Industry. December 2020. Available online at: https://www.theccc.org.uk/publication/deep-decarbonisation-pathways-for-uk-industry-element-energy/. Accessed May 2021.




Note: all figures are indicative estimates only.

**Figure D-7 - Revised BAU projection for large industrial installations by sector, using figures based on underlying data from Element Energy (2020)**




Note: all figures are indicative estimates only.

## D.6.3. Understanding the sources

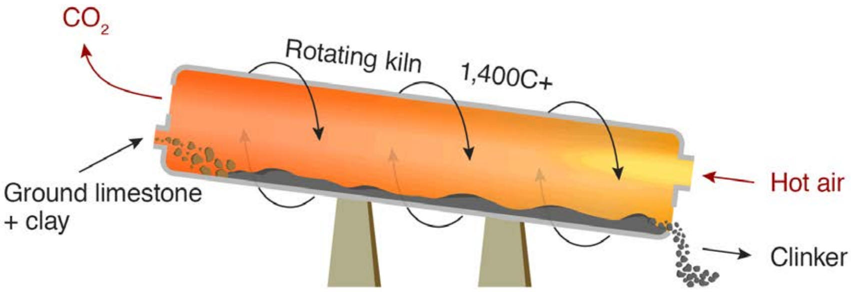
Prior to identification of mitigation measures, further work was required to understand the nature of the individual emissions sources within the baseline. A detailed site by site investigation is beyond the scope and timescales of this project. However, underlying data collated for the UK's Sixth Carbon Budget was used to inform the likely split of emissions sources, for each sector within the Lancashire Baseline. The data is presented in Table D-2. For each sector, it shows the proportion of 2018 emissions split by each type of process, e.g. for Cement, the 2018 CO2 emissions were separately attributed to the kiln (32% of Cement total), process emissions (57%, see also Figure D-9) and biomass (11%). Total emissions from each site in the Lancashire baseline were therefore attributed to the respective process types in the proportions shown within Table D-2.

**Table D-2 – Specific emission sources within each of the sectors identified in the Lancashire Baseline. Percentages relate to the proportion of 2018 emissions attributed to those sources within the UK-wide NAEI, as compiled by Element Energy (2020)**

| Sector | CCC Sector | Process | Description g | % of sub-sector emissions (UK) |
|---|---|---|---|---|
| Cement | Cement | Kiln - Cement | Direct heating of a chamber to very high temperatures, used for chemical processes | 32% |
| | | Process CO2 - Cement | Arising as a result of making clinker, as a by-product from a chemical reaction, the calcination of limestone (see Figure D-9) | 57% |
| | | Biomass Process | Used by CCC to classify any biomass fuelled process | 11% |
| Food, drink & tobacco | Food & Drink | Dryer - F&D | Typically low temperature direct drying processes (e.g. food production) although some high temperature processes exist (e.g. rotary dryers) | 19% |
| | | Oven - F&D | Heated chambers used for drying, curing or baking | 81% |

| Sector | CCC Sector | Process | Description g | % of sub-sector emissions (UK) |
|---|---|---|---|---|
| Metals | Non ferrous metal | CHP (Non BECCS allowed) | Combined heat and power unit | 4% |
| | | Metal Melting | High temperature furnaces used to melt non-ferrous metals | 44% |
| | | Metal Rolling | Metalworking process using two rolls to adjust the stock metal thickness | 44% |
| | | Non-FM - Process | Process emissions | <0.1% |
| | | Process CO2 - Other | Process emissions | 7% |
| Chemical industry | Other Chemicals | Boiler - Steam (Non BECCS allowed) | Includes both high and low temperature boilers | 23% |
| | | CHP (Non BECCS allowed) | Combined heat and power unit | 49% |
| | | Dryer - Chemicals | Typically low temperature direct drying processes (e.g. food production) although some high temperature processes exist (e.g. rotary dryers) | 12% |
| | | Process CO2 - Chemicals | Process emissions | 5% |
| | | Process CO2 - FFP | Process emissions | 2% |
| | | Pumps | Pumps powered with fossil fuels | 9% |
| Textiles, clothing, leather & footwear | Other industry | Generators | Generators to provide electricity for back-up, offshore or dispersed sites. | 80% |
| | | Incinerators | Furnace/vessel for burning waste; also applied to energy-from-waste sites | 14% |
| | | Lubrication | Emissions from combustion of lubricants in machinery | 0% |
| | | Process CO2 - Other | Process emissions | 6% |
| Paper, printing & publishing industries | Paper | Boiler - Steam | Includes both high and low temperature boilers | 33% |
| | | CHP | Combined heat and power unit | 33% |
| | | Dryer - Paper | Typically low temperature direct drying processes (e.g. food production) although some high temperature processes exist (e.g. rotary dryers) | 33% |

**Figure D-8 – Cement manufacture (Source: Carbon Brief48, 2018)**



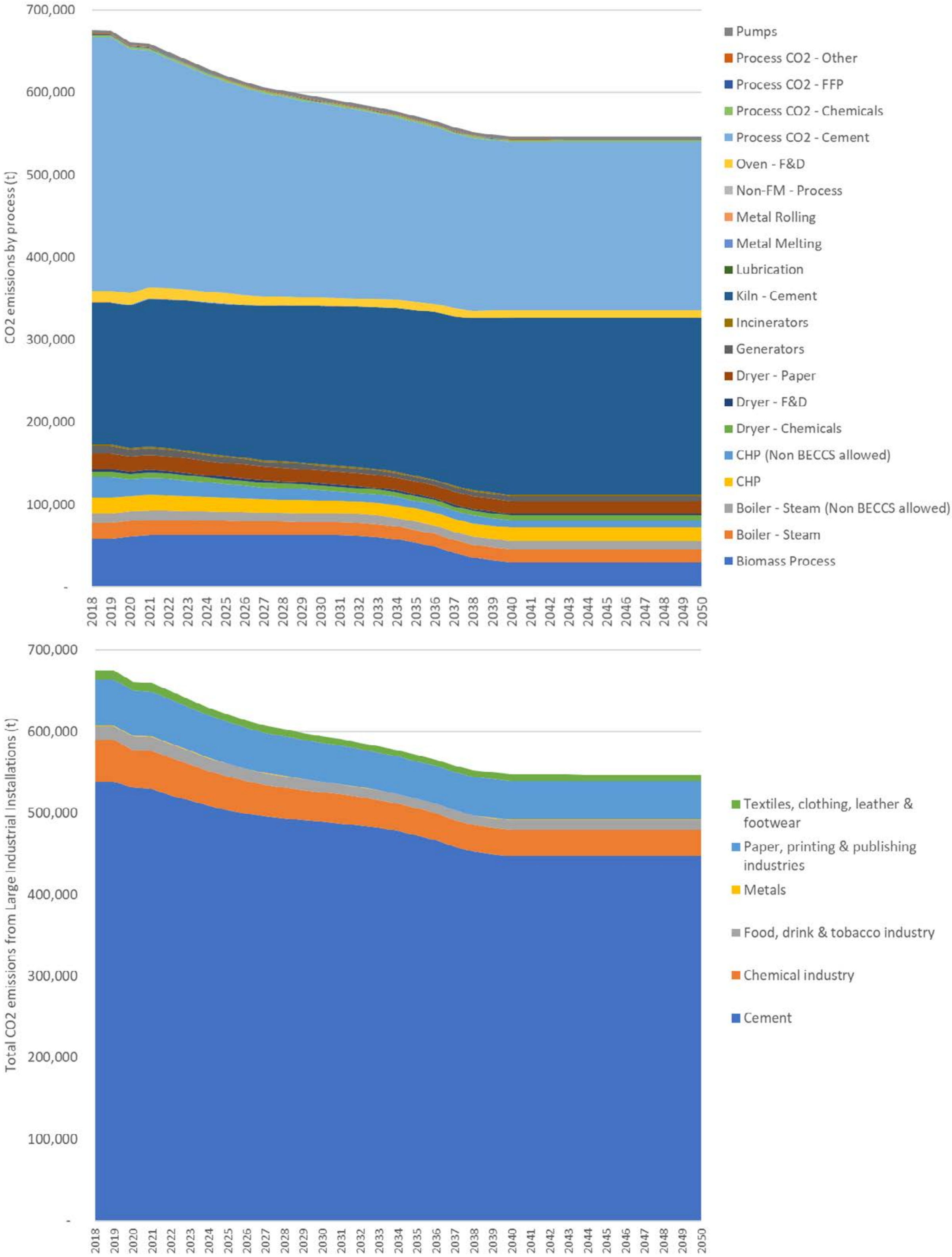

The baseline data and BAU projections clearly show that emissions from Hanson Cement in Ribble Valley dominate the total emissions, both now and in 2050, under BAU. As such, the options for reducing emissions from this site will form an important component of the pathways to Net Zero. Using the CCC split of emissions from the cement works, into kiln, process and biomass, is a proportionate approach to identifying where abatement should be focussed, within the context of this project.

The other sectors in the Lancashire baseline include more than one site. As such, and within the scope of this project, it is assumed that emissions from each site can be split into the relative proportions for each process, consistent with the CCC analysis.

The CCC data projects out to 2050, under BAU. As such, the BAU for Lancashire can also be disaggregated into the same component process types, through to 2050 (Figure D-9).

[48] Carbon Brief (2018) Why cement emissions matter for climate change. September 2018. Available online at: https://www.carbonbrief.org/qa-why-cement-emissions-matter-for-climate-change. Accessed May 2021.

**Figure D-9 –BAU projection for large industrial installations by industrial process type (above) and by industrial sector (below)**



Note: all figures are initial indicative estimates only.

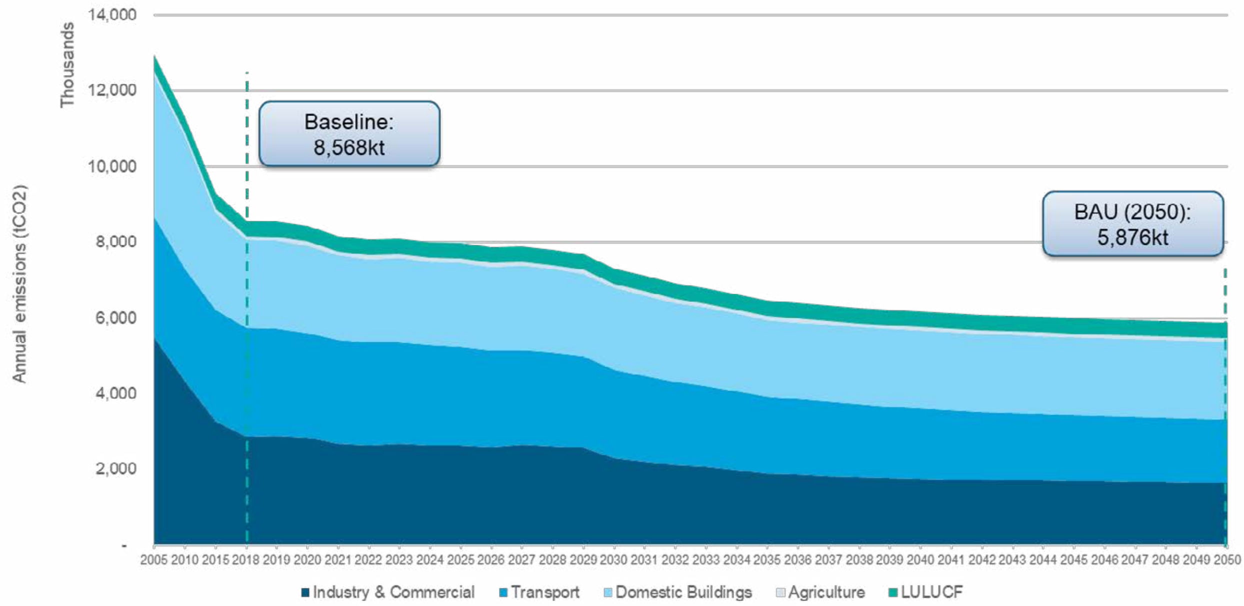
### D.6.4. Agriculture and LULUCF

Both the Agriculture and LULUCF are small contributors to the emissions in Lancashire as discussed in the baseline sections of this report. Therefore, for the BAU scenario, it has been assumed that overall Agriculture and LULUCF will remain net constant emitters without any specific interventions.

## D.7. Cross-sectoral business as usual projections

Figure D-10 illustrates Lancashire's overall carbon emissions projection out to 2050 following a BAU scenario, as well as the individual breakdowns of projections per sector.

**Figure D-10 –BAU overall carbon emissions projection to 2050**




Note: all figures are indicative estimates only.

Starting from the baseline of 8,576 $ktCO_2$ in 2018, the annual emissions in the county would decline to 5,700 $ktCO_2$ by 2050 if no action were taken by Lancashire County Council, based on current committed national policies and projects in county, as well as trends and expected changes to energy supply and demand. In this BAU scenario, there would be is a 34% decline in emissions compared with the baseline as far as 2050, but this would be in no way sufficient to reach Net Zero emissions, where around 90% reduction in absolute emissions would be required be is nowhere near enough the reduction in absolute emissions for net carbon removals to be a feasible solution in a Net Zero scenario.

# Appendix E. Deriving pathway options: methodology and calculations

This appendix sets out additional information in relation to the methodology that has been applied and calculations that have been performed to derive pathway options for each of the major sectors considered.

## E.1. Key informants of pathway options

The following key documents from have informed the development of pathways and interventions. These are described in detail in Appendix A – Evidence Review:

- Energy White Paper
- Industrial Decarbonisation Strategy
- The Transport for the North Transport Decarbonisation Strategy
- Net Zero NW Cluster Plan
- National Grid, Future Energy Scenarios
- Energy North West Limited documents
- Renewable Energy evidence project in support of Greater Lancashire Plan
- UK Net Zero Strategy
- CCC Net Zero Report
- CCC Sixth Carbon Budget
- UK Hydrogen Strategy
- BEIS Decarbonise the Electricity Sector
- UK Heat and Buildings Strategy
- Transport Decarbonisation Plan

## E.2. Transport

Views on the measures needed to reduce transport carbon emissions are generally consistent between different sources such as the Climate Change Committee (CCC)[49] and the Local Government Association's (LGA) series of briefing notes on Decarbonising Transport[50].

They identify that diverse measures are needed to achieve the scale of carbon reduction required from transport. Emphasis is also placed on the need for collaboration and co-ordination between a range of stakeholders, including national government, different levels of local authority, other public bodies, local economic partnerships, businesses and residents.

The methodology used to derive transport reduction pathways is set out in four broad steps:

1. Review relevant types of measures to identify key policy areas for action;
2. Develop a scenario to represent indicative ambitious local roll out of measures in each policy area;
3. Assess the potential impacts of each policy area on the basis of evidence from literature review on likely impacts on trip lengths, trip numbers, choice of mode and choice of vehicle; and
4. Quantify indicative emissions savings from these changes in travel behaviour.

### E.2.1. Categories of measure

The CCC groups the actions that Local Authorities need to take to reduce transport emissions into three categories of:

- **Strategy/planning** – including working with partners to deliver improved provision of sustainable modes (walking, cycling and public and shared transport).

[49] Climate Change Committee, Sixth Carbon Budget, 2020 and supporting papers on the Transport Sector and the Role of Local Authorities. Climate Change Committee (theccc.org.uk)
[50] Decarbonising transport | Local Government Association

- **Infrastructure** – including measures such as charging for use of infrastructure, including parking charges and clean air zones, as well as provision of digital infrastructure.
- **Communications and enabling actions** – highlighting the importance of raising awareness of options and the need for change in travel behaviour and of working with residents, businesses and other organisations to support change.

The LGA and several other bodies categorise the measures needed to reduce transport emissions in terms of the route through which they reduce carbon, broadly grouping them in terms of the **Avoid, Shift, Improve** hierarchy shown in Figure E-1.

**Figure E-1 – Avoid, Shift, Improve hierarchy for measures to address transport emissions**

| *Category* | *Emissions reduction approach* |
|---|---|
| Avoid | Reduce overall travel through improved access (through reduced trips or length – logistics, land use planning, online activities) |
| Shift | Increase the proportion of travel by the most efficient and sustainable modes: active, shared and public transport |
| Improve | Increase energy efficiency of vehicles and driving conditions. Move to alternative, less carbon intensive fuel/energy sources, particularly electricity. |

The main transport decarbonisation measures can be grouped into eight main policy areas against the Avoid, Shift, Improve categories as set out in Table E-1.

**Table E-1 – Key policy areas for transport decarbonisation**

| Policy Area | Category |
|---|---|
| **Land use planning** | Avoid |
| **Digital connectivity** | Avoid |
| **Active travel/personal mobility** | Shift |
| **Public/shared transport** | Shift |
| **Demand management** | Shift |
| **Supporting behaviour change** | Shift/All |
| **Efficient network management** | Improve |
| **Promoting ultra-low emission vehicles** | Improve |

**Section 7 of this report (see Main Document) provides more detail on each of the three categories of Avoid, Shift and Improve and the eight policy areas falling within them including the way in which each of the categories and policy areas could contribute to decarbonisation, along with the types of measure involved.**

## E.2.2. Assessment of potential impact of policy areas

There are considerable uncertainties around the scale of impact that different measures will have. The impact of most transport measures is dependent on behaviour change by those travelling, which is hard to predict accurately. Impacts are also typically highly location specific. For instance, a new cycle lane will have greater impact on mode shift and carbon emissions if located in a densely populated area, serving attractive destinations and linking existing cycling provision, than if located in a more isolated area.

This analysis is therefore high level, intended to help understand the potential scale of impact on the basis of general characteristics of travel in Lancashire and information on potential impact of different types of measure available from a literature review. It will help to inform understanding of what combination and scale of measures are likely to be needed to close the gap between the estimated transport baseline and Lancashire's target decarbonisation pathway.

The potential impact of each of the policy areas was estimated by developing a scenario based on a literature review of the impacts of different measures. Table E-2 outlines the scenario assessed and provides a summary of the representation of the measures. Estimates of the emissions impacts were based on consideration of:

- Amounts of travel for different purposes, by different modes and in different distance bands; and
- Evidence from a review of a wide range of literature[51] of the potential scale of impact of different types of measure on different trip types (by purpose and mode)

**Table E-2 – Overview of assessment of potential impact of policy areas**

| Policy Area | Type of measure assessed | Overview of representation |
|---|---|---|
| **Land use planning** | 20 minute neighbourhood principles i.e. changes in land use to diversify the range of land uses available in urban areas (e.g. diversify retail and entertainment availability and introduction of healthcare and remote working hubs in retail centres) | Reduction in trip length and trip number (due to combined trips) equating to 10% reduction in car travel for shopping and personal business and 5% for leisure trips (derived from sources including RTPI, ITF, CREDS/UKERC, CCC see footnote for the last bullet point above this table for sources). |
| **Digital connectivity** | Build on changes in behaviour during the COVID-19 pandemic, assuming increased working from home continues at approximately 50% the average increase seen in 2020 and a small reduction in personal trips replaced by online activity such as appointments | Reduction in commuting and business trips of just under 5% (ONS[52] identify 12% increase in homeworking between 2019 and 2020 from 8% to 25% reduction estimated assuming those who previously worked at home do on average an extra day a week at home and approx. 50% of the additional workers at home during 2020 do on average 50% of week at home in future. Also reduction of up to 5% for personal business, shopping, leisure trips assumed. |
| **Active travel** | Significant improvement in availability of routes suitable for cycling (and potentially scooting). Significant increase in willingness to cycle, including | Mode shift from car travel based on e-bike scenario in PCT for commuting. Uplifted for other purposes (not covered in the PCT) on the basis of average trip length and |

[51] CCC 6th Carbon budget supporting papers Sixth Carbon Budget - Climate Change Committee (theccc.org.uk), International Transport Forum Climate Action Directory , Transport Climate Action Directory | ITF (itf-oecd.org). BEIS MacKay Carbon Calculator MacKay Carbon Calculator - UK emissions and primary energy consumption (beis.gov.uk),RTPI, Net Zero Transport, January 2021, RTPI report on Achieving Net Zero Transport (tps.org.uk), Natcen for DfT, 2021, Switching to sustainable transport: Rapid Evidence Review Switching to sustainable transport: a rapid evidence assessment - GOV.UK (www.gov.uk), LGA decarbonising transport papers Decarbonising transport | Local Government Association, UKERC and CREDS decarbonising transport papers, Transport & Mobility – CREDS, Transport for Quality of Life Decarbonising Transport Papers Transport and Climate Change | Transport for Quality of Life plus several other sources.
[52] ONS Homeworking Statistics, May 2021.

| Policy Area | Type of measure assessed | Overview of representation |
|---|---|---|
| | use of e-bikes on longer journeys in line with the e-bike scenario in the DfT's propensity to cycle toolkit (PCT)[53] | mode share by purpose (from the DfT's National Travel Survey) and the assumption that the level of mode shift to cycle for business/personal business trips would only be 50% of the response seen for commuting for the purposes of shopping, education and leisure trips and 25% of the response for other purposes (e.g. business, personal business).<br>Assumed negligible net impact on remaining traffic due to changed speeds (some increase in emissions due to congestion due to reallocation and some decreases due to congestion relief due to mode switch). |
| **Public/shared transport** | Reversal of COVID-19 downturn and subsequent increase in demand (potentially differently distributed across the day) encouraged by better, more integrated, affordable and reliable services and MaaS system.<br>Shared transport provided as part of the integrated system with options such as bike/e-bike (and potentially e-scooter) hire, extending the reach of public transport by providing options for first, last and missing legs in journeys. Car clubs provide options for journeys where car is the only feasible alternative, without the need for car ownership. | Assumed increase in PT patronage of 25% (relative to 2019) from mode switch by 2030 (rising to 75% by 2050). Proportion of increase derived from car driver trips (and therefore reducing traffic) based on existing mode share by purpose (from National Travel Survey[54]/National Trip End Model) and assumption that mode switch is more likely from other modes (, cycle, car passenger etc.) than from car driver. |
| **Demand management** | Cars: Increased charging for parking and relocation of spaces out of central areas (increasing walking times to destinations)<br>Goods vehicles: Delivery restrictions, supported by consolidation hubs | Reduction in car travel assumed to be driven by increase in cost and inconvenience of parking (~50% cost increase (including walk time) for ~50% of commuting/business journeys, ~ 35% of shopping journeys and 25% of journeys for all other types). Impacts estimated using elasticities of car travel to cost change by journey purpose from the TRACE handbook of elasticities[55]<br>Consolidation leading to and transfer of last mile trips reducing diesel vehicle kms by ~5% by 2030 (derived from sources including RTPI, ITF, CREDS/UKERC, CCC). |

[53] Welcome to the Propensity to Cycle Tool (PCT).
[54] National Travel Survey: 2019 - GOV.UK (www.gov.uk).
[55] TRACE - Final Report (europa.eu) – although nearly 20 years old, this report was still a main reference in a 2020 review of elasticities by the Victoria Transport Planning Institute Transit Elasticities (vtpi.org).

| Policy Area | Type of measure assessed | Overview of representation |
|---|---|---|
| **Efficient network management** | Use of data and signals to improve management of network and reduce congestion | Increase average speed on 50% of the slowest links (<25mph) by 5 mph through congestion relief. |
| **Promoting ULEV** | Promotion of uptake of small and EV cars and vans amongst council, supplier and corporate fleets and through EV car clubs, also encouraging use of small vehicles.<br>Supporting uptake through additional roll out of charging infrastructure | Accelerate EV uptake locally ahead of national average (assuming petrol/diesel ban in 2030) by 9 months by 2030 and 12 months by 2032 then decreasing. |
| ***National action*** | *The promoting ULEV policy area above is in addition to the measures that will be needed locally to support the electrification of the car and van fleet in response to the ban on petrol and diesel sales from 2030. Support for roll out of sufficient charging infrastructure is assumed to be the key component of this role.*<br><br>*For the purposes of this analysis, it is also presumed that national action will be taken to accelerate decarbonisation of the HGV fleet (in line with the recommendations of the CCC 6$^{th}$ Carbon Budget). The CCC anticipate zero emission HGV sales picking up from the late 2020s through the 2030s and recommend a ban on diesel sales by 2040. These changes would require supporting infrastructure, likely to be either rapid chargers or hydrogen fuelling or both. The DfT's Transport Decarbonisation Plan (TDP) published in July 2021, after this analysis was undertaken, reinforced the relevance of this assumption. The TDP highlighted the need for rapid action on decarbonising the HGV fleet and started consultation on phasing out sales of HGVs by 2040 for vehicles over 26 tonnes and 2035 for vehicles under 26 tonnes. In November 2021 the Government confirmed these dates for the sales bans.* | *Assumed that support within Lancashire allows fleet to transition to EVs at the national average rate, as identified in fleet forecasts by UKERC[56]*<br><br>*Assumption that the decarbonisation impact of zero emissions HGVs steadily builds up through the 2030s and 2040s, in line with CCC's assumed timescales in their 6$^{th}$ Carbon Budget, Balanced Pathway* |

[56] [56] UK Energy Research Centre: Response to DfT consultation on ending the sales of new petrol, diesel and hybrid cars and vans, August 2020.

## E.2.3. Cost estimates

Estimates of the cost of implementing the measures are also influenced by a wide range of uncertainties, including uncertainty over the scale of impact resulting from behaviour change (as outlined above). Table E-3 provides broad indicative estimates of the total capital costs of implementing each measure, based on simple broad assumptions. The table also highlights that the net capital costs of several measures would be considerably lower than the total costs as the measures would enable some reference expenditure to be avoided (e.g. on conventional boilers) and several measures would also deliver operating cost savings.

**Table E-3 – Indication of total capital cost of transport measures**

| Measure | Total capex estimate to 2030 | Total capex estimate to 2035 | Offsetting cost savings/revenue | Operating costs | Likely public sector contribution | Assumptions |
|---|---|---|---|---|---|---|
| **Land use planning** | N/A | N/A | N/A | Planning staff to co-ordinate developments across Lancashire region and beyond – likely to be approx. one staff member per authority | Staff costs and relocation of own activities to new sites | Assume negligible capex as changes will be achieved through changes to existing land uses plans and staff support |
| **Digital connectivity** | ~ £1 bn | ~ £1 bn | Potential economic efficiencies of improved connectivity | Maintenance of network and hubs<br><br>Staff to run hub buildings to coordinate office space and deliveries | Grants for connections for properties that aren't commercially viable. .Noting that the majority of cost is already planned and expected to be met | Assuming costs for roll out of Gigabit technology to all premises and provision of digital hubs for access to digital connections and deliveries<br><br>Gigabit rollout:<br>• ~2.3%*£23 bn<br>• (Lancashire area ~2.3% UK total and rural population[58]),<br>• £23 Bn estimated national cost of remaining Gigabit internet roll out[59].<br><br>Digital hubs |

[58] Rural population Statistical Digest of Rural England - GOV.UK (www.gov.uk)
[59] House of Commons Library, Dec 2021, Giga-bit broadband in the UK, Government targets and policy – total cost of approx. £30bn, House of Commons, Broadband by Constituency data showed 45.7% of UK provision complete by Dec 21 (and similar proportion in NW). Assuming the lowest cost elements have been completed and the remaining elements would cost on average 3 times as much, suggests remaining expenditure of approx. £23 bn nationwide. Likely to be largely in rural areas, Lancashire has 2.3% of rural population (and total population)

| Measure | Total capex estimate to 2030 | Total capex estimate to 2035 | Offsetting cost savings/revenue | Operating costs | Likely public sector contribution | Assumptions |
|---|---|---|---|---|---|---|
| | | | | | by private sector e.g. BT.[57] | • Building cost of £2000/m$^2$ GFA[60]<br>• Assume 10m$^2$ per person (generous office space[61]) with sufficient space for 10% people of working age to use digital services 1 day per week – i.e. peak demand of 1/50 working age population plus allowance for delivery storage and sorting of 5m$^2$ per 100 households |
| **Increase active travel/ micro mobility use** | ~£0.5 bn | ~£0.5 bn | | Ongoing maintenance and costs of operation of cycle hire schemes, awareness raising | National and local support for cycling and e-mobility measures | Based on the indication by Transport for Quality of Life[62] that the equivalent of £50 p.a. p.c. investment is required to deliver a step change in cycling (as quoted by Ashden[63]) and Lancashire population >16 of 1.23 million[64]<br>NB some of investment would potentially be resource rather than capital cost |
| **Increase public/ shared transport use** | ~£0.5 bn | ~£0.5 bn | Revenue (transfer passengers to operators) | Bus Service Improvement Plan for Lancashire suggests operating costs are likely to be greater than capital costs, including running bus and demand management services | National and local contributions to upgrades and fares support | Based on costs in the two 2021 Bus Service Improvement Plans covering the area (Blackpool[65] and Lancashire with Blackburn & Darwen[66]), prorated up from the target increase in patronage identified in the BSIPs (7% and 10% respectively) to 25% assuming a linear relationship between expenditure and patronage increase |

[57] House of Commons Library, Dec 2021, Giga-bit broadband in the UK, Government targets and policy – total cost of approx. £30bn, House of Commons, Broadband by Constituency data showed 45.7% of UK provision complete by Dec 21 (and similar proportion in NW). Assuming the lowest cost elements have been completed and the remaining elements would cost on average 3 times as much, suggests remaining expenditure of approx. £23 bn nationwide. Likely to be largely in rural areas, Lancashire has 2.3% of rural population (and total population)
[60] Costmodelling - Typical building costs – approx. cost for buildings such as 1 to 2 storey un airconditioned offices and community halls
[61] How much office space do I need? | Workspace - office space including allowance for other areas such as meeting rooms
[62] https://policy.friendsoftheearth.uk/insight/segregated-cycleways-and-e-bikes-future-urban-travel
[63] https://ashden.org/storage/2020/08/31-Climate-Actions-for-Councils.pdf
[64] Estimates of the population for the UK, England and Wales, Scotland and Northern Ireland - Office for National Statistics (ons.gov.uk)
[65] Blackpool Council Bus Service Improvement Plan_October 2021
[66] National bus strategy – Bus Back Better 2021 - Lancashire County Council

| Measure | Total capex estimate to 2030 | Total capex estimate to 2035 | Offsetting cost savings/revenue | Operating costs | Likely public sector contribution | Assumptions |
|---|---|---|---|---|---|---|
| **Demand Management** | <~£0.1 bn | <~£0.1 bn | Revenue income likely to be significant from any charging measures | Ongoing staff and operating costs | Likely to be operated by or on behalf of public sector | Assumption on cost levels |
| **Efficient Network Management** | ~£0.5 bn | ~£0.5 bn | | Minor increase in operating and maintenance costs and potentially reduced cost of dealing with accident impacts | Central/local government funding for improvements | Assuming 1 scheme per 50 km of the 8100[67] km of road network in Lancashire region and average cost of £2.5 million, based on average cost of smaller congestion hotspot schemes funded by DfT in 2017[68] |
| **National action: 2030 ban on petrol/diesel car/van sales** | ~£12.5 Bn | ~£20.0 Bn | CCC estimate that the net additional cost would be <10% of total capital cost as remainder of cost would be offset by avoided reference case expenditure on conventional vehicles and significant operating cost savings as result of lower energy and maintenance costs for EVs. | Maintenance of charging infrastructure and vehicles<br><br>Operating cost savings due to lower running and maintenance costs of EVs | Some national support through grants for EV purchase plus public sector support for infrastructure | Cost based on CCC estimates of costs of EV uptake for the 6th Carbon Budget (available in the supporting dataset[69]). National totals were prorated to represent Lancashire's share on the basis of the proportion of national vehicles registered in Lancashire (using DfT vehicle licencing statistics – VEH0105[70]). As CCC forecasts of EV uptake in the Balanced Pathway scenario are more optimistic than the UKERC/SMMT forecasts of EV uptake used for the national action measure (CCC forecasts assume more national action than is currently committed) the costs used were those associated with the slower Headwinds scenario, lagged by 2 years (i.e. costs to 2028 used for 2030 and 2033 for 2035 to provide an appropriate estimate of costs for the roll out assumed for the national action measures |
| **National: presumed action to** | ~£0.5 bn | ~£1 bn | As above | As above | As above | As above for HGV costs used in CCC |

[67] Table RDL0202a Road network size and condition - GOV.UK (www.gov.uk)
[68] £220 million to help motorists beat congestion - GOV.UK (www.gov.uk)
[69] Sixth Carbon Budget - Climate Change Committee (theccc.org.uk)
[70] All vehicles (VEH01) - GOV.UK (www.gov.uk)

| Measure | Total capex estimate to 2030 | Total capex estimate to 2035 | Offsetting cost savings/revenue | Operating costs | Likely public sector contribution | Assumptions |
|---|---|---|---|---|---|---|
| **decarbonise HGV fleet** | | | | | | |
| **Accelerate ULEV uptake** | ~£0.5 bn | ~£0.5 bn | As above | As above plus staff time for promotion of uptake of amongst council (including taxi and bus), supplier and corporate fleets and staff and other support for car clubs | Additional grants and infrastructure and staff time plus other support for car clubs | Estimated on a similar basis to the national action but on the assumption that the local action to accelerate EV uptake would be equivalent to moving uptake from the levels assumed in the CCC Headwind Scenario to the CCC Balanced Pathway Scenario. The estimated difference in national cost of delivering EV car and van uptake was pro-rated to Lancashire levels on the basis of the proportion of vehicles registered in Lancashire (as for the national action calculations). |

## E.2.4. Calculation outputs

Figure E-2 provides a summary of the potential reduction in emissions that might be achieved within Lancashire if the measures associated with each of the policy areas listed in the table were implemented at an ambitious scale. These savings are in addition to the national action of banning petrol and diesel car and van sales. As described in Table E-2, for the purposes of the analysis, it has also been presumed that equivalent national action will also be implemented to accelerate decarbonisation of the HGV fleet (in line with the recommendations of the CCC 6th Carbon Budget), as significant change in the freight fleet will require national coordination and action.

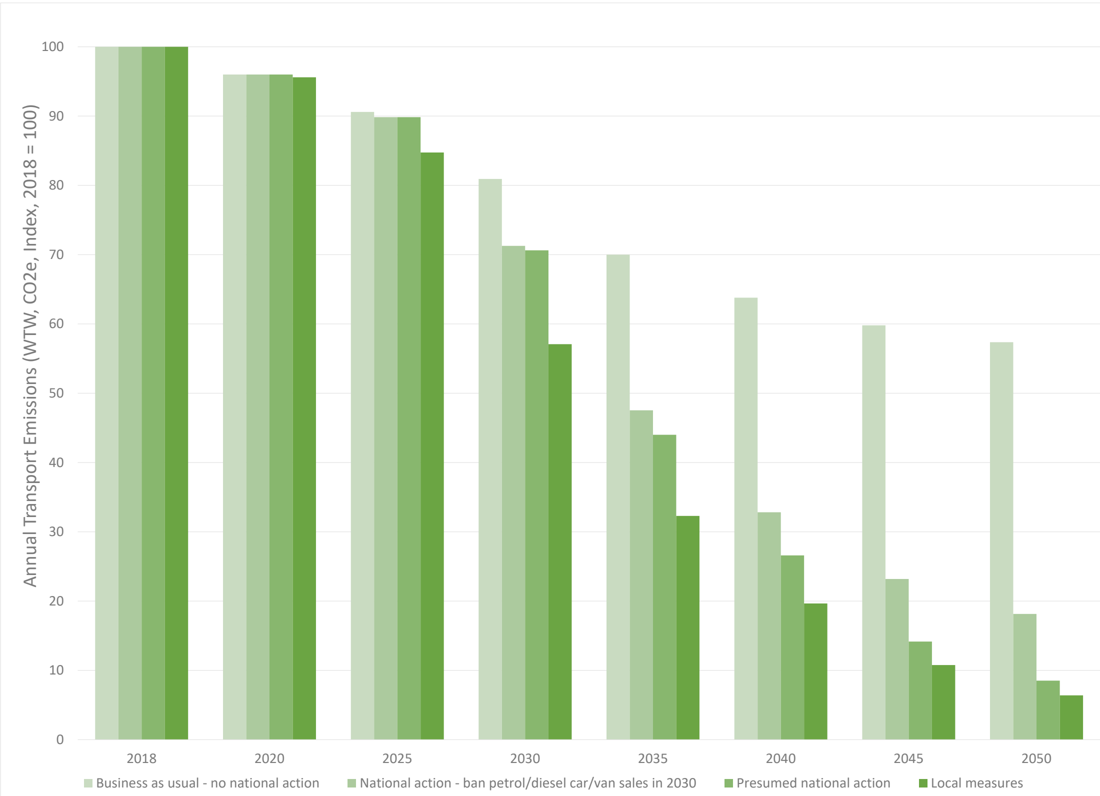
The bars on the graph represent annual transport emissions, identified as an index relative to 2018 emissions (100), at 5 year intervals from 2020 in the following four scenarios:

- Baseline - without national action to ban car/van petrol/diesel sales;
- National action - assuming ban of car/van petrol/diesel sales in 2030 and associated national and local action to support it;
- Presumed national action – including national action and the impacts of an assumed steady increase in zero emissions HGVs from 2030 and associated national and local action; and
- Local decarbonisation measures – assuming national action on the car and van fleet and presumed national action on the HGV fleet plus intensive local roll out of measures in the eight policy areas identified.

The bars in Figure E-2 show that the impacts of the national action increase in scale from 2030 and particularly 2035, as the electrified fleet increases in scale. The presumed national action on HGVs has increasing impact from 2040 as the electric and/or hydrogen vehicle numbers become increasingly significant in the fleet. The carbon reduction impacts of local measures are particularly significant in the 2020s and early 2030s, before the fleet changes from national action have fed through significantly. As the scale of the national action impact increases, the impacts of local measures become relatively less significant.

The estimates suggest that if local measures in each of the eight policy are applied at an ambitious scale across the county, emissions would be reduced by approximately a further 20% in addition to national action by 2030 and approximately 25% by 2035 (decreasing after than point as the impacts of the national action are increasingly significant).

**Figure E-2 – Indicative combined impact of local action policy areas - all transport (passenger and freight)**



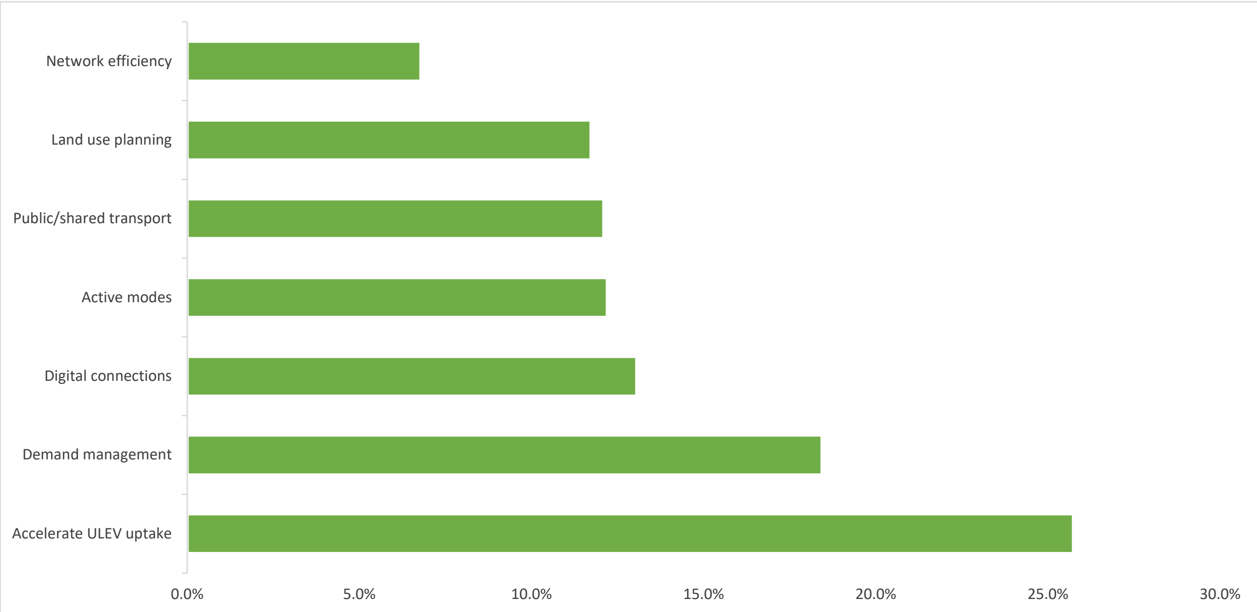

Note: all figures are indicative estimates only.

Figure E-3 provides a broad overview of the disaggregation of the projected reduction in emissions in 2030 between seven local policy areas (the eighth of behaviour change is assumed to be incorporated within the other seven).

The disaggregation suggests that all of the policy areas are needed to deliver a significant reduction in transport carbon emissions, with contributions ranging between about 5% for improved network efficiency to about 25% for accelerated ULEV uptake.

The relative contribution of each policy area would change through time with public and shared transport likely to become more significant as the impact of changes builds up, whilst acceleration of the EV uptake would become less significant through time as more of the fleet is already electrified.  Table E-4 provides further detail on the indicative estimates of emissions reductions.

**Figure E-3 – Indicative breakdown of local action impacts between policy areas, 2030**




Note: all figures are indicative estimates only.

**Table E-4 – Indicative estimate carbon reduction impacts of national and local action in key target years**

| Subsector addressed / Target emissions source | Annual Carbon Savings ($tCO_2e$ p.a., well to wheel) | | | |
|---|---|---|---|---|
| | 2025 | 2030 | 2035 | 2050 |
| *National action: ban on petrol/diesel car/van sales*[71] | 16,000 | 176,000 | 587,000 | 1,249,000 |
| *National action: Presumed HGV fleet upgrade measures* | 0 | 19,000 | 102,000 | 279,000 |
| Accelerate ULEV uptake | 8,000 | 118,000 | 110,000 | 0 |
| Increase active travel/micro mobility use | 18,000 | 59,000 | 54,000 | 7,000 |
| Increase public transport use | 7,000 | 56,000 | 54,000 | 10,000 |
| Demand management | 26,000 | 84,000 | 86,000 | 32,000 |

[71] Note that all measures at a local level (and the savings quantified) assume that this measure is in place – therefore savings decrease through time as the fleet is increasingly electrified.

| | | | | |
|---|---|---|---|---|
| Efficient network management | 29,000 | 32,000 | 20,000 | 5,000 |
| Land use planning | 22,000 | 54,000 | 49,000 | 6,000 |
| Digital connectivity | 57,000 | 60,000 | 36,000 | 5,000 |

The breakdown should be viewed as indicative only as the literature suggests broad ranges of impacts and a number of the policy areas interact. They would only achieve their full carbon reduction impact if implemented with other policy areas (e.g. the impacts of active modes and public transport measures are considerably increased by demand management measures and vice versa).

## E.3. Industry

The methodology used to derive transport reduction pathways is set out in two broad steps:

1. Identify measures and their savings potential, as identified at a national level; and
2. Analyse savings potential for Lancashire.

### E.3.1. Identification of measures and savings potential

Abatement measures to reduce CO2 emissions from the industrial processes are identified within the CCC data. This data includes % reductions, unit costs per tonne CO2 abated, equipment lifetimes and projected date of maturity of the technologies[72]. Information on these measures has been supplemented by a broader literature review, including national, regional and industry specific data sources.

Under the Sixth Carbon Budget[73], the Balanced Net Zero Pathway sees emissions from the manufacturing and construction sector reducing by 70% by 2035 and 90% by 2040 from 2018 levels, based on improvements to resource and energy efficiency, fuel switching and carbon capture and storage (CCS) (Figure E-4). The pathway assumes that the Government establishes a policy framework to support emissions reductions in a way that does not drive manufacturers overseas and that benefits jobs and investment in UK manufacturing.

The pace of reduction accelerates gradually between 2020 to 2035. Improvements in resource and efficiency lead to the largest emission reductions in the early 2020s. Infrastructures for CCS and hydrogen are deployed from 2025, starting near industrial clusters. Electricity network connection capacity is also increased around newly electrifying sites. During the 2030s, there is a substantial scale up for electrification, CCS and hydrogen. Most decarbonisation is complete by 2040. The pathway assumes that:

- policy develops rapidly to ensure that it pays for companies to implement societally cost effective measures and that non-financial barriers are addressed; and
- supply chains scale up at pace, with workers acquiring skills to implement low carbon measures, the supply of necessary technologies and equipment grows and the availability of finance increases.

[72] Termed nth of a kind (NOAK) within the CCC literature.
[73] Climate Change Committee (2020) The Sixth Carbon Budget. December 2020. Available online at: https://www.theccc.org.uk/publication/sixth-carbon-budget/. Accessed May 2021.

**Figure E-4 –CCC analysis – sources of abatement in the Balanced Net Zero Pathway for the manufacturing and construction sector (CCC, 2020)**

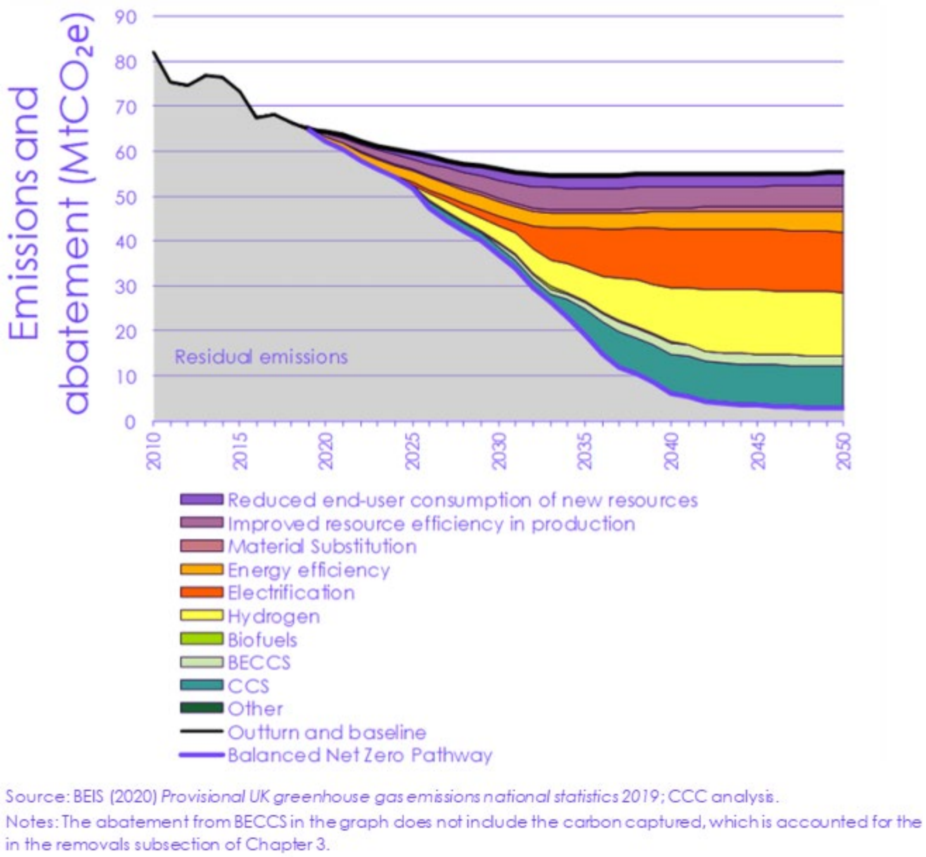



Table E-5 summarises the types of abatement measures applied and highlights key aspects for the Lancashire industrial baseline. Figure E-5 and Figure E-6 present the breakdown of abatement measures by sector and by process type.

**Table E-5 – Categories of abatement measures for application in the industrial sector**

| Category | Description | Application to Lancashire |
|---|---|---|
| Resource efficiency | Includes:<br>- reduction of end-user consumption of new resources; and<br>- improvements in resource efficiency in production, e.g. design optimisation, increased recycling and reuse and increase product utilisation and sharing. | Resource efficiency and material substitution measures have a substantial impact on the cement & lime sector, particularly as a result of measures in the construction, vehicles and fabricated metal sectors. |
| Material substitution | Material substitution can reduce manufacturing emissions by switching from high embodied-carbon materials to low-embodied-carbon materials. Measures include using replacements to clinker. Clinker substitution involves reducing the amount of clinker per unit of cement by substituting the clinker with other cementitious materials, such as pulverised fuel ash (a waste from coal fired power stations) or ground granulated blast furnace slag (a by- | |

| Category | Description | Application to Lancashire |
|---|---|---|
| | product from iron and steel manufacture), pozzolanic materials, and materials such as limestone[74] The UK Mineral Products Association[75] estimates that this could result in 12% emission reductions on a 2018 baseline. | |
| Energy efficiency | Includes:<br>- heat recovery;<br>- process upgrade;<br>- equipment upgrade; and<br>- integration / clustering. | The paper sector has the highest fraction* of abatement from energy efficiency (38% in 2050), with a substantial saving from clustering and using waste heat from other sites.<br>The largest absolute abatement from energy efficiency is in the chemicals sector (1 MtCO2e in 2050), driven largely by equipment upgrades. |
| Fuel switching (electrification) | Measures include electric boilers, switching from on-site generation to a grid connection, electric arc furnaces, electric mobile machinery, electric dryers and electric infra-red heaters | The location of sites may affect the choice of deep decarbonisation options when multiple options are possible – CCC evidence suggests that electrification has an advantage over hydrogen at dispersed sites, due to differences in electricity and hydrogen distribution options and availability, as well as existing infrastructure. |
| Fuel switching (hydrogen) | Hydrogen measures include hydrogen boilers, CHP, generators, mobile machinery and kilns. CCC latest evidence suggests that these measures can typically be retrofitted, limiting the need to wait for a replacement cycle or to scrap assets before fitting. | Potential pathways involving HyNet.<br>Also, Hanson Cement is currently undertaking a government funded research project[76] into the feasibility of a 70% biomass, 20% hydrogen and 10% plasma energy mix for fuelling the kiln. Hanson Cement has applied for a hazardous substance consent to allow the demonstration of use of hydrogen. |
| Fuel switching (bioenergy) | The use of sustainable biofuels provides carbon abatement in itself. CCC also assumes that CCS is applied to all new bioenergy use in manufacturing and construction (apart from in mobile machinery). As such, the application of CCS to bioenergy (BECCS) results in further abatement, see below. | Applicable particularly in the cement sector, which already uses bioenergy (see above re Hanson Cement), and also has potential to fit CCS. |
| CCS | CCS will be required where there are no identified alternative options to reduce emissions to near-zero. This includes processes that produce CO2 from non-combustion processes, such as cement production as well as combust fuels (internal fuels or off-gases) that are produced as part of the industrial process.<br>CCS plants involve mainly four steps. One might contain some form of pre-cleaning of the gaseous stream from where CO2 will be | Pipeline, train, truck or shipping are considered as options to transport CO2 from dispersed sites where CCS is their only deep decarbonisation option, such as cement, lime and other mineral sites.<br>The geographic location of Hanson Cement plant in Ribble Valley is likely to pose a challenge, increasing costs for deployment of CO2 transportation pipelines. Although alternative means of transport of CO2 by rail or road may be possible options. |

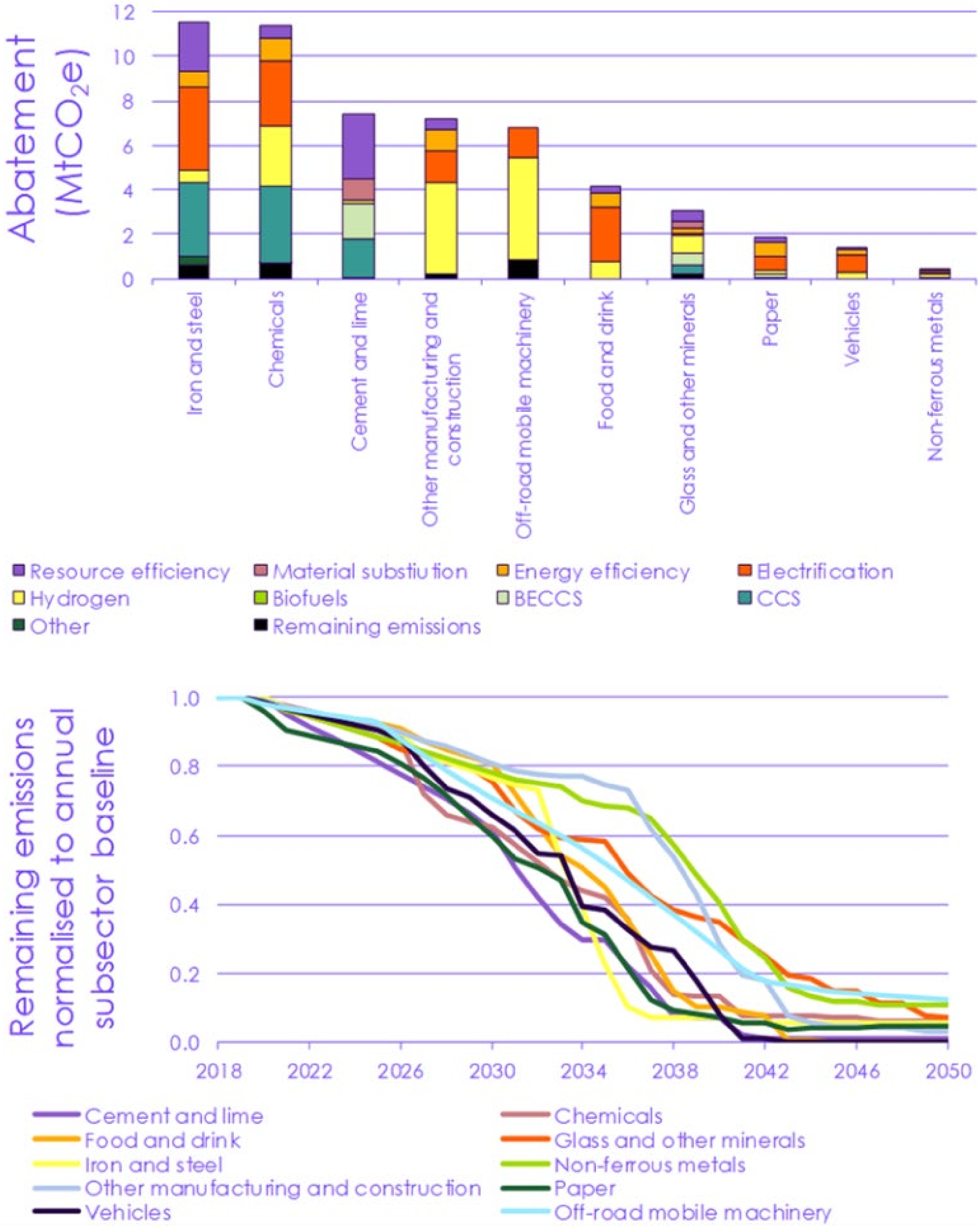
[74] Department for Business , Energy & Industrial Strategy, October 2017, Cement Sector Industrial Decarbonisation and Energy Efficiency Roadmap Action Plan. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/651222/cement-decarbonisation-action-plan.pdf. Accessed May 2021

75 Mineral Products Association (2020) UK Concrete and Cement Industry Roadmap to Beyond Net Zero. Available online at: https://www.thisisukconcrete.co.uk/TIC/media/root/Perspectives/MPA-UKC-Roadmap-to-Beyond-Net-Zero_October-2020.pdf. Accessed May 2021.

[76] Hanson Cement (2020) Fuel-switching research takes next step at Ribblesdale. Press release. 9 December 2020. Available online at: https://www.hanson-communities.co.uk/en/fuel-switching-research-at-ribblesdale. Accessed Jun 2021.

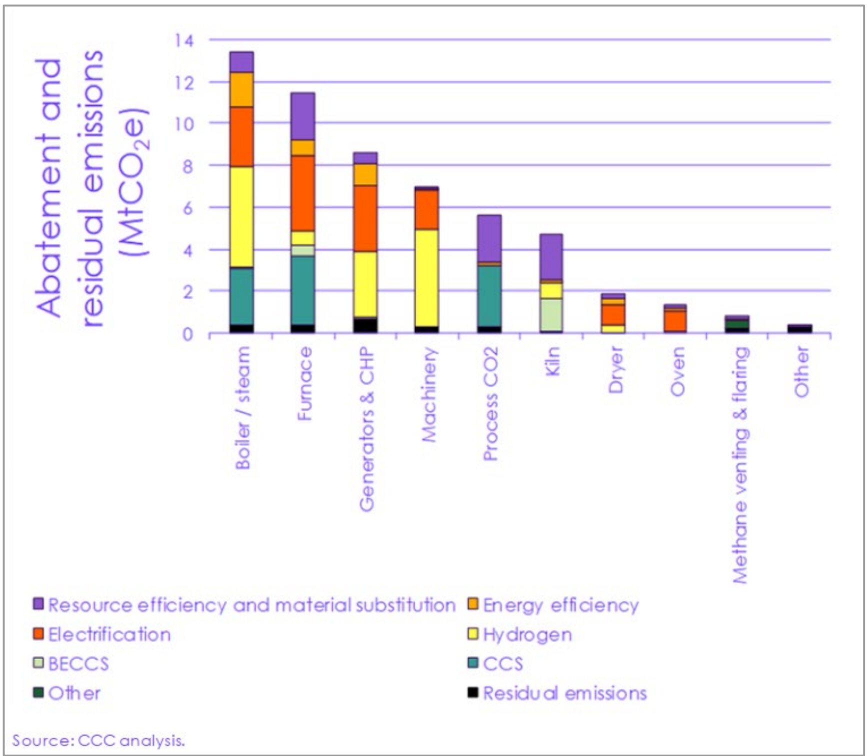
| Category | Description | Application to Lancashire |
|---|---|---|
| | captured to ensure that the stream is free from other gases that may hamper the operation of the following stages of the process. The next step is the capture of CO2, i.e., some technology that will separate the CO2 from the gaseous stream and produce a nearly pure CO2 stream. Next, there is the need to transport this CO2 stream to the storage site and finally the CO2 is injected at the storage site for permanent storage. Most storage involves some type of geological reservoir that might be located on land or in the ocean. Gas compression is usually needed in all of the steps of CCS. It is certainly important at the transport and injection stages and represents an important part of the energy demand of the whole process. | |
| Bioenergy with Carbon Capture and Storage (BECCS) | This means installing a CCS plant to capture CO2 that is produced from a bioenergy application. There are two components to this technology: CCS and the bioenergy.<br>The CCS component of BECCS is not different from non-BECCS applications of CCS. It is a technology that captures CO2 from a gaseous stream, for instance, from the combustion gases of a power plant or a cement kiln. | Potential for removals, beyond emissions abated from the plant, due to combination with bioenergy. |

**Figure E-5 - CCC analysis – Abatement and residual emissions for manufacturing and construction subsectors in 2050 in the Balanced Net Zero Pathway (CCC, 2020)**




Source: CCC analysis.

**Figure E-6 – CCC analysis – Abatement and residual emissions for manufacturing and construction processes in 2050 in the Balanced Net Zero Pathway (CCC, 2020)**




## E.3.2. Abatement options in Lancashire

The revised BAU for Lancashire is broken down into process type for each site. Data from CCC has been applied to identify a range of abatement options for each of these processes at each identified industrial site.

**Table E-6 – Data sources for abatement measures applied to Lancashire BAU**

| Measure type | Percentage reduction (figures applied to process types) | Technology lifetime and maturity date (NOAK) | Unit costs (average abatement cost in £ per tonne CO2) |
|---|---|---|---|
| Resource efficiency and material substitution<br><br>Energy efficiency | Translation of % reduction data presented in Figure E-6, to process types at site by site level. CCC (2020) states that resource efficiency, material substitution and energy efficiency begin in 2020 and increases to 2035, where it maintains consistent reductions to 2050. As such, % reductions presented in Figure E-6 are applied at 2035. It is assumed that 1/3 of the total 2035 reductions are | Both technology lifetime and estimated maturity dates are included within background data compiled by Element Energy (2020) as part of the CCC's Sixth Carbon Budget. They are contained within the N-ZIP model[77] for each sector and type of process. They can therefore be | Unit costs are listed within the CCC (2021) Sixth Carbon Budget Dataset[78] as averages for each type of measure within CCC's manufacturing and construction sector (i.e. not sub-sector or site specific), for:<br>• Bioenergy<br>• CCUS<br>• Electrification |

[77] Element Energy (2020) Deep-Decarbonisation Pathways for UK Industry. November 2020. Available online at: https://www.theccc.org.uk/publication/deep-decarbonisation-pathways-for-uk-industry-element-energy/. Accessed Jun 2021.
[78] CCC (2021) The numbers behind the budget. Available online at: https://www.theccc.org.uk/2021/02/01/the-numbers-behind-the-budget-six-ways-to-explore-the-sixth-carbon-budget-dataset/. Accessed Jun 2021.

| Measure type | Percentage reduction (figures applied to process types) | Technology lifetime and maturity date (NOAK) | Unit costs (average abatement cost in £ per tonne CO2) |
|---|---|---|---|
| | achieved by 2025 and 2/3 by 2030. | applied at an individual site level.<br>The data includes estimated dates for first of a kind (FOAK),<br>second of a kind (SOAK) and<br>nth of a kind (NOAK). The NOAK date is when the technology is mature and as such, when it is assumed available to be applied in Lancashire. | • Energy efficiency (negative cost)<br>• Hydrogen<br>• Increased resource efficiency in production and material substitution (assumed zero cost)<br>• Reduced end-user consumption of new resources (assumed zero cost)<br>• BECCS |
| Electrification | Abatement potential for each technology (specific to sub-sector and process) is included within data compiled by Element Energy (2020) as part of the CCC's Sixth Carbon Budget.<br>The data are contained within the N-ZIP model[79] for each sector and type of process. They can therefore be applied at an individual site level. | | |
| Hydrogen | | | |
| BECCS | | | |
| CCS | | | |

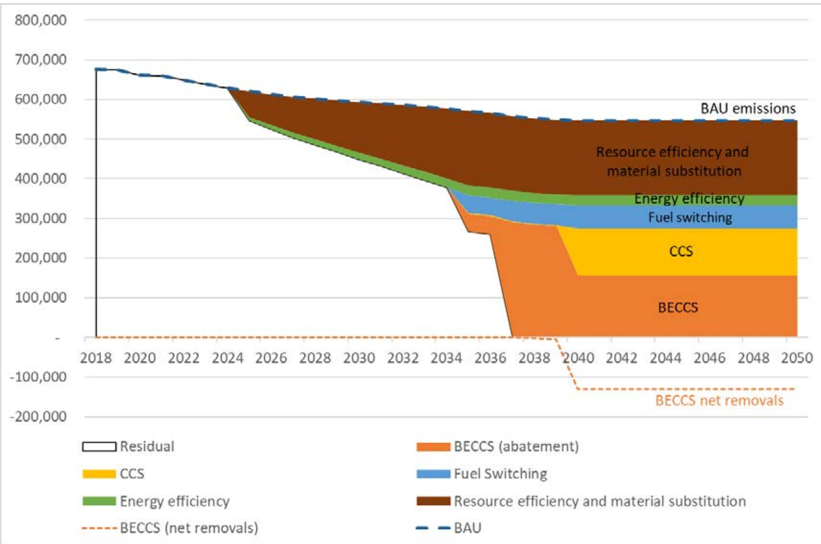
## E.3.3. Calculation outputs

The abatement measures have been applied at an individual site and process level, as described above. The results are presented in an accompanying spreadsheet. There are multiple measures identified for each process on each individual site. They broadly include:

- Resource efficiency and material substitution
- Energy efficiency
- Fuel switching (including different options for electrification, hydrogen and biomass);
- CCS; and
- BECCS.

Resource efficiency, material substitution and energy efficiency provide 'early wins'. These measures can be paired with fuel switching or CCS/BECCS, which are assumed to be mature only from 2035-2040. Figure E-67 provides an indicative Net Zero pathway for the Lancashire industrial sector, applying resource efficiency, material substitution and energy efficiency from 2025, fuel switching where possible from 2035 and CCS/BECCS from 2040.

**Figure E-7 – Indicative $CO_2$ emissions reduction pathway for Lancashire industrial sector (t)**




[79] Element Energy (2020) Deep-Decarbonisation Pathways for UK Industry. November 2020. Available online at: https://www.theccc.org.uk/publication/deep-decarbonisation-pathways-for-uk-industry-element-energy/. Accessed Jun 2021.

Note: all figures are indicative estimates only.

## E.3.4. Approach to mechanical carbon removals interventions by industry

### BECCS

The Climate Change Committee (CCC) includes BECCS within its balanced pathway for the Sixth Carbon Budget[80]. The processes and sectors determined to be suitable for fuel switching to biomass and BECCS included:

- Boilers and CHP (Paper sector)
- Furnaces (Glass sector)
- Kilns (Cement and Lime sectors)
- Other existing biomass-fuelled processes (Cement, Lime, Food & Drink, Other Chemicals, Other Industry, Paper, and Waste Processing sectors)

The CCC recognised that the amount of biomass used by the UK should be constrained by the supply of low carbon sustainable feedstocks. The national model therefore incorporates a constraint on total biomass availability for industry, taken from the CCC's internal sixth carbon budget biomass supply allocations. These allocations vary by scenario and contain the annual UK-wide limit on industry's biomass supply in TWh $yr^{-1}$ [81].

In the absence of regional calculations for Lancashire, this study assumes that application of BECCS is possible at Lancashire's cement and paper plant. The date of technology maturity is based on CCC's analysis and ranges between 2035 and 2040, depending on the type of BECCS technology[82]. The CCC also cites the unit cost per tonne saved as £126.30 (2019 prices).

Table E-7and Table E-8 show the potential reduction from BAU emissions under a scenario which assumes implementation of BECCS (alongside electrification and CCS) at paper and cement plants in Lancashire. Potential removals are -138,751 tonnes in 2037 and -143,940 tonnes in 2050.

**Table E-7 – Sites with potential for application of BECCS in Lancashire – BAU emissions**

| LA | Sector | Site | BAU $CO_2$ emissions (t) | | | |
|---|---|---|---|---|---|---|
| | | | 2018 | 2035 | 2037 | 2050 |
| **Lancaster** | Paper, printing & publishing industries | Northwood Tissue (Lancaster) Ltd | 5,222 | 4,255 | 4,314 | 4,383 |
| **Lancaster** | Paper, printing & publishing industries | Sofidel UK Ltd | 12,086 | 9,848 | 9,985 | 10,144 |
| **Ribble Valley** | Cement | Hanson Cement Ltd. (formerly Castle Cement) | 538,296 | 472,478 | 458,858 | 447,493 |
| **Rossendale** | Paper, printing & publishing industries | Essity UK Ltd (Stubbins Mill) | 22,923 | 18,678 | 18,938 | 19,239 |
| **West Lancashire** | Paper, printing & publishing industries | Essity UK Ltd (Tawd Mill) | 16,163 | 13,170 | 13,353 | 13,566 |
| | | **TOTAL** | **594,690** | **518,428** | **505,448** | **494,823** |

Note: all figures are indicative estimates only.

80 https://www.theccc.org.uk/publication/sixth-carbon-budget/.
81 https://www.theccc.org.uk/publication/deep-decarbonisation-pathways-for-uk-industry-element-energy.
82 Advanced amines or blends are assumed to be technologically mature by 2035 for paper plant and 2037 for cement. Calcium looping technology is assumed to be mature by 2040.

**Table E-8 – Sites with potential for application of BECCS in Lancashire – Scenario emissions**

| LA | Sector | Site | Abatement assumed | Scenario $CO_2$ emissions (t) | | | |
|---|---|---|---|---|---|---|---|
| | | | | 2018 | 2035 | 2037 | 2050 |
| **Lancaster** | Paper, printing & publishing industries | Northwood Tissue (Lancaster) Ltd | BECCS for boiler and CHP; electrification for dryer | 5,222 | -3,717 | -3,769 | -3,828 |
| **Lancaster** | Paper, printing & publishing industries | Sofidel UK Ltd | BECCS for boiler and CHP; electrification for dryer | 12,086 | -8,603 | -8,723 | -8,861 |
| **Ribble Valley** | Cement | Hanson Cement Ltd. (formerly Castle Cement) | BECCS for kiln; CCS for process emissions | 538,296 | 278,431 | -98,052 | -102,593 |
| **Rossendale** | Paper, printing & publishing industries | Essity UK Ltd (Stubbins Mill) | BECCS for boiler and CHP; electrification for dryer | 22,923 | -16,316 | -16,544 | -16,806 |
| **West Lancashire** | Paper, printing & publishing industries | Essity UK Ltd (Tawd Mill) | BECCS for boiler and CHP; electrification for dryer | 16,163 | -11,505 | -11,665 | -11,851 |
| | | | **TOTAL** | **594,690** | **238,290** | **-138,751** | **-143,940** |

Note: all figures are indicative estimates only.

### DACCS

Implementation of DACCS technology is not suggested as a key option for carbon removals in this strategy as the technology is still in its infancy, with key limiting factors, including:

- High energy demands, which at current levels are not necessarily carbon neutral in themselves.
- Concerns about injecting high volumes of $CO_2$ into deep reservoirs, particularly around pipelines, leakages and water pollution[83]

However, it is advised that Lancashire County Council reconsider DACCS in the future as this solution may become more feasible/affordable over time.

## E.4. Buildings

The key interventions that have been considered as part of the study at a quantitative level for both residential and non-residential buildings are:

- Fabric Improvements
- LED upgrades
- Decarbonising heating
- Building Level renewables

Other interventions have been considered qualitatively. Each type if intervention is described in Section 8 of the Main Report document.

[83] https://www.american.edu/sis/centers/carbon-removal/upload/icrlp_fact_sheet_daccs_181005.pdf

### E.4.1. Fabric Improvements

Glazing and insulation improvements have been calculated using the floor area, building typology and building age. It has been assumed that any building built after 2007 does not need fabric improvements.

In all , we would recommend taking a 'Fabric first' approach and focus initially on improving existing building stocks energy efficiency by improving glazing and insulation levels.

### E.4.2. Lighting

Of the interventions considered, lighting improvements are the cheapest but also have the smallest impact on overall carbon reduction. Low Energy Light bulbs use 70% less energy than traditional bulbs, LEDs use 90% less energy than traditional bulbs.

### E.4.3. Decarbonisation of heating

The decarbonisation of the grid allows electrification of heat, and the most efficient way to use electricity for heating is to employ heat pumps. For the purpose of this analysis for electrification, only Air Source Heat Pumps (ASHP) have been considered quantitively with a conservative COP used in calculations. Ground Source Heat Pumps (GSHPs) are also discussed.

A summary of the current incentives and grants available for the decarbonisation of heating can be found in Appendix G.

#### ASHP

Air Source Heat Pumps (ASHPs) extract heat from the external air and condense this energy to heat a smaller space within a residential or non-residential building. A pump circulates a refrigerant through a coil to absorb energy from the air. This refrigerant is then compressed to raise its temperature which can then be used for space heating and domestic hot water.

They can feed either low-temperature radiators or underfloor heating and often have electric immersion heater back-up for the winter months.

ASHPs operate effectively in buildings with a low energy demand, as they emit low levels of energy suitable for maintaining rather than dramatically increasing internal temperatures. It is therefore vital that fabric improvements are considered as a first priority as ASHP's will not work effectively in a poorly insulated building.

Underfloor heating will give the best performance and so installing heat pumps in newer buildings with underfloor heating will give the biggest benefit. Oversized radiators can also be used in buildings without underfloor heating. Radiators will typically be 33-50% larger than a typical radiator used in a boiler fed heating system.

Other considerations:

- For larger loads where multiple ASHP's are required planning permission may be required.
- Multiple units could also exceed the noise abatement limit of 42dB.

#### GSHP

GSHPs are more efficient than ASHP and are particularly suited to rural areas, to assess the impact of GSHP's in Lancashire further analysis would be required to assess the most appropriate areas and the ground make-up to predict accurate yields.

GSHPs extract heat from the ground and compress this energy to increase temperature for space heating and hot water. Pipework is installed into the ground, either through coils or in bore holes and piles, circulating a mix of water and antifreeze to extract energy from the ground, where the year-round temperature is relatively consistent (approx. 10℃ at 4 metres depth). This leads to a reliable source of heat for the building.

As with ASHPs, GSHPs perform best in well-insulated buildings with a low heating demand, they work most efficiently with an underfloor heating system but oversized radiators can also be used.

Other considerations:

- Require appropriate ground conditions to sink piles/bore holes or excavate for coils (which also require a large area of land.)
- For localised systems it costs approximately £11,000-£15,000 per dwelling dependent on the size of the system

#### Hydrogen boilers

Hydrogen boilers are gas-fired boilers, similar to existing natural gas (methane) condensing boilers, the main difference being hydrogen boilers use either 100% pure hydrogen or a blend of natural gas (methane) and hydrogen. As natural gas boilers, hydrogen boilers use hydrogen as fuel to create a flame to heat-up water that will circulate through existing heaters.

Hydrogen being a more volatile gas and a smaller molecule than methane it requires specific safety measures, different to natural gas boilers, all these safety measures are included in the hydrogen boilers and have been tested for in different trials across the UK.

Other considerations:

- Although hydrogen-ready boilers are available in the market, the type of hydrogen blend that will be available in the gas grid is not yet known, this blend will determine the configuration of the hydrogen boiler.
- Hydrogen boilers are expected to cost around 10% more than natural gas boilers, once manufacturers reached the same production quantity of current gas boilers. In addition, hydrogen, due to being a more complex fuel, it is expected to be 3-4 times more expensive than methane. Average cost of a hydrogen boiler is expected to be £37.97/m2. Hydrogen boilers in non-residential buildings are expected to be 20% higher.

**Table E-9 – £/m$^2$ costs of hydrogen boilers in residential buildings**

| BOILER SIZE | AREA (m2) | TOTAL COST | £ /m2 |
|---|---|---|---|
| 24 | <40 | £ 2,530.00 | £ 83.63 |
| 27 | <110 | £ 2,750.00 | £ 34.41 |
| 28 | <135 | £ 2,997.50 | £ 31.70 |
| 32 | <170 | £ 3,135.00 | £ 26.79 |
| 34 | <200 | £ 3,465.00 | £ 26.08 |
| 40 | <220 | £ 3,630.00 | £ 25.20 |

## E.4.4. Building level renewables

Calculations for PV panels have been considered for both residential and non-residential buildings. A number of assumptions have been made to estimate a total available roof area for each building. All calculation assumptions can be found in Appendix C.

The calculations assume the maximum possible PV roll out and currently don't consider any shading from adjacent buildings or the orientation of the building. This will reduce the maximum yield that can be achieved from PV.

Other practical considerations:

- Panels will operate most efficiently on a south-facing sloping roof (between 30 and 45-degree pitch.)
- Shading must be minimal (one shaded panel can impact the output of the rest of the array.)
- Panels must not be laid horizontally on a flat roof as they will not self-clean. Panels will therefore need to be installed at an angle and with appropriate space between them, to avoid over-shading.
- Large arrays may require upgrades to substations if exporting electricity to the grid.
- Local planning requirements may restrict installation of panels on certain elevations.
- Installation must take into account pitch and fall of the roof, along with any additional plant on the roof to ensure there is sufficient room.

## E.4.5. Other Net-Zero Interventions

District heating is a key step to reaching net zero, it is a significant opportunity as it's directly "investable" by an authority rather than reliance on national interventions. However, this hasn't been considered in this instance as this analysis has been assessing only the existing building stock.

Energy from waste will also have a significant part to play in the path to Net Zero and can be used in connection with district heating, there are already a number of these schemes within Lancashire. The impact of these hasn't been investigated at a quantitative level in this report as it is difficult to attribute building-level savings.

## E.4.6. Capital Costs

High level costs for each intervention have been calculated and are summarised in the Table E-10 below.

**Table E-10 – Unitised cost per intervention Residential Buildings**

| Intervention | £/t$CO_2$ saved |
|---|---|
| Lighting | £2,020 |

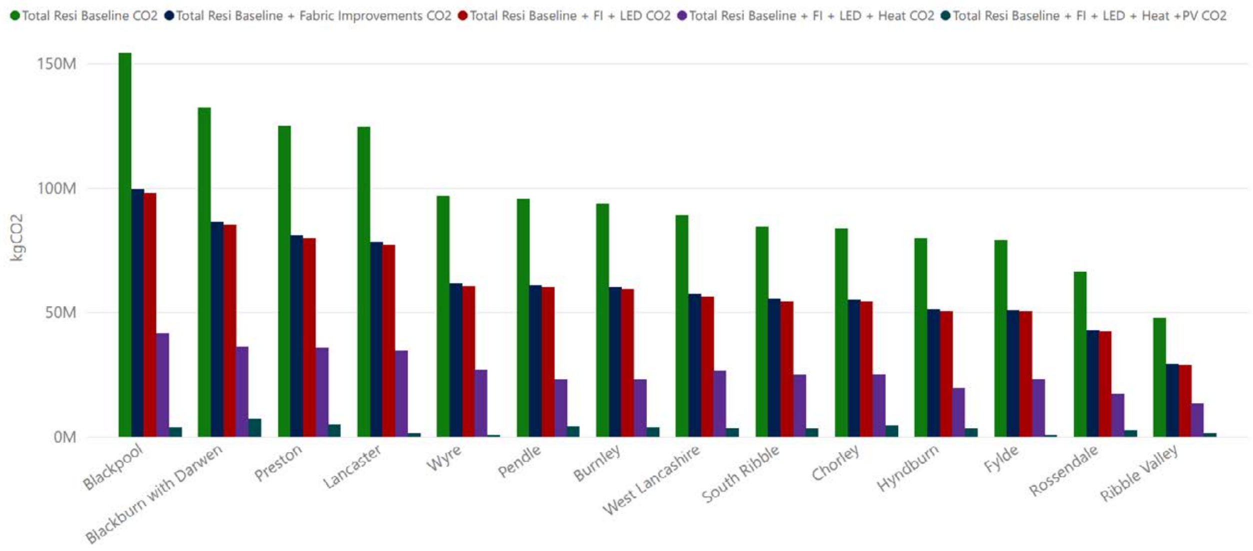
| Intervention | £/$tCO_2$ saved |
|---|---|
| Insulation | £7,460 |
| Glazing | £30,481 |
| PV Panels | £7,294 |
| Air source heat pumps | £8,892 |
| Hydrogen boilers | £1,559 |

## E.4.7. Carbon savings potential

The total carbon reduction that can be achieved with the interventions discussed are shown per local authority for residential buildings in Figure E-8 and for non-residential buildings in Figure E-9.

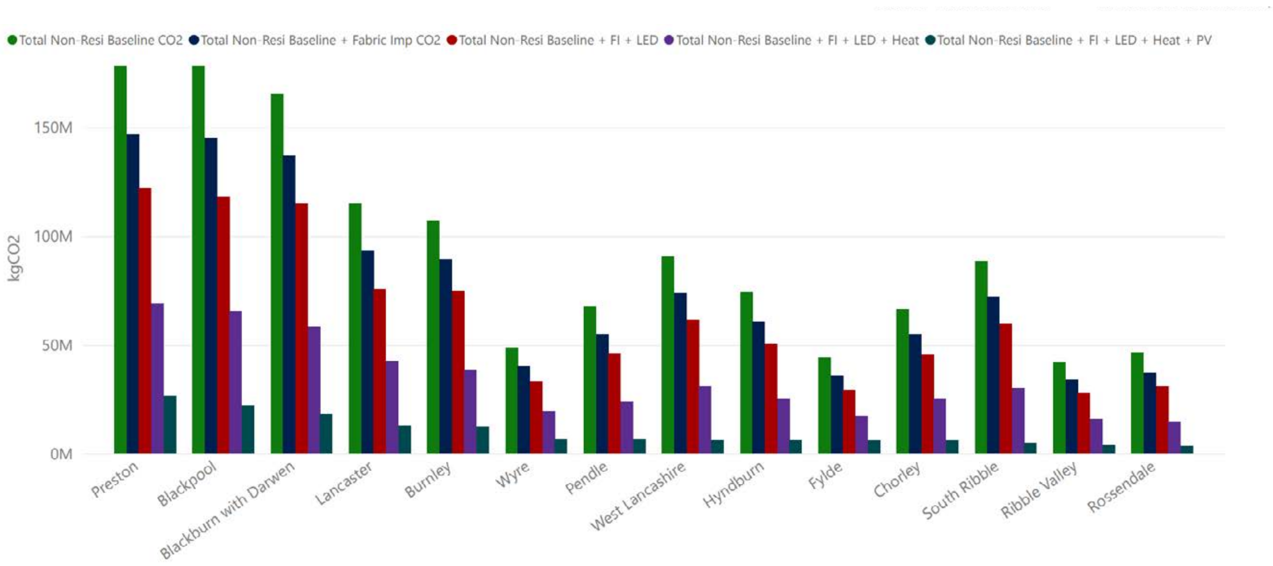
Reductions for each intervention are relatively proportional across each local authority. Further analysis into key target areas would be required to interrogate this information in more detail.

**Figure E-8 – Residential Carbon Reductions for interventions per LA**




Note: all figures are indicative estimates only.

**Figure E-9 - Residential Carbon Reductions for interventions per LA**




Note: all figures are estimates only.

Table E-11 below shows the overall % reduction that can be achieved if all measures considered are applied.

**Residential**
The overall % reduction for residential buildings that can be achieved if all the above described measures are applied and PV use is maximised on all available roof space is 97%.

**Non-Residential**
The overall % reduction for non-residential buildings that can be achieved if all the above described measures are applied and PV use is maximised on all available roof space is 89%.

**Table E-11 – Overall % reduction for residential and non-residential buildings**

| | Residential | | Non-Residential (inc. DEC data) | | All Buildings | |
|---|---|---|---|---|---|---|
| | **$kgCO_2$** | **%** | **$kgCO_2$** | **%** | **$kgCO_2$** | **%** |
| Baseline | 1,349,668,363 | 100% | 1,313,063,494 | 100% | 2,662,731,857 | 100% |
| Fabric | 868,565,039 | -36% | 1,075,756,568 | -18% | 1,944,321,607 | -27% |
| Lighting | 855,596,866 | -1% | 890,986,370 | -14% | 1,746,583,236 | -7% |
| Heating | 367,764,656 | -36% | 476,863,182 | -32% | 844,627,838 | -34% |
| PV | 42,423,118 | -24% | 142,499,049 | -25% | 184,922,167 | -25% |
| **TOTAL** | | **-97%** | | **-89%** | | **-93%** |

**Heating**

The hydrogen boiler calculations follow the same process as the heat pump calculations. The hydrogen savings and costs are calculated for unique properties connected to the mains (gas). In terms of $CO_2$ emissions savings, hydrogen was assumed to be green/blue ($CO_2$ factor of 0), while for heat pumps carbon factor of grid electricity was assumed. This leads to $CO_2$ savings from hydrogen boilers (fuelled by 100% green/blue hydrogen) to be around 48% higher than $CO_2$ savings achieved from switching to heat pumps.

## E.4.8. Recommendations

**Quick win** – Low energy/LED lighting, cheap and quick although only contributes to a 1% reduction in carbon if rolled out across all building stock.

**Quick/medium** – improving insulation and glazing on all buildings below energy band C, installing heat pumps to all new builds which already have the appropriate levels of insulation. Investigation into ground source heat pumps, particularly in rural areas.

**Medium** - PV installations – more analysis would be required to identify the most effective placing of these in relation to building orientation and shading, consideration of effective use of battery storage.

**Long Term Strategic** – Long term heating strategy i.e. making decision between retrofitting heat pumps across all building stock/relying on decarbonisation of gas network with introduction of hydrogen/connecting into district heat networks – this would require installing heat exchangers at building level and other significant upgrades.

# E.5. LULUCF

There is potential for land use change and land management changes to reduce LULUCF carbon emissions and enhance removals in Lancashire. The methodology to quantify this potential with a high-level estimate followed four main steps:

1. Identify intervention options available, both for preservation of existing carbon stocks and to increase carbon stocks over time through enhanced removals (sequestration);
2. Set out an approach to preserving existing carbon stocks;
3. Set out an approach to increasing carbon stocks through land use change; and
4. Evaluate carbon sequestration available through these measures and associated costs and benefits.

## E.5.1. Intervention Options and associated costs

There are several possible ways of reducing LULUCF emissions and enhancing carbon sequestration through land use actions across the county. These are described in Section 9 of the Main Report and are split between carbon stock preservation and carbon stock enhancement through active sequestration. Key active sequestration and preservation measures identified are: new broadleaved planting, new management of existing broadleaved and peatland restoration.

Evidence provided in CCC's[84] assessment of the wider economic and environmental impact of land use mitigation scenarios for Net Zero includes an estimation of the market and non-market impacts of implementing mitigation measures. Market impacts refer to the costs and benefits from changing land use that are reflected in market prices and exchange. Non-market impacts cover the wider set of ecosystem goods and services that flow from forestry, peatland restoration and low carbon farming for example. These goods and services generate benefits to society but are not generally priced in markets. These include wider benefits (ecosystem services in addition to carbon sequestration) such as increased recreational opportunities, improved health from increased physical activity, improved air quality, and improvements in flood alleviation, which is an important component of climate change adaptation.

Table E-8 presents the central estimation values (capital costs, operational costs, private benefits and wider social benefits) for the key active sequestration and preservation measures as identified above for Lancashire.

The establishment and operation of a broadleaved woodland over its lifetime costs around £28,000 per hectare while planting conifers costs around £26,000 per hectare as illustrated in Table E-12. Most costs accrue in the first year due to land acquisition and costs of planting trees. While ongoing costs are required to maintain the woodland, the upfront costs of forest creation underscore the potential costs of changing land use. For new management of existing broadleaf woodland, lifetime operational costs are around £5,770/ha with minimal capital cost.

Peatland does not typically generate revenue itself, so peatland restoration has a cost of between £4,300 and £5,600 per ha over its lifetime for upland and lowland peat respectively, indicating that these preservation measures will require substantial funding.

New coniferous planting delivers around £200,000 of benefits per hectare during its lifetime whereas new broadleaved woodland planting benefits range from £120,000 per hectare for rural locations and £172,000 per hectare for peri-urban locations.

Peatland restoration lifetime benefits range from £17,730 per hectare for upland restoration and £192,710 per hectare for lowland restoration.

**Table E-12 Central estimates costs and benefits for land use mitigation**

| Actions | Costs | | Benefits | | |
|---|---|---|---|---|---|
| | Capex (£/ha) | Opex (£/ha, lifetime value) | Private (Present value, £/ha) | Wider social benefits (Present value, £/ha) | |
| | | | | Total | Benefits breakdown |
| **Active sequestration** | | | | | |
| New broadleaved planting | £25,470 | £2,510 | £2,430 (wood and timber) | £117,310 (Rural)<br><br>£169,250 (Peri-urban) | Carbon sequestration: £81,590<br>Recreation: £26,850 for rural locations and £66,620 for peri-urban locations per hectare |

[84] Vivid Economics (2020), Economic impacts of Net Zero land use scenarios, https://www.theccc.org.uk/wp-content/uploads/2020/01/Economic-impacts-of-Net-Zero-land-use-scenarios-Vivid-Economics.pdf

| | | | | | |
|---|---|---|---|---|---|
| | | | | | Health: £5,040 for rural; £12,510 for peri-urban<br>Air filtration: £2,300 for rural; £6,000 peri-urban<br>Flood management: £220 for rural; £810 peri-rural |
| **Preservation** | | | | | |
| New management existing broadleaved | 0 | £5,770 | £10,740 (wood and timber) | £117,310 (Rural)<br>£169,250 (Peri-urban) | Greenhouse gas emissions reduction<br>Recreation (breakdown not available) |
| Peatland restoration<br>Upland<br>Lowland | <br>£1,430<br>£2,650 | <br>£2,936<br>£2,936 | <br>0<br>0 | <br>£17,730<br>£192,710 | |

Source: Adapted from Economic impacts of Net Zero land use scenarios report by Vivid Economics
Note: Consistent with public sector practice of cost-benefit analysis (CBA) in the UK, a declining social discount rate as recommended in the Green Book (HM Treasury, 2018). A social discount rate of 3.5% is used for the first 30 years of our analysis. The discount rate then declines in 2050 to 3% and again in 2095 to 2.5%.
- Financing costs are calculated such that capex is repaid over a 20-year period, and the cost of capital is 7% pre-tax real. This reflects the cost of raising capital in the private sector.
- The prices are expressed in 2019 terms.

## E.5.2. Approach to carbon stock preservation

In terms of a strategy for sequestration through land use, the immediate focus for Lancashire should be on preserving the wealth of existing carbon stocks across land use types, in particular existing woodland (both broadleaved and coniferous) and peatland that is in a ‘good’ i.e. near natural condition, as well as dry shrub heath.

### Forest Preservation

There are 20,042 ha of woodland in Lancashire holding a total carbon stock of 6,140 ktC. Protecting this land use would preserve this carbon stock and maintain existing removal rates by this land use category (-170ktCO2/year).

Based on the CCC’s central estimates of preservation costs per hectare (see Table E-12), preserving all broad-leaved and coniferous woodland across Lancashire would require investment in the region of £116 million. However, this would result in potential private benefits from wood and wood and timber harvesting at around £250 million and wider social benefits at around £2,350 million.

### Peatland Preservation

Due the potential for this large carbon stock to become an active emitter of $CO_2$ through poor management and due to the risks posed by climate change, it is vitally important to take action to preserve peatland that is in a ‘good’ condition. There are around estimated 9,000 hectares of peatland in good condition in Lancashire holding a total carbon stock of 1,807 kTC. Preserving the peatland in good condition would preserve this carbon stock and maintain existing removal rates by this land use category (180 $tCO_2$/year).

**Table E-13 – Forest and Peatland Preservation Interventions Summary**

| Preservation Interventions | Carbon stock protected (kt) | Area (ha) | Costs (capital and operation) | Private benefits | Wider social benefits |
|---|---|---|---|---|---|
| Forestry preservation/management (all existing woodland including coniferous plantation) | 6,140 | 20,042 | £116m | £215m | £2,350m |
| Peatland restoration/preservation (estimated area in a ‘good’ condition) | 1,807,296 | 8,996 | £50m | £0 | £17,336m |

### E.5.3. Approach to enhancement of carbon stocks

The science and verification of LULUCF based emissions reductions and removals measures is still maturing. Of the 17 carbon offsetting approaches reviewed by the Environment Agency[85], the following could be appropriate LULUCF interventions, for an area like Lancashire, to enhance carbon stocks via emissions reductions and increased sequestration:

- upland peat restoration
- lowland peat restoration
- woodland creation
- grassland management
- freshwater wetlands - floodplain restoration
- freshwater wetlands - constructed wetlands management
- saltmarsh restoration
- seagrass restoration
- kelp restoration
- agricultural soil management practices - arable land
- agricultural soil management practices - pasture grassland
- hedges and trees outside woodland
- enhanced weathering
- biochar

Of these measures only the peatland restoration and woodland creation options have been explored in this analysis. We are aware many interventions are available for achieving carbon removals using nature-based solutions and that new standards are evolving e.g. capturing carbon in agricultural soils and emerging Farm Soil Carbon Code, saltmarsh restoration with the emerging Saltmarsh Code. We chose to focus on woodland creation and peatland restoration in this analysis because they already have established standards and means of verifying removals projects i.e. the Woodland Carbon Code and Peatland Code. It is recommended that this analysis be built upon in follow-on stages of work to quantify and map opportunities for other intervention types, such as farm soil carbon capture and saltmarsh restoration.

In terms of strategy to maximise the enhancement of carbon stocks, releasing agricultural land to other land use types, ideally forest land, is the best possible approach, as forest land has a much higher potential carbon stock compared to agricultural land and is less likely to be a net emitter of carbon. In releasing land, it is vital that agricultural productivity is not lost, resulting in food being transported from further afield or imported from overseas and thus shifting emissions elsewhere. Land must be made available through measures such as sustainably increasing crop productivity and livestock grazing intensity, shifting consumption of beef, lamb and dairy products part way towards healthy eating guidelines, reducing food waste along the supply chain and moving horticulture production indoors.

This analysis explored:

- restoration of peatland estimated to not be in a ‘good’ condition in Lancashire i.e. eroding based on condition of designative sites containing peatland across England
- broadleaved woodland creation on existing scrub, grassland and arable field
- To estimate the potential removals, the difference in the per ha emissions and removals rates between the original land cover and the proposed land cover was calculated.

As it is unrealistic for 100% of the available land area to be converted from grassland, scrub and arable land to forest land, it was assumed that 90% of scrub, 60% of grassland and 30% of arable land can be converted to forestland. It was also assumed that peatland and tree planting is carried out at annual deployment rate of 5%. It takes several years to a few decades for the new land-use to reach equilibrium before full sequestration rates would be active. In this study, it was assumed that it would take 10 years for a new woodland to start sequestering carbon, while restored peatland would continue emitting carbon for the first 16 years (albeit a lower rate than a peatland that is not restored) and only after 16 years it would start removing carbon from the atmosphere.

Table E-14 provides afforestation potential annual sequestration increase and associated costs and benefits in Lancashire. Afforestation of 94,893 ha of grassland, scrub and arable in Lancashire would provide a sequestration increase of -1,298 ktCO2/year. Based on the CCC’s central estimates of preservation costs per hectare (see Table E-12), afforestation across

[85] Environment Agency external corporate report template (publishing.service.gov.uk)

Lancashire would require investment in the region of £2.7 billion. However, this would result in potential private benefits from wood and wood and timber harvesting at around £0.2 billion and wider social benefits at around £11 billion.

**Table E-14 – Afforestation across grassland, scrub, and arable land**

| Land Use Change Interventions | Potential annual sequestration increase (kt $CO_2$) | Area (ha) | Costs (Capital and opex) | Private benefits | Wider social benefits |
|---|---|---|---|---|---|
| Afforestation across 60% improved grassland, 90% scrub and 30% arable land | -1,296 | 94,893 | £2.7bn | £0.2bn | £11bn |

It should also be noted that careful consideration should be given to the species of tree selected based on what is the best fit for local biodiversity and existing soil conditions and also to ensure alignment with the principles of Biodiversity Net Gain (BNG) to maximise BNG potential. Detailed net-zero land management plans should be developed, with ongoing auditing through each stage to ensure that expected removals are occurring.

Additional to the conversion of grassland to forest land, consideration should also be given to maximising green space in urban areas through tree planting, which may also provide social value benefits. In the case of agricultural land, the ALC grade should be considered to protect the food producing function too.

Following this report, an opportunity mapping exercise is recommended to explore the feasibility of a longer list of LULUCF interventions for reducing emissions and enhancing removals. This would include consideration of interventions which could not be explored in earlier work such as farm soil carbon capture, saltmarsh restoration and arable reversion, in addition to woodland creation and peatland restoration. Building on the initial LULUCF analysis in this report, a range of opensource datasets (see list below) would be used to map Lancashire's natural capital assets (i.e. habitats) according to the UKHab classification system. Condition data will also be used where available as habitat condition can determine whether key habitat types are sources or sinks of carbon e.g. SSSI condition data for peatlands. These data will then be used in conjunction with the updated carbon factors table based on Natural England's 2021 carbon by habitat dataset. It is recommended that Natural England's Biodiversity Metric is used to identify where these interventions can be applied in a way that would not reduce biodiversity and identify where interventions could deliver biodiversity net gain (BNG). This is important for understanding the feasibility of these interventions in the context of the Environment Bill and the biodiversity as well as climate emergency. This would also offer insights regarding alternative funding routes for interventions focused on carbon removals, such as via Biodiversity Credits in emerging ecosystem services markets. It is recommended that this opportunity mapping piece include engagement with existing LULUCF carbon projects in Lancashire for refining feasibility criteria and capturing lessons learned from real case studies in the county e.g. peatland restoration projects on the Abbystead Estate in the Forest of Bowland and the Winmarleigh Moss carbon farm.

Examples of additional datasets to be consulted in landcover mapping (in addition to CROME, National Forest Inventory and peatland soils data already used):

- Ancient Woodland (England) inventory
- Priority Habitats Inventory
- CORINE landcover map
- OS Mastermap (Lancs CC would need to provide)
- OS Open Green Space
- Marine Conservation Zones Broadscale Habitat
- Marine Conservation Areas England
- Local Nature Reserves England
- Possible SAC/SPA
- Registered parks and gardens
- RAMSAR and proposed RAMSAR
- SPA, SSSI, SACs
- Environmental Stewardship Schemes

## E.6. Cross-sector pathways generation

Having established individual sector measures and their emissions savings, the emissions model calculated how the effects of these measures could be combined to assess how these savings taken together compared against the required savings over time – the 'target pathways' identified as follows:

- Net Zero emissions by 2030 (100% reduction from 1990 levels);
- 68% reduction of emissions by 2030 (from 1990 levels); and
- 78% reduction of emissions by 2035 (from 1990 levels).

The steps taken to achieve these cross-sector pathways are as follows:

1. Compile interventions and their aggregated savings, if applied to the fullest extent as early as possible, against each target pathway scenario;
2. Set out a means of adjusting the 'rate of intervention' for each measure in each scenario;
3. Assess the feasibility of achieving each scenario with maximum intervention;
4. Where feasible *in extremis*, test the effects of 'turning off' the rate of intervention for the key sectors, so that the limit of feasibility can be found (sensitivity testing);
5. Adjust the 'rates of intervention' applied to each measure, to find a balanced set of measures that will meet the target pathway in each case;
6. Extend to 2050 and combine with carbon removals to identify date of reaching Net Zero emissions, where possible.

### E.6.1. Compiling interventions

Each measure was drawn into a 'Measures inventory' which referenced the source of emissions, sector and subsector of application. This created a comprehensive list that any scenario or option could call on. Each measure was characterised by the expected annual $CO_2$ savings from 2022-50. This inventory also carries the costs for each measure, as fully applied to address all relevant emissions in Lancashire.

Then, relevant measures were drawn into the reporting tab of the model for each scenario. This created a summary view for a range of options within target pathway scenario, which could be prepared as appropriate. In each case, the summary effect of measures applied within the option could be compared with the target pathway as appropriate.

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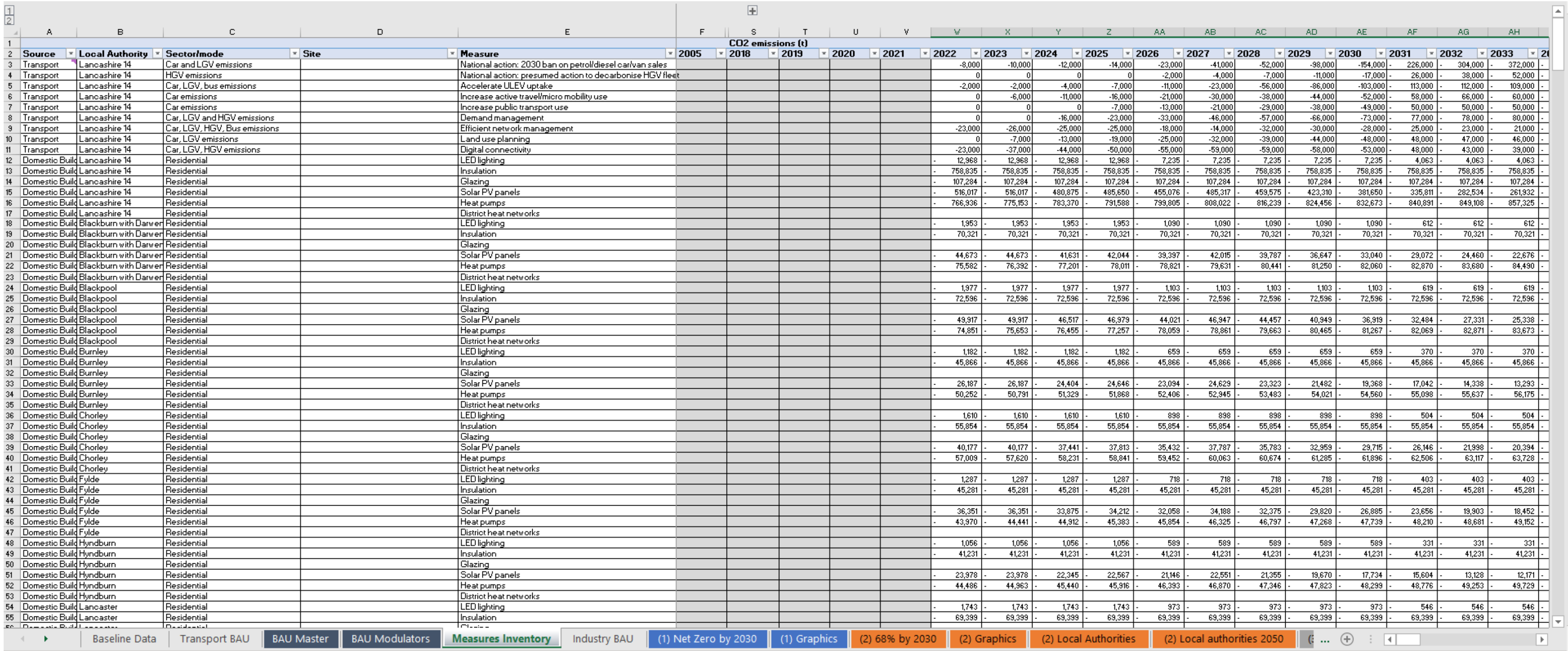
**Figure E-10 -Snapshot of compiled measures within Measures inventory**



| Source | Local Authority | Sector/mode | Site | Measure | 2005 | 2018 (CO2 emissions (t)) | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transport | Lancashire 14 | Car and LGV emissions | | National action: 2030 ban on petrol/diesel car/van sales | | | | | | -8,000 | -10,000 | -12,000 | -14,000 | -23,000 | -41,000 | -52,000 | -98,000 | -154,000 | -226,000 | -304,000 | -372,000 |
| Transport | Lancashire 14 | HGV emissions | | National action: presumed action to decarbonise HGV fleet | | | | | | 0 | 0 | 0 | 0 | -2,000 | -4,000 | -7,000 | -11,000 | -17,000 | -26,000 | -38,000 | -52,000 |
| Transport | Lancashire 14 | Car, LGV, bus emissions | | Accelerate ULEV uptake | | | | | | -2,000 | -2,000 | -4,000 | -7,000 | -11,000 | -23,000 | -56,000 | -86,000 | -103,000 | -113,000 | -112,000 | -109,000 |
| Transport | Lancashire 14 | Car emissions | | Increase active travel/micro mobility use | | | | | | 0 | -6,000 | -11,000 | -16,000 | -21,000 | -30,000 | -38,000 | -44,000 | -52,000 | -58,000 | -66,000 | -60,000 |
| Transport | Lancashire 14 | Car emissions | | Increase public transport use | | | | | | 0 | 0 | 0 | -7,000 | -13,000 | -21,000 | -29,000 | -38,000 | -49,000 | -50,000 | -50,000 | -50,000 |
| Transport | Lancashire 14 | Car, LGV and HGV emissions | | Demand management | | | | | | 0 | 0 | -16,000 | -23,000 | -33,000 | -46,000 | -57,000 | -66,000 | -73,000 | -77,000 | -78,000 | -80,000 |
| Transport | Lancashire 14 | Car, LGV, HGV, Bus emissions | | Efficient network management | | | | | | -23,000 | -26,000 | -25,000 | -25,000 | -18,000 | -14,000 | -32,000 | -30,000 | -28,000 | -25,000 | -23,000 | -21,000 |
| Transport | Lancashire 14 | Car, LGV emissions | | Land use planning | | | | | | 0 | -7,000 | -13,000 | -19,000 | -25,000 | -32,000 | -39,000 | -44,000 | -48,000 | -48,000 | -47,000 | -46,000 |
| Transport | Lancashire 14 | Car, LGV, HGV emissions | | Digital connectivity | | | | | | -23,000 | -37,000 | -44,000 | -50,000 | -55,000 | -59,000 | -59,000 | -58,000 | -53,000 | -48,000 | -43,000 | -39,000 |
| Domestic Build | Lancashire 14 | Residential | | LED lighting | | | | | | -12,968 | -12,968 | -12,968 | -12,968 | -7,235 | -7,235 | -7,235 | -7,235 | -7,235 | -4,063 | -4,063 | -4,063 |
| Domestic Build | Lancashire 14 | Residential | | Insulation | | | | | | -758,835 | -758,835 | -758,835 | -758,835 | -758,835 | -758,835 | -758,835 | -758,835 | -758,835 | -758,835 | -758,835 | -758,835 |
| Domestic Build | Lancashire 14 | Residential | | Glazing | | | | | | -107,284 | -107,284 | -107,284 | -107,284 | -107,284 | -107,284 | -107,284 | -107,284 | -107,284 | -107,284 | -107,284 | -107,284 |
| Domestic Build | Lancashire 14 | Residential | | Solar PV panels | | | | | | -516,017 | -516,017 | -480,875 | -485,650 | -455,076 | -485,317 | -459,575 | -423,310 | -381,650 | -335,811 | -282,534 | -261,932 |
| Domestic Build | Lancashire 14 | Residential | | Heat pumps | | | | | | -766,936 | -775,153 | -783,370 | -791,588 | -799,805 | -808,022 | -816,239 | -824,456 | -832,673 | -840,891 | -849,108 | -857,325 |
| Domestic Build | Lancashire 14 | Residential | | District heat networks | | | | | | | | | | | | | | | | | |
| Domestic Build | Blackburn with Darwen | Residential | | LED lighting | | | | | | -1,953 | -1,953 | -1,953 | -1,953 | -1,090 | -1,090 | -1,090 | -1,090 | -1,090 | -612 | -612 | -612 |
| Domestic Build | Blackburn with Darwen | Residential | | Insulation | | | | | | -70,321 | -70,321 | -70,321 | -70,321 | -70,321 | -70,321 | -70,321 | -70,321 | -70,321 | -70,321 | -70,321 | -70,321 |
| Domestic Build | Blackburn with Darwen | Residential | | Glazing | | | | | | | | | | | | | | | | | |
| Domestic Build | Blackburn with Darwen | Residential | | Solar PV panels | | | | | | -44,673 | -44,673 | -41,631 | -42,044 | -39,397 | -42,015 | -39,787 | -36,647 | -33,040 | -29,072 | -24,460 | -22,676 |
| Domestic Build | Blackburn with Darwen | Residential | | Heat pumps | | | | | | -75,582 | -76,392 | -77,201 | -78,011 | -78,821 | -79,631 | -80,441 | -81,250 | -82,060 | -82,870 | -83,680 | -84,490 |
| Domestic Build | Blackburn with Darwen | Residential | | District heat networks | | | | | | | | | | | | | | | | | |
| Domestic Build | Blackpool | Residential | | LED lighting | | | | | | -1,977 | -1,977 | -1,977 | -1,977 | -1,103 | -1,103 | -1,103 | -1,103 | -1,103 | -619 | -619 | -619 |
| Domestic Build | Blackpool | Residential | | Insulation | | | | | | -72,596 | -72,596 | -72,596 | -72,596 | -72,596 | -72,596 | -72,596 | -72,596 | -72,596 | -72,596 | -72,596 | -72,596 |
| Domestic Build | Blackpool | Residential | | Glazing | | | | | | | | | | | | | | | | | |
| Domestic Build | Blackpool | Residential | | Solar PV panels | | | | | | -49,917 | -49,917 | -46,517 | -46,979 | -44,021 | -46,947 | -44,457 | -40,949 | -36,919 | -32,484 | -27,331 | -25,338 |
| Domestic Build | Blackpool | Residential | | Heat pumps | | | | | | -74,851 | -75,653 | -76,455 | -77,257 | -78,059 | -78,861 | -79,663 | -80,465 | -81,267 | -82,069 | -82,871 | -83,673 |
| Domestic Build | Blackpool | Residential | | District heat networks | | | | | | | | | | | | | | | | | |
| Domestic Build | Burnley | Residential | | LED lighting | | | | | | -1,182 | -1,182 | -1,182 | -1,182 | -659 | -659 | -659 | -659 | -659 | -370 | -370 | -370 |
| Domestic Build | Burnley | Residential | | Insulation | | | | | | -45,866 | -45,866 | -45,866 | -45,866 | -45,866 | -45,866 | -45,866 | -45,866 | -45,866 | -45,866 | -45,866 | -45,866 |
| Domestic Build | Burnley | Residential | | Glazing | | | | | | | | | | | | | | | | | |
| Domestic Build | Burnley | Residential | | Solar PV panels | | | | | | -26,187 | -26,187 | -24,404 | -24,646 | -23,094 | -24,629 | -23,323 | -21,482 | -19,368 | -17,042 | -14,338 | -13,293 |
| Domestic Build | Burnley | Residential | | Heat pumps | | | | | | -50,252 | -50,791 | -51,329 | -51,868 | -52,406 | -52,945 | -53,483 | -54,021 | -54,560 | -55,098 | -55,637 | -56,175 |
| Domestic Build | Burnley | Residential | | District heat networks | | | | | | | | | | | | | | | | | |
| Domestic Build | Chorley | Residential | | LED lighting | | | | | | -1,610 | -1,610 | -1,610 | -1,610 | -898 | -898 | -898 | -898 | -898 | -504 | -504 | -504 |
| Domestic Build | Chorley | Residential | | Insulation | | | | | | -55,854 | -55,854 | -55,854 | -55,854 | -55,854 | -55,854 | -55,854 | -55,854 | -55,854 | -55,854 | -55,854 | -55,854 |
| Domestic Build | Chorley | Residential | | Glazing | | | | | | | | | | | | | | | | | |
| Domestic Build | Chorley | Residential | | Solar PV panels | | | | | | -40,177 | -40,177 | -37,441 | -37,813 | -35,432 | -37,787 | -35,783 | -32,959 | -29,715 | -26,146 | -21,998 | -20,394 |
| Domestic Build | Chorley | Residential | | Heat pumps | | | | | | -57,009 | -57,620 | -58,231 | -58,841 | -59,452 | -60,063 | -60,674 | -61,285 | -61,896 | -62,506 | -63,117 | -63,728 |
| Domestic Build | Chorley | Residential | | District heat networks | | | | | | | | | | | | | | | | | |
| Domestic Build | Fylde | Residential | | LED lighting | | | | | | -1,287 | -1,287 | -1,287 | -1,287 | -718 | -718 | -718 | -718 | -718 | -403 | -403 | -403 |
| Domestic Build | Fylde | Residential | | Insulation | | | | | | -45,281 | -45,281 | -45,281 | -45,281 | -45,281 | -45,281 | -45,281 | -45,281 | -45,281 | -45,281 | -45,281 | -45,281 |
| Domestic Build | Fylde | Residential | | Glazing | | | | | | | | | | | | | | | | | |
| Domestic Build | Fylde | Residential | | Solar PV panels | | | | | | -36,351 | -36,351 | -33,875 | -34,212 | -32,058 | -34,188 | -32,375 | -29,820 | -26,885 | -23,656 | -19,903 | -18,452 |
| Domestic Build | Fylde | Residential | | Heat pumps | | | | | | -43,970 | -44,441 | -44,912 | -45,383 | -45,854 | -46,325 | -46,797 | -47,268 | -47,739 | -48,210 | -48,681 | -49,152 |
| Domestic Build | Fylde | Residential | | District heat networks | | | | | | | | | | | | | | | | | |
| Domestic Build | Hyndburn | Residential | | LED lighting | | | | | | -1,056 | -1,056 | -1,056 | -1,056 | -589 | -589 | -589 | -589 | -589 | -331 | -331 | -331 |
| Domestic Build | Hyndburn | Residential | | Insulation | | | | | | -41,231 | -41,231 | -41,231 | -41,231 | -41,231 | -41,231 | -41,231 | -41,231 | -41,231 | -41,231 | -41,231 | -41,231 |
| Domestic Build | Hyndburn | Residential | | Glazing | | | | | | | | | | | | | | | | | |
| Domestic Build | Hyndburn | Residential | | Solar PV panels | | | | | | -23,978 | -23,978 | -22,345 | -22,567 | -21,146 | -22,551 | -21,355 | -19,670 | -17,734 | -15,604 | -13,128 | -12,171 |
| Domestic Build | Hyndburn | Residential | | Heat pumps | | | | | | -44,486 | -44,963 | -45,440 | -45,916 | -46,393 | -46,870 | -47,346 | -47,823 | -48,299 | -48,776 | -49,253 | -49,729 |
| Domestic Build | Hyndburn | Residential | | District heat networks | | | | | | | | | | | | | | | | | |
| Domestic Build | Lancaster | Residential | | LED lighting | | | | | | -1,743 | -1,743 | -1,743 | -1,743 | -973 | -973 | -973 | -973 | -973 | -546 | -546 | -546 |
| Domestic Build | Lancaster | Residential | | Insulation | | | | | | -69,399 | -69,399 | -69,399 | -69,399 | -69,399 | -69,399 | -69,399 | -69,399 | -69,399 | -69,399 | -69,399 | -69,399 |



Note: all figures are indicative estimates only.

### Figure E-11 - Summary 'report card' for the Net Zero by 2030 target pathway

| | A | B | C | D | G | V | AI | AJ | AK | AL | AM | AN | AO | AP | AQ | AR | AS | AT | AU | AV | AW | AX | AY | AZ | BA | BB | BC | BD | BE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Scenario 1: Net Zero emissions by 2030** | | | | **Emissions Savings** | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | **Year** | | | | **1990** | **2005** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024** | **2025** | **2026** | **2027** | **2028** | **2029** | **2030** | **2031** | **2032** | **2033** | **2034** | **2035** | **2036** | **2037** | **2038** | **2039** | **2040** |
| 3 | Business as Usual | | | | 14,807 | 12,956 | 8,568 | 8,548 | 8,428 | 8,165 | 8,065 | 8,097 | 7,998 | 7,973 | 7,864 | 7,896 | 7,802 | 7,683 | 7,300 | 7,111 | 6,907 | 6,787 | 6,627 | 6,459 | 6,392 | 6,327 | 6,269 | 6,220 | 6,170 |
| 4 | Net Zero by 2030 | | | | 14,807 | 12,956 | 8,568 | 7,861 | 7,147 | 6,432 | 5,717 | 5,003 | 4,288 | 3,573 | 2,859 | 2,144 | 1,429 | 715 | 0 | | | | | | | | | | |
| 5 | 68% reduction by 2030 | | | | 14,807 | 12,956 | 8,568 | 8,248 | 7,920 | 7,591 | 7,263 | 6,935 | 6,607 | 6,279 | 5,950 | 5,622 | 5,294 | 4,966 | 4,738 | 4,343 | 4,048 | 3,753 | 3,458 | 3,163 | 2,868 | 2,573 | 2,278 | 1,983 | 1,689 |
| 6 | 78% reduction by 2035 | | | | 14,807 | 12,956 | 8,568 | 8,259 | 7,942 | 7,625 | 7,308 | 6,991 | 6,674 | 6,358 | 6,041 | 5,724 | 5,407 | 5,090 | 4,773 | 4,456 | 4,139 | 3,822 | 3,505 | 3,258 | 2,895 | 2,602 | 2,308 | 2,015 | 1,721 |
| 7 | Net Zero by 2050 | | | | 14,807 | 12,956 | 8,568 | 7,882 | 7,587 | 7,292 | 6,997 | 6,702 | 6,407 | 6,112 | 5,817 | 5,523 | 5,228 | 4,933 | 4,738 | 4,406 | 4,174 | 3,942 | 3,710 | 3,478 | 3,246 | 3,015 | 2,783 | 2,551 | 2,319 |
| 8 | | | | | | | | | | | | | | | | | | | 0.21 | | | | | | | | | | |
| 9 | **Emissions Saving Summary** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | Baseline / BAU | | | | 14,807 | 12,956 | 8,568 | 8,548 | 8,428 | 8,165 | 8,065 | 8,097 | 7,998 | 7,973 | 7,864 | 7,896 | 7,802 | 7,683 | 7,300 | 7,111 | 6,907 | 6,787 | 6,627 | 6,459 | 6,392 | 6,327 | 6,269 | 6,220 | 6,170 |
| 11 | Maximum ambition | | | | 14,807 | 12,956 | 8,568 | 8,548 | 8,428 | 8,165 | 7,270 | 6,897 | 6,410 | 5,933 | 5,494 | 5,038 | 4,490 | 3,931 | 3,129 | 2,965 | 2,740 | 2,560 | 2,370 | 2,111 | 2,034 | 1,898 | 1,774 | 1,661 | 1,323 |
| 12 | Minimum ambition | | | | 14,807 | 12,956 | 8,568 | 8,548 | 8,428 | 8,165 | 8,065 | 8,097 | 7,998 | 7,973 | 7,864 | 7,896 | 7,802 | 7,683 | 7,300 | 7,111 | 6,907 | 6,787 | 6,627 | 6,459 | 6,392 | 6,327 | 6,269 | 6,220 | 6,170 |
| 13 | Option 3 | | | | 14,807 | 12,956 | 8,568 | 8,548 | 8,428 | 8,165 | 8,065 | 8,097 | 7,998 | 7,973 | 7,864 | 7,896 | 7,802 | 7,683 | 7,300 | 7,111 | 6,907 | 6,787 | 6,627 | 6,459 | 6,392 | 6,327 | 6,269 | 6,220 | 6,170 |
| 14 | Option 4 | | | | 14,807 | 12,956 | 8,568 | 8,548 | 8,428 | 8,165 | 8,065 | 8,097 | 7,998 | 7,973 | 7,864 | 7,896 | 7,802 | 7,683 | 7,300 | 7,111 | 6,907 | 6,787 | 6,627 | 6,459 | 6,392 | 6,327 | 6,269 | 6,220 | 6,170 |
| 15 | Carbon removals | | | | - | - | - | - | - | - | (29) | (59) | (88) | (118) | (147) | (177) | (206) | (236) | (265) | (295) | (389) | (483) | (578) | (695) | (789) | (1,144) | (1,252) | (1,361) | (1,47 |
| 16 | Hydrogen economy | | | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 17 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | **Maximum ambition** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | Source | Local Authority | Sector/Mode | Measure | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | Baseline | | | | | | 8,567,702 | 8,567,702 | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 |
| 120 | | | | | | | **8,567,702** | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### |
| 121 | Industry & Commercial | | | | | | 2,868,115 | 2,881,423 | 2,847,193 | ####### | ####### | ####### | 2,029,021 | 1,845,326 | 1,714,224 | 1,583,227 | 1,400,544 | 1,209,186 | 793,381 | 786,414 | 712,047 | 659,868 | 587,378 | 446,604 | 459,882 | 415,034 | 379,388 | 346,887 | 85,546 |
| 122 | Transport | | | | | | 2,868,714 | 2,829,341 | ####### | 2,732,196 | ####### | 2,593,160 | ####### | 2,445,148 | ####### | ####### | 2,091,145 | 1,937,647 | 1,758,850 | 1,593,611 | 1,436,615 | 1,308,936 | 1,189,045 | 1,066,745 | 977,282 | 889,065 | 803,332 | 726,010 | 652,116 |
| 123 | Domestic Buildings | | | | | | 2,324,296 | 2,330,833 | 2,316,454 | ####### | 1,770,405 | 1,576,243 | 1,347,182 | 1,136,399 | 918,373 | 709,815 | 491,808 | 277,860 | 70,228 | 78,355 | 84,269 | 84,885 | 87,488 | 90,666 | 90,384 | 87,598 | 84,811 | 82,024 | 79,237 |
| 124 | Agriculture | | | | | | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 |
| 125 | LULUCF | | | | | | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 |
| 126 | | | | | | | | | | | | | | | | 0.253555 | 0.562106 | 0.61 | 0.276621 | 0.0337114 | | | | | | | | | |
| 127 | **Minimum ambition** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 128 | Source | Local Authority | Sector/Mode | Measure | | | | | | | | | | | | | | | | | | | | | | | | | |
| 129 | Baseline | | | | | | 8,567,702 | 8,567,702 | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 |
| 229 | | | | | | | **8,567,702** | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### |
| 230 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 231 | **Option 3** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 232 | Source | Local Authority | Sector/Mode | Measure | | | | | | | | | | | | | | | | | | | | | | | | | |
| 233 | Baseline | | | | | | 8,567,702 | 8,567,702 | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 |
| 333 | | | | | | | **8,567,702** | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### |
| 334 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 335 | **Option 4** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 336 | Source | Local Authority | Sector/Mode | Measure | | | | | | | | | | | | | | | | | | | | | | | | | |
| 337 | Baseline | | | | | | 8,567,702 | 8,567,702 | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 |
| 437 | | | | | | | **8,567,702** | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### | ####### |
| 438 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 439 | **Carbon Removals** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 440 | Source | Local Authority | Sector/Mode | Measure | | | | | | | | | | | | | | | | | | | | | | | | | |
| 492 | **Total** | | | | | | - | - | - | - | (29,485) | (58,970) | (88,455) | (117,940) | (147,425) | (176,909) | (206,394) | (235,879) | (265,364) | (294,849) | (389,128) | (483,407) | (577,686) | (695,067) | (789,416) | ####### | ####### | (1,361,491) | ####### |
| 493 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 494 | **Mitigation from Hydrogen** | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 495 | Source | Local Authority | Sector/Mode | Measure | | | | | | | | | | | | | | | | | | | | | | | | | |
| 515 | | | | | | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 516 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Baseline Data | Transport BAU | BAU Master | BAU Modulators | Measures Inventory | Industry BAU | (1) Net Zero by 2030 | (1) Graphics | (2) 68% by 2030 | (2) Graphics | (2) Local Authorities | (2) Local authorities 2050

Note: all figures are indicative estimates only.

### Figure E-12 -Summary 'report card' for Net Zero by 2030 target pathway (maximum ambition option shown)

| | A | B | C | D | G | V | AI | AJ | AK | AL | AM | AN | AO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Scenario 1: Net Zero emissions by 2030 | | | | Emissions Savings | | | | | | | | |
| 2 | Year | | | | 1990 | 2005 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
| 3 | Business as Usual | | | | 14,807 | 12,956 | 8,568 | 8,548 | 8,428 | 8,165 | 8,065 | 8,097 | 7,998 |
| 4 | Net Zero by 2030 | | | | 14,807 | 12,956 | 8,568 | 7,861 | 7,147 | 6,432 | 5,717 | 5,003 | 4,288 |
| 5 | 68% reduction by 2030 | | | | 14,807 | 12,956 | 8,568 | 8,248 | 7,920 | 7,591 | 7,263 | 6,935 | 6,607 |
| 6 | 78% reduction by 2035 | | | | 14,807 | 12,956 | 8,568 | 8,259 | 7,942 | 7,625 | 7,308 | 6,991 | 6,674 |
| 7 | Net Zero by 2050 | | | | 14,807 | 12,956 | 8,568 | 7,882 | 7,587 | 7,292 | 6,997 | 6,702 | 6,407 |
| 8 | | | | | | | | | | | | | |
| 9 | Emissions Saving Summary | | | | | | | | | | | | |
| 10 | Baseline / BAU | | | | 14,807 | 12,956 | 8,568 | 8,548 | 8,428 | 8,165 | 8,065 | 8,097 | 7,998 |
| 11 | Maximum ambition | | | | 14,807 | 12,956 | 8,568 | 8,548 | 8,428 | 8,165 | 7,270 | 6,897 | 6,410 |
| 12 | Minimum ambition | | | | 14,807 | 12,956 | 8,568 | 8,548 | 8,428 | 8,165 | 8,065 | 8,097 | 7,998 |
| 13 | Option 3 | | | | 14,807 | 12,956 | 8,568 | 8,548 | 8,428 | 8,165 | 8,065 | 8,097 | 7,998 |
| 14 | Option 4 | | | | 14,807 | 12,956 | 8,568 | 8,548 | 8,428 | 8,165 | 8,065 | 8,097 | 7,998 |
| 15 | Carbon removals | | | | - | - | - | - | - | - | (29) | (59) | (88) |
| 16 | Hydrogen economy | | | | - | - | - | - | - | - | - | - | - |
| 17 | | | | | | | | | | | | | |
| 18 | Maximum ambition | | | | | | | | | | | | |
| 19 | Source | Local Authority | Sector/Mode | Measure | | | | | | | | | |
| 20 | Baseline | | | | | | 8,567,702 | 8,567,702 | ####### | ####### | ####### | ####### | ####### |
| 21 | Industry & Commercial | | | Business as Usual | | | 2,868,115 | 2,881,423 | 2,847,193 | 2,698,842 | 2,649,142 | 2,682,410 | 2,635,377 |
| 22 | Transport | | | Business as Usual | | | 2,868,714 | 2,829,341 | 2,758,090 | 2,732,196 | 2,706,065 | 2,681,160 | 2,651,772 |
| 23 | Domestic Buildings | | | Business as Usual | | | 2,324,296 | 2,330,833 | 2,316,454 | 2,227,468 | 2,202,813 | 2,227,320 | 2,204,515 |
| 24 | Agriculture | | | Business as Usual | | | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 |
| 25 | LULUCF | | | Business as Usual | | | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 |
| 26 | Transpor | Lancashire 14 | Car and LGV emissions | National action: 2030 ban on petrol/diesel car/van sales | | | | | | | -8,000 | -10,000 | -12,000 |
| 27 | Transpor | Lancashire 14 | HGV emissions | National action: presumed action to decarbonise HGV fleet | | | | | | | 0 | 0 | 0 |
| 28 | Transpor | Lancashire 14 | Car, LGV, bus emission | Accelerate ULEV uptake | | | | | | | -2,000 | -2,000 | -4,000 |
| 29 | Transpor | Lancashire 14 | Car emissions | Increase active travel/micro mobility use | | | | | | | 0 | -6,000 | -11,000 |
| 30 | Transpor | Lancashire 14 | Car emissions | Increase public transport use | | | | | | | 0 | 0 | 0 |
| 31 | Transpor | Lancashire 14 | Car, LGV and HGV emis | Demand management | | | | | | | 0 | 0 | -16,000 |
| 32 | Transpor | Lancashire 14 | Car, LGV, HGV, Bus em | Efficient network management | | | | | | | -23,000 | -26,000 | -25,000 |
| 33 | Transpor | Lancashire 14 | Car, LGV emissions | Land use planning | | | | | | | 0 | -7,000 | -13,000 |
| 34 | Transpor | Lancashire 14 | Car, LGV, HGV emissior | Digital connectivity | | | | | | | -23,000 | -37,000 | -44,000 |
| 35 | Domestic | Lancashire 14 | Residential | Insulation | | | | | | | -151,767 | -227,651 | -303,534 |
| 36 | Domestic | Lancashire 14 | Residential | Glazing | | | | | | | -21,457 | -32,185 | -42,914 |
| 37 | Domestic | Lancashire 14 | Residential | Heat pumps | | | | | | | -153,387 | -232,546 | -313,348 |
| 38 | Domestic | Lancashire 14 | Residential | LED lighting | | | | | | | -2,594 | -3,890 | -5,187 |
| 39 | Domestic | Lancashire 14 | Residential | Solar PV panels | | | | | | | -103,203 | -154,805 | -192,350 |
| 40 | Domestic | Lancashire 14 | Residential | District heat networks | | | | | | | 0 | 0 | 0 |
| 41 | Industry & | Lancashire 14 | Industrial/Commercial | Insulation | | | | | | | -49,977 | -74,966 | -99,954 |
| 42 | Industry & | Lancashire 14 | Industrial/Commercial | Glazing | | | | | | | -14,096 | -21,144 | -28,192 |
| 43 | Industry & | Lancashire 14 | Industrial/Commercial | Heat pumps | | | | | | | -109,846 | -166,535 | -224,400 |
| 44 | Industry & | Lancashire 14 | Industrial/Commercial | LED lighting | | | | | | | -49,596 | -74,394 | -99,192 |
| 45 | Industry & | Lancashire 14 | Industrial/Commercial | Solar PV panels | | | | | | | -82,958 | -124,438 | -154,618 |
| 46 | Industry & | Lancashire 14 | Industrial/Commercial | District heat networks | | | | | | | 0 | 0 | 0 |
| 47 | Industry & | Lancashire 14 | Large industrial installat | Energy efficiency | | | | | | | 0 | 0 | 0 |
| 48 | Industry & | Lancashire 14 | Large industrial installat | Resource efficiency and material substitution | | | | | | | 0 | 0 | 0 |
| 49 | Industry & | Lancashire 14 | Large industrial installat | Electrification | | | | | | | 0 | 0 | 0 |
| 50 | Industry & | Lancashire 14 | Large industrial installat | Carbon capture and storage | | | | | | | 0 | 0 | 0 |
| 51 | | | | | | | | | | | 0 | 0 | 0 |
| 52 | | | | | | | | | | | 0 | 0 | 0 |
| 53 | | | | | | | | | | | 0 | 0 | 0 |

| | AP | AQ | AR | AS | AT | AU | AV | AW | AX | AY | AZ | BA | BB | BC | BD | BE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | | | | | |
| 2 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 |
| 3 | 7,973 | 7,864 | 7,896 | 7,802 | 7,683 | 7,300 | 7,111 | 6,907 | 6,787 | 6,627 | 6,459 | 6,392 | 6,327 | 6,269 | 6,220 | 6,170 |
| 4 | 3,573 | 2,859 | 2,144 | 1,429 | 715 | 0 | | | | | | | | | | |
| 5 | 6,279 | 5,950 | 5,622 | 5,294 | 4,966 | 4,738 | 4,343 | 4,048 | 3,753 | 3,458 | 3,163 | 2,868 | 2,573 | 2,278 | 1,983 | 1,689 |
| 6 | 6,358 | 6,041 | 5,724 | 5,407 | 5,090 | 4,773 | 4,456 | 4,139 | 3,822 | 3,505 | 3,258 | 2,895 | 2,602 | 2,308 | 2,015 | 1,721 |
| 7 | 6,112 | 5,817 | 5,523 | 5,228 | 4,933 | 4,738 | 4,406 | 4,174 | 3,942 | 3,710 | 3,478 | 3,246 | 3,015 | 2,783 | 2,551 | 2,319 |
| 8 | | | | | | 0.21 | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | |
| 10 | 7,973 | 7,864 | 7,896 | 7,802 | 7,683 | 7,300 | 7,111 | 6,907 | 6,787 | 6,627 | 6,459 | 6,392 | 6,327 | 6,269 | 6,220 | 6,170 |
| 11 | 5,933 | 5,494 | 5,038 | 4,490 | 3,931 | 3,129 | 2,965 | 2,740 | 2,560 | 2,370 | 2,111 | 2,034 | 1,898 | 1,774 | 1,661 | 1,323 |
| 12 | 7,973 | 7,864 | 7,896 | 7,802 | 7,683 | 7,300 | 7,111 | 6,907 | 6,787 | 6,627 | 6,459 | 6,392 | 6,327 | 6,269 | 6,220 | 6,170 |
| 13 | 7,973 | 7,864 | 7,896 | 7,802 | 7,683 | 7,300 | 7,111 | 6,907 | 6,787 | 6,627 | 6,459 | 6,392 | 6,327 | 6,269 | 6,220 | 6,170 |
| 14 | 7,973 | 7,864 | 7,896 | 7,802 | 7,683 | 7,300 | 7,111 | 6,907 | 6,787 | 6,627 | 6,459 | 6,392 | 6,327 | 6,269 | 6,220 | 6,170 |
| 15 | (118) | (147) | (177) | (206) | (236) | (265) | (295) | (389) | (483) | (578) | (695) | (789) | (1,144) | (1,252) | (1,361) | (1,47 |
| 16 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 17 | | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | | | | | |
| 20 | ####### | ####### | ####### | ####### | ####### | ####### | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 | 8,567,702 |
| 21 | 2,645,533 | 2,605,838 | 2,654,325 | 2,623,948 | 2,577,106 | 2,299,613 | 2,214,680 | 2,117,033 | 2,067,838 | 1,987,358 | 1,898,218 | 1,869,356 | 1,838,383 | 1,809,379 | 1,783,053 | 1,756,98 |
| 22 | 2,606,148 | 2,555,858 | 2,508,242 | 2,460,145 | 2,412,647 | 2,335,850 | 2,264,611 | 2,197,615 | 2,137,936 | 2,082,045 | 2,030,745 | 1,987,282 | 1,948,065 | 1,913,332 | 1,885,010 | 1,856,11 |
| 23 | 2,214,561 | 2,195,314 | 2,226,500 | 2,211,142 | 2,186,868 | 2,157,905 | 2,125,239 | 2,086,093 | 2,074,323 | 2,050,888 | 2,023,152 | 2,028,582 | 2,034,013 | 2,039,443 | 2,044,874 | 2,050,30 |
| 24 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,946 | 97,94 |
| 25 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,631 | 408,63 |
| 26 | -14,000 | -23,000 | -41,000 | -52,000 | -98,000 | -154,000 | -226,000 | -304,000 | -372,000 | -444,000 | -515,000 | -580,000 | -639,000 | -701,000 | -765,000 | -824,00 |
| 27 | 0 | -2,000 | -4,000 | -7,000 | -11,000 | -17,000 | -26,000 | -38,000 | -52,000 | -69,000 | -89,000 | -108,000 | -125,000 | -142,000 | -159,000 | -177,00 |
| 28 | -7,000 | -11,000 | -23,000 | -56,000 | -86,000 | -103,000 | -113,000 | -112,000 | -109,000 | -100,000 | -97,000 | -79,000 | -69,000 | -58,000 | -47,000 | -35,00 |
| 29 | -16,000 | -21,000 | -30,000 | -38,000 | -44,000 | -52,000 | -58,000 | -66,000 | -60,000 | -54,000 | -48,000 | -43,000 | -39,000 | -34,000 | -30,000 | -26,00 |
| 30 | -7,000 | -13,000 | -21,000 | -29,000 | -38,000 | -49,000 | -50,000 | -50,000 | -50,000 | -49,000 | -48,000 | -48,000 | -47,000 | -47,000 | -42,000 | -36,00 |
| 31 | -23,000 | -33,000 | -46,000 | -57,000 | -66,000 | -73,000 | -77,000 | -78,000 | -80,000 | -78,000 | -75,000 | -70,000 | -65,000 | -61,000 | -57,000 | -53,00 |
| 32 | -25,000 | -18,000 | -14,000 | -32,000 | -30,000 | -28,000 | -25,000 | -23,000 | -21,000 | -19,000 | -17,000 | -16,000 | -15,000 | -13,000 | -12,000 | -11,00 |
| 33 | -19,000 | -25,000 | -32,000 | -39,000 | -44,000 | -48,000 | -48,000 | -47,000 | -46,000 | -45,000 | -43,000 | -38,000 | -34,000 | -31,000 | -27,000 | -24,00 |
| 34 | -50,000 | -55,000 | -59,000 | -59,000 | -58,000 | -53,000 | -48,000 | -43,000 | -39,000 | -35,000 | -32,000 | -28,000 | -26,000 | -23,000 | -20,000 | -18,00 |
| 35 | -379,418 | -455,301 | -531,185 | -607,068 | -682,952 | -758,835 | -758,835 | -758,835 | -758,835 | -758,835 | -758,835 | -758,835 | -758,835 | -758,835 | -758,835 | -758,83 |
| 36 | -53,642 | -64,370 | -75,099 | -85,827 | -96,556 | -107,284 | -107,284 | -107,284 | -107,284 | -107,284 | -107,284 | -107,284 | -107,284 | -107,284 | -107,284 | -107,28 |
| 37 | -395,794 | -479,883 | -565,615 | -652,991 | -742,011 | -832,673 | -840,891 | -849,108 | -857,325 | -865,542 | -873,759 | -881,976 | -890,194 | -898,411 | -906,628 | -914,84 |
| 38 | -6,484 | -4,341 | -5,065 | -5,788 | -6,512 | -7,235 | -4,063 | -4,063 | -4,063 | -4,063 | -4,063 | -1,558 | -1,558 | -1,558 | -1,558 | -1,55 |
| 39 | -242,825 | -273,045 | -339,722 | -367,660 | -380,979 | -381,650 | -335,811 | -282,534 | -261,932 | -227,676 | -188,544 | -188,544 | -188,544 | -188,544 | -188,544 | -188,54 |
| 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 41 | -124,943 | -149,931 | -174,920 | -199,908 | -224,897 | -249,885 | -249,885 | -249,885 | -249,885 | -249,885 | -249,885 | -249,885 | -249,885 | -249,885 | -249,885 | -249,88 |
| 42 | -35,240 | -42,288 | -49,336 | -56,384 | -63,432 | -70,481 | -70,481 | -70,481 | -70,481 | -70,481 | -70,481 | -70,481 | -70,481 | -70,481 | -70,481 | -70,48 |
| 43 | -283,442 | -343,662 | -405,058 | -467,631 | -531,381 | -596,308 | -602,193 | -608,077 | -613,962 | -619,846 | -625,731 | -631,616 | -637,500 | -643,385 | -649,270 | -655,15 |
| 44 | -123,990 | -83,015 | -96,851 | -110,686 | -124,522 | -138,358 | -77,693 | -77,693 | -77,693 | -77,693 | -77,693 | -29,800 | -29,800 | -29,800 | -29,800 | -29,80 |
| 45 | -195,191 | -219,483 | -273,080 | -295,537 | -306,244 | -306,783 | -269,936 | -227,110 | -210,550 | -183,014 | -151,558 | -151,558 | -151,558 | -151,558 | -151,558 | -151,55 |
| 46 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 47 | -4,468 | -6,315 | -8,479 | -10,961 | -13,760 | -16,877 | -18,423 | -19,969 | -21,516 | -23,062 | -24,608 | -24,612 | -24,670 | -24,749 | -24,787 | -24,84 |
| 48 | -32,871 | -46,840 | -63,274 | -82,173 | -103,536 | -127,365 | -139,472 | -151,580 | -163,687 | -175,795 | -187,903 | -187,808 | -187,749 | -187,868 | -188,102 | -188,44 |
| 49 | -61 | -80 | -100 | -123 | -148 | -175 | -182 | -189 | -197 | -204 | -61,859 | -61,833 | -69,839 | -70,412 | -70,444 | -75,96 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1,896 | -1,881 | -1,866 | -1,852 | -1,839 | -225,31 |
| 51 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 52 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| 53 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

Baseline Data | Transport BAU | BAU Master | BAU Modulators | Measures Inventory | Industry BAU | (1) Net Zero by 2030 | (1) Graphics | (2) 68% by 2030 | (2) Graphics | (2) Local Authorities | (2) Local authorities 2050

Note: all figures are indicative estimates only.

### E.6.2. Adjustable rates of intervention

For all measures, a means of adjusting the way in which that measure would be rolled out in the scenario was created. This modified the number of emissions savings that would be achieved through the measure in any given year. Each ‘rate of intervention’ was fully adjustable for each year and each measure; but generally these would be applied as ‘run rates’ to apply a smooth path for applying the intervention.

For example, where ‘Insulation’ is given at the rate of 50% in 2025 in Figure E-13 below, this means that 50% of all emissions savings associated with insulation have been applied in the option being prepared. Note that this does not necessarily represent half of all properties in Lancashire, since the building stock is not evenly responsible for emissions due to space heating. It is also not addressing 50% of all emissions due to space heating in Lancashire; since we have identified some residual emissions will remain after this measure is fully applied. Thus, it is capturing 50% of all the savings possible through the measure, as logged in the Measures inventory.

As this rate inclines towards 100% by 2030, it is capturing a steady rate of whole-house insulation roll-out as defined in the insulation measure. By 2030, any emissions that could be saved through insulation have been saved through this measure being applied, in the scenario defined. It is important to note that residual emissions will be outstanding after the measure has been fully applied – which becomes particularly important for transport sector – and these residual emissions are captured in the bottom line.

**Figure E-13 - Example option to address Net Zero by 2030 pathway, with rates of intervention shown**

| | A | B | C | D | G | V |
|---|---|---|---|---|---|---|
| 1 | **Scenario 1: Net Zero emissions by 2030** | | | | Emissions | Savings |
| 2 | Year | | | | 1990 | 2005 |
| 3 | Business as Usual | | | | 14,807 | 12,956 |
| 4 | Net Zero by 2030 | | | | 14,807 | 12,956 |
| 5 | 68% reduction by 2030 | | | | 14,807 | 12,956 |
| 6 | 78% reduction by 2035 | | | | 14,807 | 12,956 |
| 7 | Net Zero by 2050 | | | | 14,807 | 12,956 |
| 8 | | | | | | |
| 9 | **Emissions Saving Summary** | | | | | |
| 10 | Baseline / BAU | | | | 14,807 | 12,956 |
| 11 | Maximum ambition | | | | 14,807 | 12,956 |
| 12 | Minimum ambition | | | | 14,807 | 12,956 |
| 13 | Option 3 | | | | 14,807 | 12,956 |
| 14 | Option 4 | | | | 14,807 | 12,956 |
| 15 | Carbon removals | | | | - | - |
| 16 | Hydrogen economy | | | | - | - |
| 17 | | | | | | |
| 18 | **Maximum ambition** | | | | | |
| 19 | Source | Local Authority | Sector/Mode | Measure | | |
| 20 | Baseline | | | | | |
| 21 | Industry & Commercial | | | Business as Usual | | |
| 22 | Transport | | | Business as Usual | | |
| 23 | Domestic Buildings | | | Business as Usual | | |
| 24 | Agriculture | | | Business as Usual | | |
| 25 | LULUCF | | | Business as Usual | | |
| 26 | Transpor | Lancashire 14 | Car and LGV emission | National action: 2030 ban on petrol/diesel car/van sales | | |
| 27 | Transpor | Lancashire 14 | HGV emissions | National action: presumed action to decarbonise HGV fleet | | |
| 28 | Transpor | Lancashire 14 | Car, LGV, bus emissio | Accelerate ULEV uptake | | |
| 29 | Transpor | Lancashire 14 | Car emissions | Increase active travel/micro mobility use | | |
| 30 | Transpor | Lancashire 14 | Car emissions | Increase public transport use | | |
| 31 | Transpor | Lancashire 14 | Car, LGV and HGV emi | Demand management | | |
| 32 | Transpor | Lancashire 14 | Car, LGV, HGV, Bus en | Efficient network management | | |
| 33 | Transpor | Lancashire 14 | Car, LGV emissions | Land use planning | | |
| 34 | Transpor | Lancashire 14 | Car, LGV, HGV emissi | Digital connectivity | | |
| 35 | Domesti | Lancashire 14 | Residential | Insulation | | |
| 36 | Domesti | Lancashire 14 | Residential | Glazing | | |
| 37 | Domesti | Lancashire 14 | Residential | Heat pumps | | |
| 38 | Domesti | Lancashire 14 | Residential | LED lighting | | |
| 39 | Domesti | Lancashire 14 | Residential | Solar PV panels | | |
| 40 | Domesti | Lancashire 14 | Residential | District heat networks | | |
| 41 | Industry & | Lancashire 14 | Industrial/Commercial | Insulation | | |
| 42 | Industry & | Lancashire 14 | Industrial/Commercial | Glazing | | |
| 43 | Industry & | Lancashire 14 | Industrial/Commercial | Heat pumps | | |
| 44 | Industry & | Lancashire 14 | Industrial/Commercial | LED lighting | | |
| 45 | Industry & | Lancashire 14 | Industrial/Commercial | Solar PV panels | | |
| 46 | Industry & | Lancashire 14 | Industrial/Commercial | District heat networks | | |

Rates of Intervention

| | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 | 2037 | 2038 | 2039 | 2040 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | | | | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 27 | | | | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 28 | | | | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 29 | | | | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 30 | | | | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 31 | | | | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 32 | | | | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 33 | | | | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 34 | | | | | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 35 | | | | | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 36 | | | | | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 37 | | | | | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 38 | | | | | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 39 | | | | | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 40 | | | | | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 41 | | | | | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 42 | | | | | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 43 | | | | | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 44 | | | | | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 45 | | | | | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| 46 | | | | | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

Baseline Data | Transport BAU | BAU Master | BAU Modulators | Measures Inventory | Industry BAU | (1) Net Zero by 2030 | (1) Graphics | (2) 68% by 2030 | (2) Graphics | (2) Local Authorities | (2) Local authorities 2050

Note: all figures are initial indicative estimates only. The transport proportions all show as 100% because the ramp up of transport measures is dealt with in a different way at an earlier stage of the calculations. The ramp up proportions assumed are shown in Table E-15 onwards.

## E.6.3. Feasibility assessment

For each scenario, the 'Maximum ambition' option was identified, which sets all rates of intervention to 100% by 2030, in order to define the basic feasibility to achieve the target pathway and serve as a point of reference for other options considered.

When applying the feasibility test, it has been found that based on the sector data made available, there is no feasible path to meeting Net Zero emissions by 2030 (see Section 10 of the Main Report). There are several ways to achieve the 68% reduction by 2030 and 78% reduction by 2035 target pathways, leaving a space of options available to further explore (see Sections 11 and 12 of the Main Report).

## E.6.4. Sensitivity testing

In seeking a balanced set of interventions that provide a workable option for meeting the target pathway, we are ultimately looking to find an even application of key measures over time, rather than relying on major interventions to eliminate emissions in one sector.

However, we assessed how far each sector emissions could be addressed 'at the limit', to gain insights towards finding the correct balance. In assessing two options for each of the feasible pathways, two options have been tested:

- Option 1 (Ambitious transport intervention); and
- Option 2 (Limited transport intervention).

### Sensitivity testing for 68% reduction by 2030 pathway

If Lancashire were to focus on Transport measures and implement as fully as possible, it would not be able to achieve the target, without meaningful action to address emissions from buildings (Option 1). In this option, Lancashire would have to reach 72% of buildings for insulation, glazing and installation of solar PV; it would also need to reach 36% of buildings for installation of heat pumps. This highlights the reality that emissions from the Transport sector will continue to a large extent by 2030, even with focused action in the short term. Note also that we have assumed 72% of commercial and industrial buildings will also need to be reached for installation of heat pumps. This has been proposed on the basis that commercial building owners are easier to influence than private home-owners.

On the other hand, our analysis shows that if Lancashire were to reach 80% of the buildings in the county for a full set of measures (including heat pumps and solar PV panels), but not to implement any local measures relating to Transport, it could still achieve the target pathway by 2030 (Option 2). We took a low-confidence view of the emissions savings that could be achieved through 'national action' in this case, setting our rate of intervention to 40% of emissions savings currently expected from national action on ULEVs by 2030. This reflected minimal intervention on the part of the County Council.

### Sensitivity testing for 78% reduction by 2035

Our analysis shows that if Lancashire were to reach 80% of the buildings in the county for a full set of measures (including heat pumps and solar PV panels), but not to implement any local measures relating to Transport, it could achieve the target pathway by 2035 (Option 2). This assumes that 40% of emissions savings currently expected from national action on ULEVs by 2030 would materialise (as with the sensitivity test above); but our confidence grows after 2030 so that by 2035, 90% expected savings are modelled. This reflects a view that more sustained national action will be forthcoming after the ban on petrol/diesel vehicle sales.

On the other hand, if Lancashire were to focus more closely on Transport measures, it would not be able to achieve the target, without meaningful action to address emissions from buildings (Option 1). In this option, Lancashire would have to reach 70% of buildings for insulation, glazing and heat pumps. Reflecting the somewhat easier path in this case, no solar panels would need to be installed in this option. This means that even with increased savings available from Transport between 2030-35, Lancashire's ability to 'relax' its targeting of Buildings measures would be limited compared with the sensitivity test to 2030.

## E.6.5. Finding a balanced pathway / balanced option

To complete the analysis, we set out to create a 'balanced option' that meets the target pathway in each case (68% reduction by 2030 and 78% reduction by 2035), finding an even approach across all measures that would suitably meet the target.

Starting from an even application of each measure, the following steps were undertaken:

- For each measure, track as close to 50% rate of intervention as possible.
- Where a gap exists to meet the target pathway (excess emissions), adjust upwards to meet the necessary savings, starting with the first intervention in each sector (for example, insulation for residential buildings, in line with the 'fabric first' approach). This will be reflected in the graphics when the option pathway meets the target pathway.

- Test, through trial and error. the easing of difficult or costly measures, in particular heat pumps. Continue to strengthen intervention at the top of the hierarchy, and relax intervention rates towards the bottom end, until the option pathway aligns with the target[86].
- Once a broadly even path is found that focuses toward easier measures to implement, set an intervention path smoothly towards the target date[87].

Tables E-15 to E-19 below provide the rates of intervention for the three pathways under two scenarios. Note that the building and commercial and industry sectors percentages represent the proportion of premises in which measures are implemented, building up to 100% of all premises being affected. There is no directly equivalent metric for most of the transport measures (as they relate to intensity of impact on different elements of travel behaviour). The percentages for the transport sector therefore represent intensity of implementation as a proportion of the intensity of application in 2050 in the maximum ambition pathway.

**Table E-15 – Maximum ambition (Net zero by 2030) pathway intervention implementation levels**

| Sector | Area | Intervention | 2022 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Transport | Car and LGV emissions | National action: 2030 ban on petrol/diesel car/van sales | 5 % | 5 % | 25 % | 50 % | 75 % | 95 % | 100% |
| Transport | HGV emissions | National action: presumed action to decarbonise HGV fleet | 0% | 0% | 5 % | 35 % | 75 % | 100% | 100% |
| Transport | Car, LGV, bus emissions | Accelerate ULEV uptake | 0% | 50% | 100% | 100% | 100% | 100% | 100% |
| Transport | Car emissions | Increase active travel/micro mobility use | 0% | 15% | 65% | 100% | 100% | 100% | 100% |
| Transport | Car emissions | Increase public transport use | 0% | 5% | 35% | 65% | 100% | 100% | 100% |
| Transport | Car, LGV and HGV emissions | Demand management | 0% | 20% | 65% | 100% | 100% | 100% | 100% |
| Transport | Car, LGV, HGV, Bus emissions | Efficient network management | 0% | 50% | 100% | 100% | 100% | 100% | 100% |
| Transport | Car, LGV emissions | Land use planning | 0% | 20% | 65% | 100% | 100% | 100% | 100% |
| Transport | Car, LGV, HGV emissions | Digital connectivity | 30% | 70% | 100% | 100% | 100% | 100% | 100% |
| Domestic Buildings | Residential | Insulation | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Domestic Buildings | Residential | Glazing | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Domestic Buildings | Residential | Heat pumps | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Domestic Buildings | Residential | LED lighting | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Domestic Buildings | Residential | Solar PV panels | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Insulation | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Glazing | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Heat pumps | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | LED lighting | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Solar PV panels | 20% | 50% | 100% | 100% | 100% | 100% | 100% |

[86] Ideally there would be alignment with the whole target pathway, but for this exercise focus was maintained on meeting the target date with a balanced set of measures.
[87] Heat pumps have been modelled in a bespoke way, to track known information from the Energy White Paper, and so have a different path which becomes an even rate of intervention after 2030.

| Sector | Area | Intervention | 2022 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Industry & Commercial | Large industrial installations | Energy efficiency | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Large industrial installations | Resource efficiency and material substitution | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Large industrial installations | Electrification | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Large industrial installations | Carbon capture and storage | 20% | 50% | 100% | 100% | 100% | 100% | 100% |

**Table E-16 – 68% reduction by 2030 pathway intervention implementation levels under high electrification scenario**

| Sector | Area | Intervention | 2022 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Transport | Car and LGV emissions | National action: 2030 ban on petrol/diesel car/van sales | 5% | 5% | 25% | 50% | 75% | 95% | 100% |
| Transport | HGV emissions | National action: presumed action to decarbonise HGV fleet | 0% | 0% | 5% | 35% | 75% | 100% | 100% |
| Transport | Car, LGV, bus emissions | Accelerate ULEV uptake | 0% | 30% | 70% | 95% | 100% | 100% | 100% |
| Transport | Car emissions | Increase active travel/micro mobility use | 0% | 10% | 45% | 95% | 100% | 100% | 100% |
| Transport | Car emissions | Increase public transport use | 0% | 0% | 25% | 65% | 100% | 100% | 100% |
| Transport | Car, LGV and HGV emissions | Demand management | 0% | 10% | 45% | 95% | 100% | 100% | 100% |
| Transport | Car, LGV, HGV, Bus emissions | Efficient network management | 0% | 30% | 70% | 95% | 100% | 100% | 100% |
| Transport | Car, LGV emissions | Land use planning | 0% | 10% | 45% | 95% | 100% | 100% | 100% |
| Transport | Car, LGV, HGV emissions | Digital connectivity | 15% | 40% | 70% | 95% | 100% | 100% | 100% |
| Domestic Buildings | Residential | Insulation | 8% | 32% | 72% | 100% | 100% | 100% | 100% |
| Domestic Buildings | Residential | Glazing | 8% | 32% | 72% | 100% | 100% | 100% | 100% |
| Domestic Buildings | Residential | Heat pumps | 5% | 16% | 43% | 63% | 81% | 100% | 100% |
| Domestic Buildings | Residential | LED lighting | 0% | 23% | 60% | 98% | 100% | 100% | 100% |
| Domestic Buildings | Residential | Solar PV panels | 0% | 23% | 60% | 98% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Insulation | 8% | 32% | 72% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Glazing | 8% | 32% | 72% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Heat pumps | 5% | 16% | 44% | 63% | 81% | 100% | 100% |
| Industry & Commercial | Industrial/Commercial | LED lighting | 8% | 32% | 72% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Solar PV panels | 0% | 23% | 60% | 98% | 100% | 100% | 100% |

| Sector | Area | Intervention | 2022 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Industry & Commercial | Large industrial installations | Energy efficiency | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Large industrial installations | Resource efficiency and material substitution | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Large industrial installations | Electrification | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Large industrial installations | Carbon capture and storage | 20% | 50% | 100% | 100% | 100% | 100% | 100% |

**Table E-17 – 68% reduction by 2030 pathway intervention implementation levels under high hydrogen scenario**

| Sector | Area | Intervention | 2022 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Transport | Car and LGV emissions | National action: 2030 ban on petrol/diesel car/van sales | 5% | 5% | 25% | 50% | 75% | 95% | 100% |
| Transport | HGV emissions | National action: presumed action to decarbonise HGV fleet | 0% | 0% | 5% | 35% | 75% | 100% | 100% |
| Transport | Car, LGV, bus emissions | Accelerate ULEV uptake | 0% | 30% | 70% | 95% | 100% | 100% | 100% |
| Transport | Car emissions | Increase active travel/micro mobility use | 0% | 10% | 45% | 95% | 100% | 100% | 100% |
| Transport | Car emissions | Increase public transport use | 0% | 0% | 25% | 65% | 100% | 100% | 100% |
| Transport | Car, LGV and HGV emissions | Demand management | 0% | 10% | 45% | 95% | 100% | 100% | 100% |
| Transport | Car, LGV, HGV, Bus emissions | Efficient network management | 0% | 30% | 70% | 95% | 100% | 100% | 100% |
| Transport | Car, LGV emissions | Land use planning | 0% | 10% | 45% | 95% | 100% | 100% | 100% |
| Transport | Car, LGV, HGV emissions | Digital connectivity | 15% | 40% | 70% | 95% | 100% | 100% | 100% |
| Domestic Buildings | Residential | Insulation | 8% | 32% | 72% | 100% | 100% | 100% | 100% |
| Domestic Buildings | Residential | Glazing | 8% | 32% | 72% | 100% | 100% | 100% | 100% |
| Domestic Buildings | Residential | Heat pumps | 5% | 16% | 39% | 42% | 43% | 43% | 43% |
| Domestic Buildings | Residential | LED lighting | 0% | 23% | 60% | 98% | 100% | 100% | 100% |
| Domestic Buildings | Residential | Solar PV panels | 0% | 23% | 60% | 98% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Insulation | 8% | 32% | 72% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Glazing | 8% | 32% | 72% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Heat pumps | 5% | 16% | 45% | 63% | 70% | 70% | 70% |
| Industry & Commercial | Industrial/ Commercial | LED lighting | 8% | 32% | 72% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Solar PV panels | 0% | 23% | 60% | 98% | 100% | 100% | 100% |
| Industry & Commercial | Large industrial installations | Energy efficiency | 20% | 50% | 100% | 100% | 100% | 100% | 100% |

| Sector | Area | Intervention | 2022 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Industry & Commercial | Large industrial installations | Resource efficiency and material substitution | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Large industrial installations | Electrification | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Large industrial installations | Carbon capture and storage | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Domestic Buildings | Residential | Hydrogen boilers | 0% | 0% | 6% | 18% | 34% | 48% | 57% |
| Industry & Commercial | Industrial/ Commercial | Hydrogen boilers | 0% | 0% | 5% | 17% | 30% | 30% | 30% |
| | | Hydrogen blend in the gas network | 0% | 0% | 0% | 20% | 54% | 83% | 100% |

**Table E-18 –78% reduction by 2035 pathway intervention implementation levels under high electrification scenario**

| Sector | Area | Intervention | 2022 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Transport | Car and LGV emissions | National action: 2030 ban on petrol/diesel car/van sales | 5% | 5% | 25% | 50% | 75% | 95% | 100% |
| Transport | HGV emissions | National action: presumed action to decarbonise HGV fleet | 0% | 0% | 5% | 35% | 75% | 100% | 100% |
| Transport | Car, LGV, bus emissions | Accelerate ULEV uptake | 0% | 20% | 55% | 75% | 100% | 100% | 100% |
| Transport | Car emissions | Increase active travel/micro mobility use | 0% | 5% | 35% | 75% | 100% | 100% | 100% |
| Transport | Car emissions | Increase public transport use | 0% | 0% | 20% | 50% | 100% | 100% | 100% |
| Transport | Car, LGV and HGV emissions | Demand management | 0% | 10% | 35% | 75% | 100% | 100% | 100% |
| Transport | Car, LGV, HGV, Bus emissions | Efficient network management | 0% | 20% | 55% | 75% | 100% | 100% | 100% |
| Transport | Car, LGV emissions | Land use planning | 0% | 10% | 35% | 75% | 100% | 100% | 100% |
| Transport | Car, LGV, HGV emissions | Digital connectivity | 10% | 30% | 55% | 75% | 100% | 100% | 100% |
| Domestic Buildings | Residential | Insulation | 5% | 20% | 45% | 70% | 95% | 100% | 100% |
| Domestic Buildings | Residential | Glazing | 5% | 20% | 45% | 70% | 95% | 100% | 100% |
| Domestic Buildings | Residential | Heat pumps | 0% | 5% | 23% | 43% | 62% | 82% | 100% |
| Domestic Buildings | Residential | LED lighting | 5% | 20% | 45% | 70% | 95% | 100% | 100% |
| Domestic Buildings | Residential | Solar PV panels | 0% | 10% | 40% | 70% | 95% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Insulation | 8% | 32% | 72% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Glazing | 8% | 32% | 72% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Heat pumps | 1% | 15% | 40% | 70% | 85% | 100% | 100% |

| Sector | Area | Intervention | 2022 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Industry & Commercial | Industrial/ Commercial | LED lighting | 5% | 20% | 45% | 70% | 95% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Solar PV panels | 1% | 16% | 46% | 80% | 100% | 100% | 100% |
| Industry & Commercial | Large industrial installations | Energy efficiency | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Large industrial installations | Resource efficiency and material substitution | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Large industrial installations | Electrification | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Large industrial installations | Carbon capture and storage | 20% | 50% | 100% | 100% | 100% | 100% | 100% |

**Table E-19 –78% reduction by 2035 pathway intervention implementation levels under high hydrogen scenario**

| Sector | Area | Intervention | 2022 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Transport | Car and LGV emissions | National action: 2030 ban on petrol/diesel car/van sales | 5% | 5% | 25% | 50% | 75% | 95% | 100% |
| Transport | HGV emissions | National action: presumed action to decarbonise HGV fleet | 0% | 0% | 5% | 35% | 75% | 100% | 100% |
| Transport | Car, LGV, bus emissions | Accelerate ULEV uptake | 0% | 20% | 55% | 75% | 100% | 100% | 100% |
| Transport | Car emissions | Increase active travel/micro mobility use | 0% | 5% | 35% | 75% | 100% | 100% | 100% |
| Transport | Car emissions | Increase public transport use | 0% | 0% | 20% | 50% | 100% | 100% | 100% |
| Transport | Car, LGV and HGV emissions | Demand management | 0% | 10% | 35% | 75% | 100% | 100% | 100% |
| Transport | Car, LGV, HGV, Bus emissions | Efficient network management | 0% | 20% | 55% | 75% | 100% | 100% | 100% |
| Transport | Car, LGV emissions | Land use planning | 0% | 10% | 35% | 75% | 100% | 100% | 100% |
| Transport | Car, LGV, HGV emissions | Digital connectivity | 10% | 30% | 55% | 75% | 100% | 100% | 100% |
| Domestic Buildings | Residential | Insulation | 5% | 20% | 45% | 70% | 95% | 100% | 100% |
| Domestic Buildings | Residential | Glazing | 5% | 20% | 45% | 70% | 95% | 100% | 100% |
| Domestic Buildings | Residential | Heat pumps | 0% | 5% | 23% | 39% | 41% | 43% | 43% |
| Domestic Buildings | Residential | LED lighting | 5% | 20% | 45% | 70% | 95% | 100% | 100% |
| Domestic Buildings | Residential | Solar PV panels | 0% | 10% | 40% | 70% | 95% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Insulation | 8% | 32% | 72% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Glazing | 8% | 32% | 72% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Heat pumps | 1% | 15% | 40% | 65% | 68% | 70% | 70% |
| Industry & Commercial | Industrial/ Commercial | LED lighting | 5% | 20% | 45% | 70% | 95% | 100% | 100% |
| Industry & Commercial | Industrial/ Commercial | Solar PV panels | 1% | 16% | 46% | 80% | 100% | 100% | 100% |
| Industry & Commercial | Large industrial installations | Energy efficiency | 20% | 50% | 100% | 100% | 100% | 100% | 100% |

| Sector | Area | Intervention | 2022 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---|---|---|---|---|---|---|---|---|---|
| Industry & Commercial | Large industrial installations | Resource efficiency and material substitution | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Large industrial installations | Electrification | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Industry & Commercial | Large industrial installations | Carbon capture and storage | 20% | 50% | 100% | 100% | 100% | 100% | 100% |
| Domestic Buildings | Residential | Hydrogen boilers | 0% | 0% | 6% | 18% | 34% | 48% | 57% |
| Industry & Commercial | Industrial/Commercial | Hydrogen boilers | 0% | 0% | 5% | 17% | 30% | 30% | 30% |
| | | Hydrogen blend in the gas network | 0% | 0% | 0% | 20% | 54% | 83% | 100% |

## E.6.6. Achieving Net Zero emissions in each pathway option

To establish when Net Zero emissions could be achieved, we continued the pathways into the future to 2050 in the following way:

- In deriving the target pathways extending to 2050 to identify where they reach Net Zero target years, two technological scenarios have been considered:
  - High electrification: exploring the impact of using widespread electrification to support transport, heating, and industry decarbonisation coupled with deep decarbonisation of electricity supply.
  - High hydrogen: exploring the impact of using low-carbon hydrogen more extensively, particularly for decarbonising buildings, industry and heavy vehicles.
  - The intervention implementation levels under two scenarios are provided in in Tables E-14 to E-17.
- Extend emission reduction intervention rates at a smooth path until all measures reach 100% intervention (at their own dates depending on the rate of intervention set in each case).
- Introduce identified mechanical carbon removal measures for industry (this involves the use of BECCS)
- Introduce identified carbon sequestration measures applied to a reasonable maximum extent (note that this implies early planting of new woodland through land use change for agriculture land, grassland and scrub and peatland restoration, which will not start to take meaningful effect until the mid-2030s even if they are planted this year).
- Set the residual emissions after intervention against net negative emissions from carbon removals, year over year, to find a date at which Net Zero emissions could be achieved.

All pathway results obtained through the application of the above methodology are discussed in Sections 10, 11, 12 and 13 of the Main Report.

## E.6.7. Creating a local authority view

Once having completed the pathway assessments at a county level, we then turned to identify the indicative pathways at a local authority level. To achieve this, we undertook the following steps:

- For each target pathway under each scenario, set out the generic rate of emissions savings, per sector and per year. This was done by taking the residual emissions from the balanced option and creating a ‘run rate’ that applied to each sector, capturing the percentage saving year-over-year, compared with the baseline.
- Apply the baseline emissions for each local authority, so that the proportional emissions savings can be seen in each year per sector. This creates a representative savings for the district which reflects the overall pathway.
- Check the proportions of baseline emissions for each local authority, so that any authority where the run rates can be seen as not applicable can be flagged as an exception.
- For each exception, identify which source of emissions is most responsible for deviation from the county-level rate of emissions savings, and create a bespoke emissions savings path for that source, to match the view more closely for the authority in question.
- Represent each local authority-specific pathway analysis graphically, with proportional target reductions to meet the county-level pathway shown.
- Extend each pathway to 2050 under high electrification and high hydrogen scenarios using the same approach.

# Appendix F. Building heat grant schemes

The below information captures information on open grant schemes available currently.

**Domestic Renewable heat incentive** (https://www.ofgem.gov.uk/environmental-programmes/domestic-rhi)

- Applications close **31st March 2022** (systems must be installed by this date)
- To be eligible you must either own you own home or be a private landlord
- New build properties will not normally be eligible.
- To be replaced by the **Clean Heat Grant Scheme**

**Clean Heat Grant Scheme** (https://www.renewableenergyinstaller.co.uk/2020/05/an-installers-guide-to-the-clean-heat-grant/)

- £4000 grant targeted at households and small non-domestic buildings to enable the installation of heat pumps and biomass in limited circumstances, hybrid heat pumps will not be supported.
- It is proposing that systems with a capacity of up to 45kW be eligible for the scheme.
- A sitewide heat pump solution would not be eligible for the scheme as it would be above the 45kW threshold and heat networks are excluded.
- If a localised heat pump solution was used then there is potential this funding could be applicable however it is not clear how the application process would work for a Developer and if multiple applications could be made for a scheme/phase.

**Green Gas Support Scheme** (https://www.dmt-et.com/the-green-gas-support-scheme/)

- Financed by a Green Gas Levy.
- Expected to run for 4 years and will only support biomethane that is produced from biomass feedstocks that are processed through anaerobic digestion and injected into the national gas grid.
- My initial thought was that this could be applicable for our suggestion of using anaerobic digestion from RHS Wisely as a fuel source for a CHP system. However, reading further into it we would not be eligible as we wouldn't be injecting the gas back into the grid. (https://www.dmt-et.com/the-green-gas-support-scheme/)

**Green Homes Grant** (https://www.gov.uk/guidance/apply-for-the-green-homes-grant-scheme)

- £5-10k vouchers for homeowners and landlords for energy saving renovations.
- To be eligible all works must be carried out by **31st March 2022**.
- Newly-built properties that have not been occupied previously are not eligible under the Green Homes Grant.

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