A Carbon Reduction Assessment for Yorkshire and the Humber

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Your Climate Strategy

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Executive Summary

Aims and Scope

- Yorkshire and Humber has a target to reach net zero by 2038. This report assesses the progress made towards that target to date, and the opportunities to move further towards the target in the years ahead.

- The focus of the analysis is on the decarbonisation options that could be adopted within the region. The report considers many of the options that could be adopted in homes, public and commercial buildings, transport, industry and land-use.

- The report does not focus on changes to national infrastructure (e.g. the large-scale electricity generation, or networks and offshore infrastructure necessary for carbon capture, utilisation and storage) that are driven primarily by national rather than regional or local policies – but it does take the potential impact of such changes on the region's carbon footprint into account.

- Similarly, the analysis does not directly consider the impacts of those goods and services produced elsewhere but consumed within the region. These consumption-based emissions are undoubtedly important and they are being considered elsewhere.

- The focus of the analysis is on the technical and economic viability of many of the different decarbonisation options that could be adopted within the region. The aim is to assess the opportunity for change, and the direct costs and benefits of change (e.g. the costs of adopting different options and the energy bill savings that they could generate).

- We consider the potential for investments in decarbonisation to create employment in the region. The broader indirect costs and benefits of the various options (e.g. the benefits of improved mobility, improved air quality, increased physical activity) are also considered. Some key wider impacts, such as those to biodiversity and climate resilience are not considered. The wider impacts assessed here provide a step towards a more comprehensive analysis of the costs and benefits of the transition to net zero, but need to be complemented by further analysis.

- We fully understand that technical and economic viability are not the only criteria that should be applied when considering the desirability of different options for decarbonisation. Broader social, environmental, political and many other factors are obviously important considerations – but they are not the focus of this report.

- We also fully understand that even if an option is technically and economically viable, there can be many obstacles to change, and that capacities frequently need to be built to overcome these obstacles if the opportunities are to be adopted. Although the obstacles to change are not the primary focus of the analysis, the report helps to identify where new capacities for change could have the biggest benefit.

- Although we consider the scope to adopt more than 700 options the analysis is not exhaustive[1]. There are undoubtedly other options that for various reasons (e.g. novelty, data availability) have not been included in the analysis. New options for decarbonisation are constantly being developed and applied and understanding of their potential impacts is growing.

- Notwithstanding these limitations, by providing an evidence-based analysis

[1] The interventions aren't all unique technologies, but are all commonly applied low-carbon measures suitable for deployment in Yorkshire and the Humber modelled iteratively across different housing archetypes/public and commercial buildings/scenarios for example, resulting in unique mitigation numbers, investment requirements and financial benefits.

of the scope to adopt many of the different options for decarbonisation that are open to the region, the report seeks to enable the Yorkshire and Humber Climate Commission and its partners and stakeholders to:

a) evaluate progress with decarbonisation to date

b) understand the changing composition of our carbon footprint

c) assess the prospects and options for further decarbonisation

d) consider what needs to be done to accelerate progress

e) enable prioritisation of those options with the largest potential for decarbonisation

f) identify other options for future consideration.

Headline Findings

- The analysis shows that the Yorkshire and Humber region has reduced its direct carbon emissions by 44% since 2000, and we estimate that it has reduced its direct carbon emissions by 50% since 1990.

- These figures include carbon emissions from all forms of land and fuel use in the region, and those associated with electricity consumption in the region. They exclude emissions from large-scale energy generation in the region as responsibility for these is attributed to electricity consumers across the UK national grid.

- Currently, 33% of all emissions from the region come from industry, with transport accounting for 29%, homes 19%, land-use 9%, public and commercial buildings 6% and the waste sector 4%.[2]

- We predict that, based on 2000 levels[3] and a continuation of current trends, Yorkshire and the Humber will have cut its direct carbon footprint by 56% by 2038 and by 60% by 2050. These predictions take into account on-going economic and population growth, continued efficiency improvements in homes, buildings and transport, the gradual switch to electric vehicles and the continuing decarbonisation of grid electricity in the UK as a response to national policy,

- Significant progress towards net zero has therefore been made, but the analysis shows that without extra activity, current trends will not lead to the meeting of the regional target of net zero by 2038, or the national target of net zero by 2050.

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[2] Emissions from the waste sector haven't been modelled as they are relatively negligible in Yorkshire and the Humber and are indirectly reduced from interventions in other sectors.
[3] The year 2000 selected due to improved data resolution compared to 1990 for local authorities

- The analysis shows though that meeting the regional target of net zero by 2038 is possible, and that while meeting it will require significant investments over a prolonged period of time, many of the required investments would be economically attractive in their own right, and many more could generate significant wider social, economic and environmental benefits for the region.

To illustrate the nature of the opportunity, and the scale of the associated investment needs, we focus on three levels of change, based on an economic assessment of investment levels required as well as the difficulty in implementing the recommendations:

1. The ***Easy Win & Financially Beneficial*** scenario

   Under this scenario, we consider the impact of the region adopting all of the 'no regrets' options for decarbonisation that would more than pay for themselves through the energy savings that they would generate. Measures in this scenario include shifts from cars to walking, cycling and buses, investments in energy efficiency in industry, and investments in the fabric and heating systems of buildings.

   Adopting all the options in this category would enable Yorkshire and the Humber to close the gap between its projected 'business as usual' emissions in 2038 and net zero by more than a third (36%). To exploit these options, £1.6 billion a year would need to be invested across Yorkshire and the Humber for the next 15 years, but these investments would cut Yorkshire and the Humber's total energy bill by £3.2 billion p.a. by 2038 and create 43,000 years of extra employment (i.e. 2100 jobs for 20 years).

   Overall, broader research indicates that every £1 invested in the options included in this scenario would generate £3.1 of direct financial savings and at least £7.5 of wider social, environmental and economic benefits in the period through to 2050. In total these benefits would amount to £175 billion in value to Yorkshire and Humber residents.

2. The ***Mainstreaming Change & Economically Beneficial*** scenario

   Under this scenario, we consider the impact not only of the 'no regrets' options that would pay for themselves, but also of other technically viable options that collectively would break even through their direct returns if they were adopted. Measures in this scenario include deep retrofit of buildings and electric heavy duty vehicles.

   By expanding the scope of decarbonization to include all of the options in this category, Yorkshire and the Humber could close the gap between its projected 'business as usual' emissions in 2038 and net zero by 50%. This would require investments of £3.7 billion a year for the next 15 years, but this would cut Yorkshire and the Humber's total energy bill by £3.4 billion a year from 2038 whilst creating 108,000 years of extra employment (i.e. 5,400 jobs for 20 years).

   Overall, we forecast that every £1 invested in the options included in this scenario would over time generate £1.5 of direct financial savings and at least £4 of wider social, environmental and economic benefits in the period through to 2050. In total these benefits would amount to more than £220 billion in value to Yorkshire and Humber residents.

3. The ***Mission Driven & Environmentally Beneficial*** scenario

   Under this scenario the full set of options available for Yorkshire and the Humber are deployed. Included in these options are measures that are currently financially costly and that may be challenging to justify if we focus narrowly on financial returns. Many of these options, however, potentially generate substantial social and environmental benefits. Measures in this scenario include widespread and rapid deployment of heat pumps in buildings, use of green hydrogen, electrification and carbon capture utilization and storage in industry, and achievement of the 30x30 biodiversity targets.

These measures allow Yorkshire and the Humber to realise its 2038 and generate substantial wider social and environmental benefits. Some of these benefits are quantified in this analysis, but many, including the benefits to biodiversity and climate resilience, need to be explored by future analysis.

Tackling these most technically, socially and politically challenging aspects of decarbonisation could enable Yorkshire and the Humber to close the gap between its projected ‘business as usual’ emissions in 2038 and net zero by 102%. This step-change in the level of decarbonisation would require investments of £7.3 billion a year for the next 15 years, but this would cut Yorkshire and the Humber’s energy bill by £4.6 billion a year from 2038 whilst creating 242,000 years of extra employment (i.e. 12,000 jobs for 20 years).

Taken together, we forecast that every £1 invested in all of the actions in this scenario would generate £1.1 of direct financial savings and at least £2.3 of wider social, environmental and economic benefits. However, it’s important to note that in the land-use sector, the costs and benefits of interventions haven’t been modelled. These additional costs contribute to making the economic case of this scenario less financially viable compared to those previously outlined. The make-up of interventions in this scenario are also less cost-effective on average, with much lower returns on investment; making the interventions less viable for private funding models for example. Therefore, while this scenario is currently cost-effective on paper the financial case is more complex than the more 'clear-cut' net-positive (Easy Win & Financially Beneficial) or net-neutral (Mainstreaming Change & Economically Beneficial) scenarios. Unlocking this level of mitigation would result in significant social benefits, amounting to more than £250 billion in value to Yorkshire and Humber residents.

Headline conclusions

- The Yorkshire and Humber region has come a long way towards decarbonisation, but it still has much to do.

- It won't reach its net zero target by 2038 if it follows existing trends. Business as usual – even with a nod to net zero - won't deliver.

- It has taken 33 years to reduce the region's emissions by the first 50%. We now have 15 years to deliver the second 50%. The rate of change needs to accelerate significantly if we are to meet our regional target.

- Getting to net zero by 2038 is technically and economically possible – indeed it could generate significant social, economic and environmental benefits for the region.

- However, there are also significant obstacles that frequently prevent us taking these opportunities for decarbonisation. We urgently need to identify, understand and address these obstacles.

- There is no silver bullet – multiple changes are needed across every sector.

- The scale of the opportunity, the significance of the obstacles and the cross-cutting nature of the issue suggest that net zero needs to be an integral part of broader development strategies.

- Decarbonisation to date will not provide a roadmap for the future. We not only need to move faster, but we need wider-spread leadership on climate action. To date a small number of actors have made the most significant investments, but before 2038 we need nearly every home and business will need to take actions to support the journey to net zero.

- While the scale of the investment required to reach net zero is approximately 3% of regional GDP[4], in aggregate terms the scale of the investment required is vast – almost £110 billion.

- The sum total of undiscounted energy savings across sectors in 2038 (£4.6 billion) would rise to 2.7% of present-day regional GDP levels[5].

- There are some investments that relate specifically to net zero. We need to mobilise new sources of finance and develop other forms of support to better enable these.

- There are many other broader investments that significantly affect our ability to reach net zero. These broader investments are much bigger and more influential than explicitly net zero investments.

- We need to unlock the potential of these broader investments and to redirect existing forms of investment to ensure that they actively support the transition to net zero. This requires the mainstreaming of net zero into every area of decision making.

- New options for decarbonisation are constantly emerging – we need to monitor, understand these and where possible expand the analysis to factor them in.

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[4] Regional GDP in 2022 was £152 billion (Fenton, Trevor (25 April 2023). "Regional gross domestic product: all ITL regions". *Office for National Statistics).* The investment period considered in 2024-2050.

[5] https://www.ons.gov.uk/economy/grossdomesticproductgdp/bulletins/regionaleconomicactivitybygrossdomesticproductuk/1998to2022

Developing an Evidence-Based Routemap for Yorkshire and the Humber

Addressing energy use and carbon emissions in Yorkshire and the Humber will require different actors to engage in multiple actions across diverse sectors over an extended period. Designing and delivering an effective regional approach will be much easier with a strong evidence base and a clear vision of the way forward.

In this report we set out a baseline that predicts what will happen to energy use and carbon emissions in Yorkshire and the Humber under a 'business as usual' scenario where recent trends continue and current commitments are delivered but with no new major initiatives being adopted. Against this baseline, we assess what Yorkshire and the Humber needs to do to achieve its 2038 net-zero target.

We then identify and evaluate the performance and scope for deployment of a wide range of different energy-saving or carbon-cutting options that could be adopted across the area. We assess these options and provide evidence on a measure-by-measure and a sector-by-sector basis, but we also aggregate the assessment to show what could or should happen across the region as a whole.

Crucially, we look at the costs and the benefits of different levels of action and ambition. We therefore identify both the investment needs and the paybacks that come from the direct energy savings that could be generated with different forms and levels of action.

We also consider some of the wider co-benefits of action to help show how Yorkshire and the Humber can tackle its contribution to climate change in a way that joins up with its wider social, economic and environmental priorities.

This evidence base and report shows what could be done – and it sets out some indicative actions that highlight the scale and the pace of change that will be required. This should form the basis of a fuller climate action plan for Yorkshire and the Humber that considers the actors and the resources that need to be mobilised, the roles and responsibilities that need to be defined and the capacities (individual, organisational and region-wide) that need to be built.

Identifying and Evaluating Carbon Reduction Options for Yorkshire and the Humber

The Scope of the Work

Climate change is a cross-cutting issue. We use energy – and hence generate carbon emissions– in almost everything that we do. We also generate carbon through some forms of land-use and absorb and store it through others. As a result, changes are needed in our homes, offices, retail and leisure spaces, businesses, transport systems, approaches to agriculture and land-use and to waste management and so on. There are no 'silver bullets' or 'big bangs' – decarbonisation requires wide ranging and far-reaching change.

In this analysis we evaluate the potential contribution of different energy-saving and carbon-cutting options. In the main, we focus on tried and tested options that are already widely available. However, we also consider the contribution that some more innovative or 'stretch' options could make, and the extent to which any residual emissions could be off-set through measures such as tree-planting.

For homes and public and commercial buildings, we consider both upgrading existing buildings and adopting higher standards for new buildings. For existing buildings, we analyse the impacts of improving insulation in lofts, walls, floors, windows and doors, incorporating renewables such as solar panels or air or ground source heat pumps, upgrading or replacing heating systems and switching to more efficient appliances. For new buildings, we consider the potential to build more efficient and well-insulated buildings that are more comfortable and that require less energy throughout their lifetimes and that incorporate renewables into their design.

For transport we consider the potential for more active travel including walking and cycling. We also look at the scope to promote further use of public transport - especially buses and trains – and for switching the vehicle stock to either electric or more fuel-efficient cars, vans, buses and lorries.

Local and regional data are used to understand the current travel journeys being made by different travel modes (walking, cycling, driving) in Yorkshire and the Humber. Using examples from other parts of the UK, and established transport methodologies, we then make two changes to these trips. First, we shift travel journeys from higher to lower carbon travel modes. For example, we shift private vehicle travel to walking and cycling while taking into account that only a portion of trips made by car are possible on foot and by bicycle. We then assess the remaining trips in higher carbon travel modes and improve the efficiency of these trips by calculating the effect of petrol and diesel cars, buses and trucks being replaced by electric versions. Both travel shifts and travel improvements are made gradually over the period from 2023 to 2035 to accommodate the need for new infrastructure and time for changes in travel habits.

In industry, we consider the opportunities to switch to more efficient facilities – for example with enhanced energy management and better lighting, heating and cooling, pumping, condensing and processing. We also consider opportunities for electrifying energy use – an opportunity that is growing as high temperature heat pumps are developed – and the use of hydrogen for making steel, concrete and fertilisers. Finally, we consider the potential impact of carbon capture utilization and storage (CCUS) technologies for removing remaining emissions.

In land-use, we look at the scope to minimise forms of land-use that give rise to emissions; for example from some agricultural practices and peatland degradation. We also consider the potential to maximise forms of land-use that capture and store carbon, for example through accelerated land restoration, improved soil management or accelerated tree planting schemes.

In all, we consider the potential contribution of over 700 low carbon interventions[6] in the region – taking into account their purchasing, installation and maintenance costs, their realistic installed performance (adjusted to account for rebound effects) and their expected lifetimes. We assess the potential rate and extent to which each option could be deployed, taking into account current conditions, background trends and the expected rates of population and economic growth in the region, our analysis factors in forecast energy prices and the on-going decarbonisation of grid electricity over time.

Throughout this report, the term net-zero is used as a metric to describe the trajectory of overall carbon emissions reaching zero; as a result of reduced emissions through efficiency improvements and demand reduction as well as the sequestration of CO2e within the land-use sector (eg through afforestation) and the industry sector (through Carbon Capture and Storage). The sum total of CO2e emitted and removed are the 'net emissions.' Modelling the roadmap to net-zero for Yorkshire and the Humber in the following sections does not equate to 'zero carbon' due to some residual emissions across sectors, but the total sum of net emissions being carbon-neutral.

As well as assessing carbon savings, we look at overall investment needs and the extent to which investments payback through the energy savings that they generate. We also consider the extent to which investments could generate new jobs in Yorkshire and the Humber, taking into account the number of jobs per £1m of turnover in each area and the extent to which any jobs created are likely to be retained in Yorkshire and the Humber.

Analysis also includes some of the wider benefits of climate actions, including

[6] The interventions aren't all unique technologies, but are all commonly applied low-carbon measures suitable for deployment in Yorkshire and the Humber modelled iteratively across different housing archetypes/public and commercial buildings/scenarios for example, resulting in unique mitigation numbers, investment requirements and financial benefits.

those benefits to public health from increased exercise and cleaner air, to the economy from new employment opportunities and better connectivity, and to local budgets from reduced costs from road maintenance and congestion. The set of co-benefits assessed here, however, is not comprehensive. Key co-benefits, including those to biodiversity, are not included.

The Presentation of the Results

To present the aggregated results in a structured and accessible way, we look at three levels of change, based on an economic assessment of investment levels required as well as the difficulty in implementing the recommendations:

Easy Win & Financially Beneficial:

Under this level of change, we consider the impact of the region adopting all of the 'no regrets' options for decarbonisation, measures have a strong economic case for action and are readily available. The measures would more than pay for themselves as the financial benefits of the interventions are more significant than the investment costs over the period 2024 – 2050.

- *Examples: Non-motorized transport, high build standards for new construction, heat-pumps in new construction*

Mainstreaming Change & Economically Beneficial:

Under this level of change, we consider the impact not only of the 'no regrets' options that would pay for themselves, but also of other technically viable options that collectively would break even through their direct returns if they were adopted. These measures present a strong case for action in social, environmental, political and economic terms, but can be more challenging to implement than those in the 'Easy-Win' interventions.

- *Examples: Heat pumps in existing buildings, deep retrofit of existing buildings, expansion of rail network*

Mission Driven & Environmentally Beneficial:

Under this level of change the full set of options available for Yorkshire and the Humber are deployed. Included in these options are measures that are currently financially costly and that may be challenging to justify if we focus narrowly on financial returns. Many of these options, however, potentially generate substantial social and environmental benefits.

- *Examples:* widespread and rapid deployment of heat pumps in buildings, use of green hydrogen, electrification and carbon capture utilization and storage in industry, and achievement of the 30x30 biodiversity targets.

In the land-use and agriculture, and in the industry sector, exceptions are made due to the unique circumstances of these sectors. In the land-use and agriculture sector two scenarios are presented, one that maintains current land-use, and a second which shows the impact of achieving 30x30 – a commitment made by the UK to protect 30% of its lands and waters by 2030 – on GHG emissions in Yorkshire and the Humber.

In the industry sector a single scenario that meets net zero is shown. This is not the only pathway for the sector to meet net zero, however key interdependencies that should be the basis for developing alternative pathways to net zero emissions are outside of the scope of this analysis. We therefore present one scenario and characterize the underlying measures.

We also present results for each of the key sectors in Yorkshire and the Humber and overall league tables of the most cost and carbon effective options, both in the form of 'top ten' tables for each sector and through complete tables of measures.

Yorkshire and the Humber's Carbon Footprint

Past and Present Emissions

Yorkshire and the Humber's direct carbon footprint – coming from its use of fuels such as petrol, diesel and gas (also known as Scope 1 emissions) and from its use of electricity (Scope 2 emissions) and other territorial emission such as from land use fell by 44% between 2000 and 2024. In 2000, Yorkshire and the Humber's direct emissions were 66.7 Mt CO_2e, in 2024 and 37.2 Mt CO_2e

This substantial reduction in the region's emissions stems from a mix of electricity decarbonisation, gradual improvements in the efficiency of buildings and vehicles and structural changes in the economy, for example linked to the switch from manufacturing to higher-value production and services.

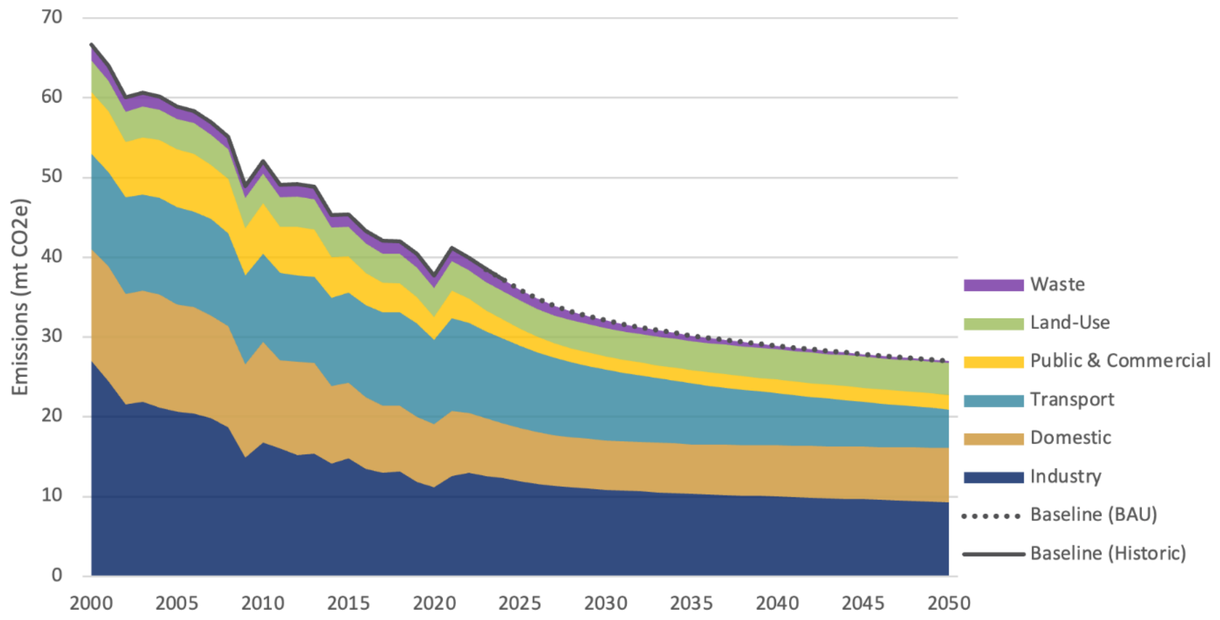

Figure 1: Yorkshire and the Humber's Carbon Footprint - Past, Present and Projected (Scope 1 and 2 Emissions)

A Sectoral Breakdown of Current Emissions

Currently, 33% of all emissions from the region come from industry, with transport accounting for 29%, homes 19%, land-use 9%, public and commercial buildings 6% and the waste sector 4%.

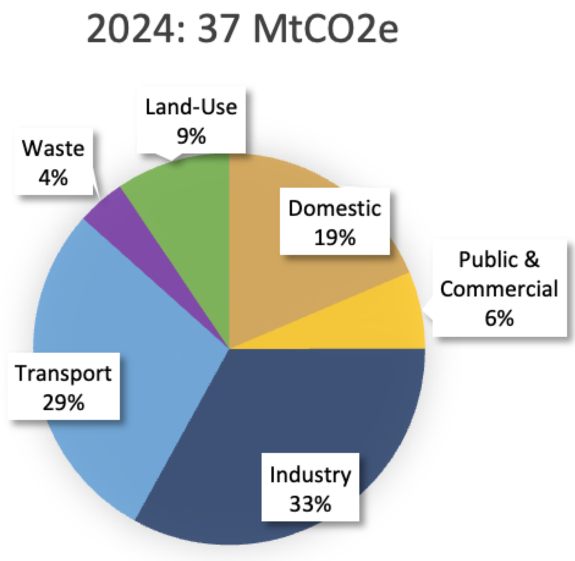

Figure 2: Yorkshire and the Humber's Carbon Footprint - Sectoral Breakdown (Scope 1 and 2 Emissions (2024)

A Projection of Future Emissions

All projections are uncertain, but if we take into account on-going economic and population growth in Yorkshire and the Humber, continued efficiency improvements in homes, buildings and transport, the gradual switch to electric vehicles and the continuing decarbonisation of grid electricity in the UK in line with national carbon targets, then we predict that, based on 2000 levels and on a continuation of current trends, Yorkshire and the Humber will have cut its direct carbon footprint by 56% by 2038 and by 60% by 2050.

We predict that much of the reduction in Yorkshire and the Humber's emissions in the period through to 2038 will come from the switch to electric vehicles, and efficiency improvements in public and commercial buildings and industry. We also expect that household emissions will fall on average, primarily due to ongoing decarbonisation of the electricity grid.

With accelerated changes in national energy infrastructure including more rapid deployment of renewable energy, heat pumps and non-motorised transport infrastructure, regional emissions could be lower than forecast. However, if national targets are weakened or are not delivered, then regional emissions could be higher than forecast.

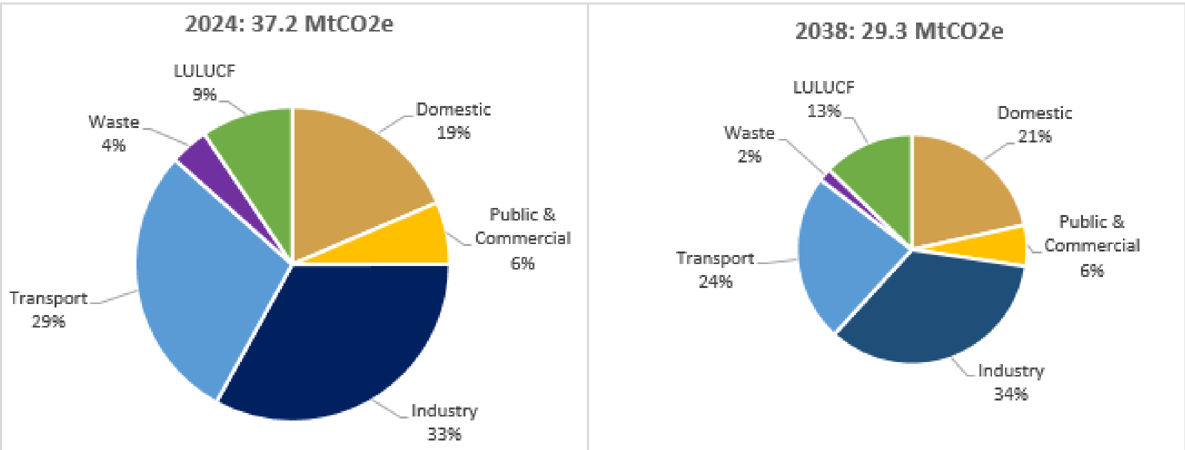

Figure 3: Yorkshire and the Humber's Carbon Footprint - Present and Projected (Business-As-Usual) Sectoral Emissions (Scope 1 and 2)

Yorkshire and the Humber's Energy Bills

Total Energy Bills

In 2024, Yorkshire and the Humber's total energy bill – covering the cost of all purchases of petrol, diesel, gas and electricity in the region – will amount to an estimated £13 billion. This annual cost of energy represents a major drain on the region's economy and a strain for many households, businesses and public service providers. We assume, based on government forecasts, that energy prices will begin to return to normal levels from recent peaks before decreasing gradually over time through to 2050. Under this assumption, the total energy bill for the region could equal £10 billion a year by 2038 and £9 billion a year by 2050.

Household Energy Bills

We estimate that in 2024 the average household in Yorkshire and the Humber will spend £3,653 a year on energy (including household heating and energy use and household level transport costs). For individual households, under current assumptions the average annual household energy bill could decrease to £2,502 a year by 2038 and £2296 by 2050.

Joining-up Action on Energy Bills and Carbon

Electrification of energy supply is a major component of national decarbonisation and is outside the scope of this report. But, whether at the regional, local or the household level, energy bills represent a huge outgoing. It is clear that promoting energy efficiency can play a major role in cutting bills, tackling fuel poverty, protecting businesses and public services whilst at the same time cutting carbon emissions. We have therefore examined the fuel bill savings that could be derived from efficiency measures and from fuel switching.

We find that Yorkshire and the Humber could cut its current carbon emissions by 34% and save £3 billion a year from its energy bill by investing in measures that would more than pay for themselves over their lifetime through the energy savings that they would generate. If it went further to adopt all of the measures that are currently viable, Yorkshire and the Humber could cut its carbon emissions by 102% (in other words it could meet its net zero target) and save £4.5 billion a year from its annual energy bill.

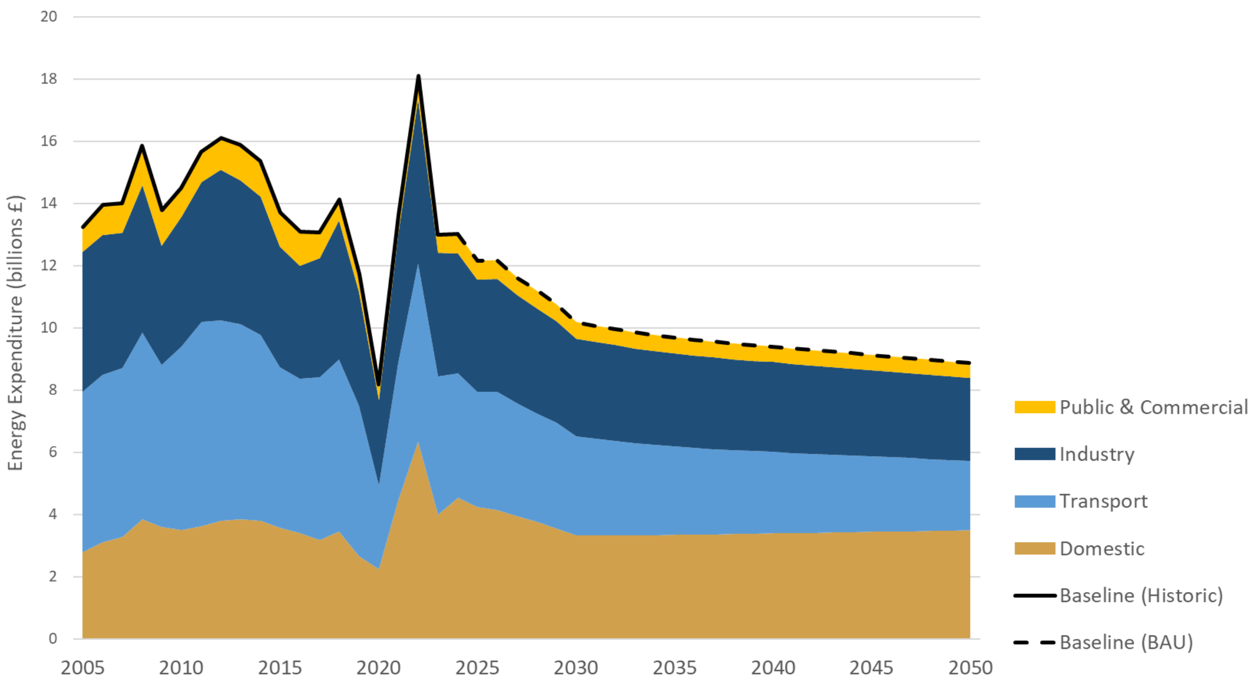

Figure 4: Yorkshire and the Humber's Total Energy Bill - Past, Present and Projected

Results by Level of Change

The aggregated results show the contribution that each of the levels of activity could make to cutting Yorkshire and the Humber's carbon footprint.

» ***Easy Win & Financially Beneficial***

Adopting all the options in this category would enable Yorkshire and the Humber to close the gap between its projected 'business as usual' emissions in 2038 and net zero by 36%. To exploit these options, £1.6 billion a year would need to be invested across Yorkshire and the Humber for the next 15 years, but these investments would cut Yorkshire and the Humber's total energy bill by £2.4 billion p.a. by 2038 and create 43,000 years of extra employment (i.e. 2100 jobs every year for 20 years).

» ***Mainstreaming Change & Economically Beneficial***

Expanding the scope of decarbonization beyond Easy Win & Financially Beneficial to adopt all of the options in this category would enable Yorkshire and the Humber to close the gap between its projected 'business as usual' emissions in 2038 and net zero by 50%. This would require investments of £3.7 billion a year for the next 15 years, but this would cut Yorkshire and the Humber's total energy bill by £3.2 billion a year from 2038 whilst creating 108,000 years of extra employment (i.e. 5,400 jobs for 20 years).

» ***Mission Driven & Environmentally Beneficial***

Tackling the most technically, socially and politically challenging aspects of decarbonisation could enable Yorkshire and the Humber to close the gap between its projected 'business as usual' emissions in 2038 and net zero by 102%. This step-change in the level of decarbonisation would require investments of £7.3 billion a year for the next 15 years, but this would cut Yorkshire and the Humber's energy bill by £4.5 billion a year from 2038 whilst creating 242,000 years of extra employment (i.e. 12,000 jobs for 20 years).

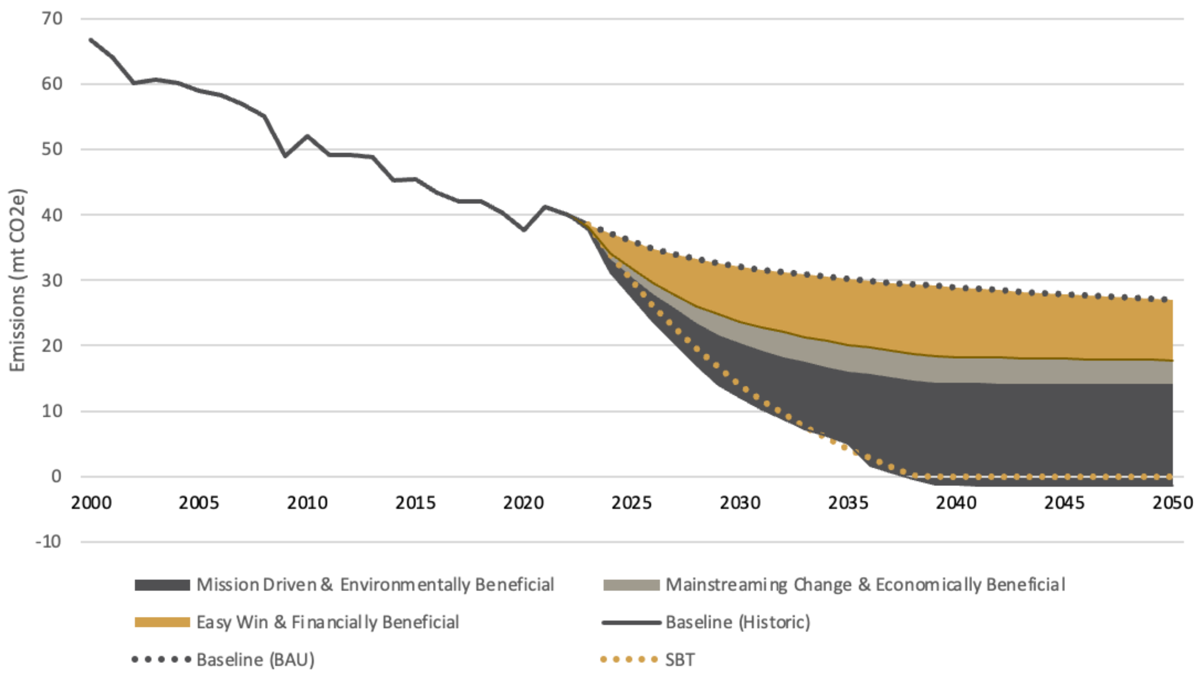

Figure 5: Yorkshire and the Humber's Carbon Reduction Potential

The Most Carbon-and Cost-Effective Options for Yorkshire and the Humber

There are multiple options that could be deployed as Yorkshire and the Humber transitions towards net zero. In this analysis, we focus on the carbon- and cost-effectiveness of different options, and below we present the 'top ten' league tables of the most carbon- and cost-effective options. We note that the domestic, land-use and industry sectors all have options in the top-ten most carbon-effective league table. This emphasises the need for a cross-cutting, region-wide decarbonisation programme. In Appendices 3 and 4 we present the full league tables extending to over 700 measures.

In the tables throughout this report, the carbon-effective tables use the metric "Mitigation" which refers to the total amount of CO_2e avoided for each low-carbon option across the study period (2024-2050). As previously mentioned, Yorkshire and the Humber have a net-zero target of 2038, which is referenced in the tables throughout this report. The legally binding target of 2050, which the UK as a whole is responsible for meeting, must also be modelled throughout this analysis. Therefore, the mitigation metrics shown are consistent with 2050, but with modelling objectives set to meet the 2038 target.

The cost-effective tables use cost per tonne, referring to the lifetime cost (capital and operational) divided by the total carbon mitigated from 2024 – 2050. Negative values for cost per tonne metrics indicate positive returns; i.e. the positive economic returns (energy savings) outweigh the capital and operating costs.

Of course, decision-making should be guided by a wider range of criteria than just carbon- and cost-effectiveness. Assessing the readiness or capacity of Yorkshire and the Humber to adopt different options – for example considering their political, social, financial and institutional readiness – can provide a more rounded or multi-criteria view of the most suitable options. Whatever criteria are applied, there should be clear social, economic and environmental benefits from having an informed, evidence-based approach.

We emphasise that the investment needs set out below would be spread across the region as a whole – and include investments made by households, businesses, the public sector and so on. The challenge for policy makers is to enable and encourage these investments.

Table 1: Top Ten List of the Most Carbon-Effective Options

Sector	Process	Mitigation ($Mt CO_2e$, 2024 - 2050)	% of total YH GHG emissions through 2038	Context
Transport	Light goods vehicle (Diesel) to Light goods vehicle (electric)	29.7	6%	24.7 billion km shifted
Land use and Agriculture	Beef cattle to broadleaf forest	24.1	5%	Beef cattle reduction - 35%
Land use and Agriculture	Dairy cattle to broadleaf forest	21.1	4.4%	Dairy cattle reduction - 43%
Industry	CHP (Non BECCS allowed) - Green hydrogen, Blue Hydrogen, Biomass	17.2	3.6%	Homes affected in YH - 8%
Domestic	Semi Detached (Age Band C) - Deep + appliances retrofit	13.8	3.6%	Homes affected in YH - 8%
Land use and Agriculture	Sheep to broadleaf forest	13.1	2.9%	Sheep reduction - 11%
Domestic	Semi Detached (Age Band C) - Medium retrofit	12.9	2.7%	Homes affected in YH - 8%
Land use and Agriculture	Improved farming practices	12.3	2.5%	Cropland affected - 8%
Domestic	Mid Terrace (Age Band B) - Deep + appliances retrofit	11.1	2.3%	Homes affected in YH - 8%
Industry	Primary Iron Production - A - HiSarna + CCS - Calcium Looping	10.9	2.3%	-

Table 2: Top Ten List of the Most Cost-Effective Options

Sector	Process	Cost per tonne (£)
Transport	Cars to walking and cycling	-1802
Transport	Bus (Diesel) to Bus (electric)	-1316
Transport	Light goods vehicle (Diesel) to Light goods vehicle (electric)	-1154
Transport	Electric vehicles replacing conventional private vehicles	-1154
Transport	Cars to electric trains	-1050
Commercial	Electric and heating retrofits	-1007

Transport	Electric heavy goods vehicles	-965
Industry	Compressed Air Systems efficiency	-603
Industry	Pump Upgrades, Repairs and Maintenance	-575
Industry	Flaring - Gas recovery for sales (bio or fossil)	-457

The Co-Benefits of Climate Action in Yorkshire and the Humber

Few investments in our communities are made expressly with the purpose of reducing GHG emissions. Homes are built for shelter, bike and bus lanes for mobility and offices and commercial spaces for business and commerce. Aligning investments with a net zero future, however, is not only necessary, but generates substantial social, economic and environmental benefits in addition to reducing GHG emissions.

The wider benefits of climate action in Yorkshire and the Humber are presented below. These monetised estimates include benefits from improved health, increases in productivity, reduced congestion and avoided future expenditure on GHG mitigation. These estimates are developed from work previously undertaken for UKRI[7]. Further information on the methodology behind this analysis can be found in the accompanying methodology document.

Two key caveats are important to note before looking at this data. Due to a lack of available data, a number of key benefits are not included. Among these are nature-based services, including those that provide benefits in the form of biodiversity, clean water and flooding risk. These actions are key to avoiding the worst impacts of climate change and therefore have the potential to yield substantial benefits. Future analysis is needed to consider the potential of these measures at the Yorkshire and Humber level.

[7] https://www.ukri.org/publications/accelerating-net-zero-delivery/

Of greater significance, the shift to Net Zero is a generational opportunity for addressing public health and social and economic inequalities at a societal level[8]. Analysis here connects climate action with social, environmental and economic benefits, but does not systematically explore the conflicts and complementarities between decarbonisation and wider societal challenges, nor does it provide a pathway to net zero that maximises these benefits. Further work is therefore needed to understand these complexities.

Across all sectors, actions are found to generate as much as £250 billion through 2050. Of these benefits, approximately half is attributable to the economic benefits of increased physical activity. Comparing these benefits to the cost of action underlines the need for climate policymaking to be embedded in the way wider social and environmental challenges are approached in Yorkshire and the Humber. For the lowest level of action (Easy Win & Financially Beneficial) the co-benefits of climate action are 7.5x larger than the cost of action. For the second most ambitious program of action (Mainstreaming Change & Economically Beneficial) the benefits of action are 4x the cost of action. And even for the most ambitious program of action (Set the Decision Timeline) the benefits of action are 2.3x the cost of action.

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[8] https://yhphnetwork.co.uk/links-and-resources/adph-priorities/climate-change-sustainability/yh-adph-climate-and-health-narrative/#:~:text=We%20have%20developed%20a%20local,inequalities%20running%20through%20the%20resource.

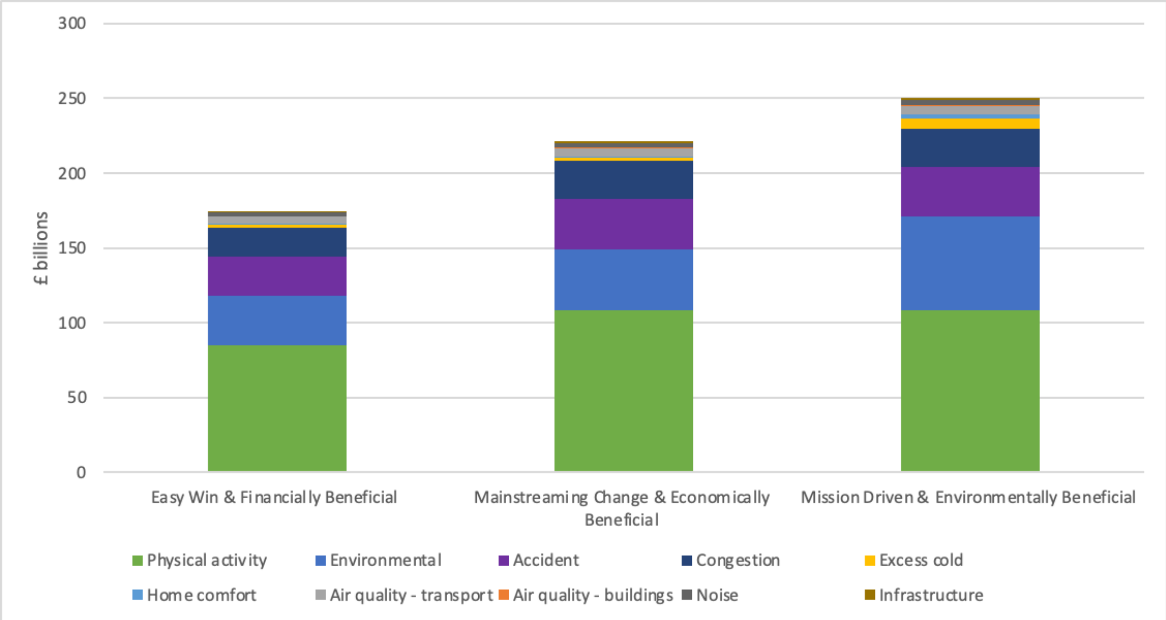

Figure 6: Co-benefits of Climate Action by Level of Action in Yorkshire and the Humber[9]

Co-benefit	Definition
Environmental benefits	Greenhouse gas emissions values ("carbon values") are used by government for valuing impacts on GHG emissions resulting from policy interventions. Carbon values represent a monetary value that society place on carbon dioxide equivalent (£/tCO_2e).
Congestion	The value of reduced time spent traveling and road repairs from reduced numbers of vehicles on roads
Air quality - transport	The value of public health benefits from reduced air pollution from transport.
Air quality - buildings	The value of public health benefits from reduced air pollution from buildings.
Physical activity	The value of health benefits from increased walking and cycling.
Excess cold	The value to the NHS of elimination visits to hospital attributable to insufficient heating.
Home comfort	The additional comfort to households when higher efficiency of appliances allows those appliances to be used more frequently.
Accidents avoided	The value of reduced vehicle repairs and lives lost from a change in the number of vehicle accidents.
Noise	The value to public health and worker productivity from reduced noise. This benefit is primarily from actions in the transport sector.

Table 3: Explanation of Key Co-Benefits from Low-Carbon Interventions

[9] The 'environmental' co-benefit here is a carbon value set by the UK government which places a monetary estimate on the value of mitigating one tonne of carbon, as a result of reduced need for future investment in carbon mitigation. It represents a societal benefit which reduces future spending by the Exchequer and society as a whole; and therefore is not included in the sectoral graphs throughout this report but is shown here and in the total output estimates.
https://assets.publishing.service.gov.uk/media/613f61ae8fa8f503c4b208e8/carbon-values-lit-review.pdf

Results by Sector: Housing

Emissions have fallen in the housing sector over recent years but are likely to rise through to 2050 due to population growth and lack of national policy direction for retrofitting old homes. In order to meet its 2038 target, urgent and wide-reaching interventions are therefore required across the region.

Tackling the issue of decarbonising homes in Yorkshire and the Humber poses significant challenges. Across the region, 5.48 million people live across a diverse housing stock of 2.2 million dwellings[10], with variations in typology, occupancy type and energy efficiency requiring a variety of approaches. The most common EPC (Energy Performance Certificate) rating in the region is D, representing 45% of homes, with only 0.1% of homes holding the highest A rating[11]. Yorkshire and the Humber's housing stock is less energy efficient than the rest of England, with 28% of homes holding a C rating compared to 48% across England. Approximately 78% of the region's homes rely on gas heating, while 0.3% are known to have air or ground source heat pumps already installed. Successful projects for decarbonising homes in Yorkshire and the Humber include work by Calderdale Community Energy to facilitate the installation of heat pumps across the borough's domestic properties[12] and the Leeds PIPES project for connecting homes to the city's heat network[13].

[10] https://res.cloudinary.com/commonplace-digital-limited/image/upload/v1685532586/projects/62d182474a11a6e6f19288b4/media-upload/Better%20Homes%20%2526%20Places%20Draft%20Climate%20Action%20Report%20v2.pdf/dhb2pf6e7dxcswxokssu.pdf
[11] https://epc.opendatacommunities.org/domestic/search
[12] https://communityenergyengland.org/files/document/353/1575564696_CatalysingPeople-poweredEnergyinYorkshireandtheHumberReport2019.pdf
[13] https://www.westyorks-ca.gov.uk/projects/clean-energy-and-environmental-resilience/leeds-pipes/

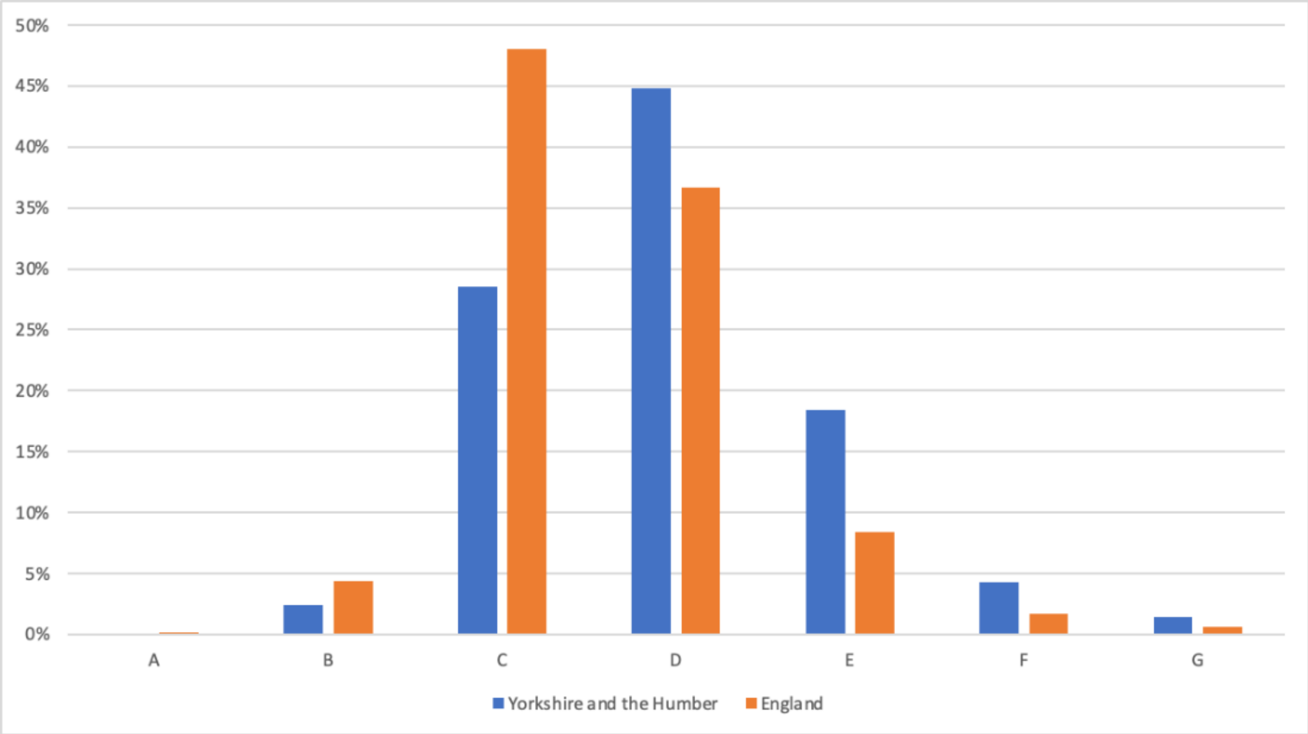

Figure 7: Domestic EPC Ratings in Yorkshire and the Humber[14]

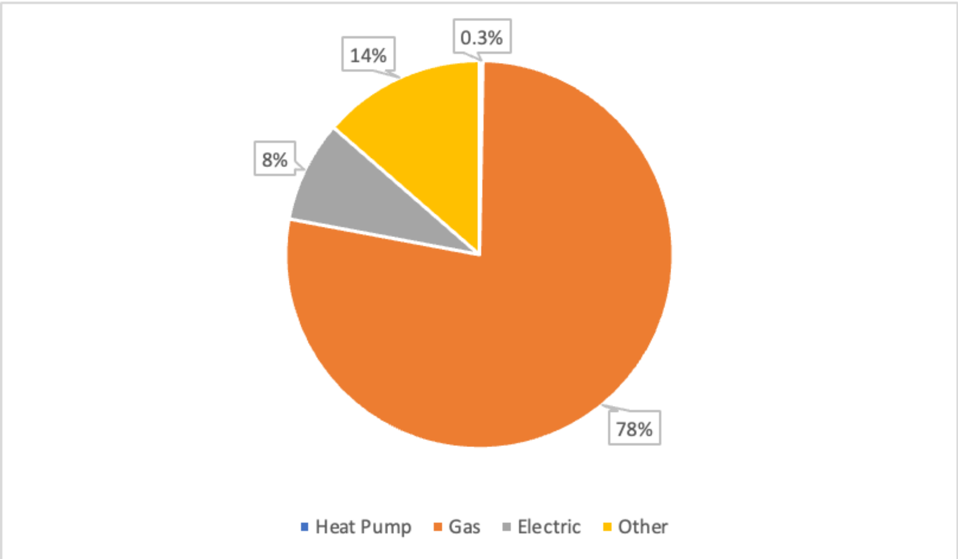

Figure 8: Main Heating Description in Yorkshire and the Humber[15]

[14] https://www.gov.uk/government/statistical-data-sets/live-tables-on-energy-performance-of-buildings-certificates#epcs-for-all-domestic-properties-existing-and-new-dwellings

[15] https://epc.opendatacommunities.org/

To consider interventions in the housing sector, data is organised into archetypes based on the form of the dwelling (for example flat, terrace homes and detached homes), and the age of the dwelling. For each of 82 archetypes we then assess a low, medium, high and high plus appliances retrofit. Details of these retrofits are found in the appendix. The lowest level of retrofit in this analysis costs approximately £2000 and only reduces energy and emissions by a small percentage while the deepest retrofits cost in excess of £30,000 and reduce energy use and emissions by 80% or more. This approach allows analysis to cover the entirety of the housing stock in Yorkshire and the Humber but will be unlikely to provide accurate estimates of cost and benefits for specific dwellings.

Area-based retrofits and related projects haven't been included in this sector's analysis, due to the specific conditions affecting their implementation. However, previous research has shown that delivery of an area-based project results in significant cost reductions when compared to an individual retrofit approach[16]. Other important considerations omitted from this analysis include Modern Methods of Construction (MMC) and Design for Manufacture and Assembly (DMA). These practices could significantly improve the delivery and nature of retrofit and housebuilding projects at scale, as well as reductions in required costs and labour[17].

Under a business-as-usual scenario, which includes on-going decarbonisation of grid electricity, a continuation of the background trends that are gradually improving the energy efficiency of the housing stock in Yorkshire and the Humber, and accounting for changes in housing stock and population numbers, we project that housing-related carbon emissions will decrease by 8% by 2038 against 2024 levels.

The following scenarios demonstrate how net zero can be achieved by 2038:

» Easy Win & Financially Beneficial

[16] https://www.e3g.org/wp-content/uploads/2023_07-locally-led-retrofit-report.pdf
[17] https://res.cloudinary.com/commonplace-digital-limited/image/upload/v1685532586/projects/62d182474a11a6e6f19288b4/media-upload/Better%20Homes%20%2526%20Places%20Draft%20Climate%20Action%20Report%20v2.pdf/dhb2pf6e7dxcswxokssu.pdf

With investments of £854 million a year for the next 15 years, overall emissions from Yorkshire and the Humber's housing stock could be reduced by 29% by 2038. This would also reduce the average household energy bill (excluding transport) by £408 a year in 2038, for a total of £886 million in annual energy savings across Yorkshire and the Humber.

» Mainstreaming Change & Economically Beneficial

With investments of £1.1 billion a year for the next 15 years, overall emissions from Yorkshire and the Humber's housing stock could be reduced by 33% by 2038. This would also reduce the average household energy bill (excluding transport) by £458 a year in 2038, for a total of £995 million in annual energy savings across Yorkshire and the Humber.

» Mission Driven & Environmentally Beneficial

With investments of £3.4 billion a year for the next 15 years, overall emissions from Yorkshire and the Humber's growing housing stock could be reduced by 99% by 2038. This would also reduce the average household energy bill (excluding transport) by £1,190 a year in 2038, for a total of £2.6 billion in annual energy savings across Yorkshire and the Humber.

Table 4: Top 10 Most Carbon-Effective Options in Homes[18]

Intervention	Mitigation (Mt CO_2e)	% Applied to Total Homes in YH
Semi Detached (Age Band C) - Deep + appliances retrofit	13.8	8%
Semi Detached (Age Band C) - Deep retrofit	13.7	8%
Semi Detached (Age Band C) - Medium retrofit	12.9	8%
Mid Terrace (Age Band B) - Deep + appliances retrofit	11.1	8%
Mid Terrace (Age Band B) - Deep retrofit	11	8%
Mid Terrace (Age Band B) - Medium retrofit	10.4	8%

[18] Note - depending on selected scenario in the model, exclusive options for each specific archetype (eg (eg Semi Detached Age Band C) would be selected to avoid overlapping across retrofit options for the same house. The % applied to total homes column is exclusive of other retrofit options within this table across the same archetypes.

Semi Detached (Age Band D) - Deep + appliances retrofit	10	7%
Semi Detached (Age Band D) - Deep retrofit	9.8	7%
Semi Detached (Age Band D) - Medium retrofit	9.3	7%
Mid Terrace (Age Band A) - Deep + appliances retrofit	7.5	5%

Table 5: Top 10 Most Cost-Effective Options in Homes

Intervention	Cost per tonne (£)
End Terrace (B) - Shallow retrofit	-87
Mid Terrace (D) - Shallow retrofit	-85
End Terrace (A) - Shallow retrofit	-84
Bungalow (B) - Shallow retrofit	-69
Semi Detached (B) - Shallow retrofit	-67
Bungalow (A) - Shallow retrofit	-66
Mid Terrace (E) - Shallow retrofit	-66
Purpose Built Flat (C) - Shallow retrofit	-65
End Terrace (D) - Shallow retrofit	-63
Semi Detached (A) - Shallow retrofit	-63

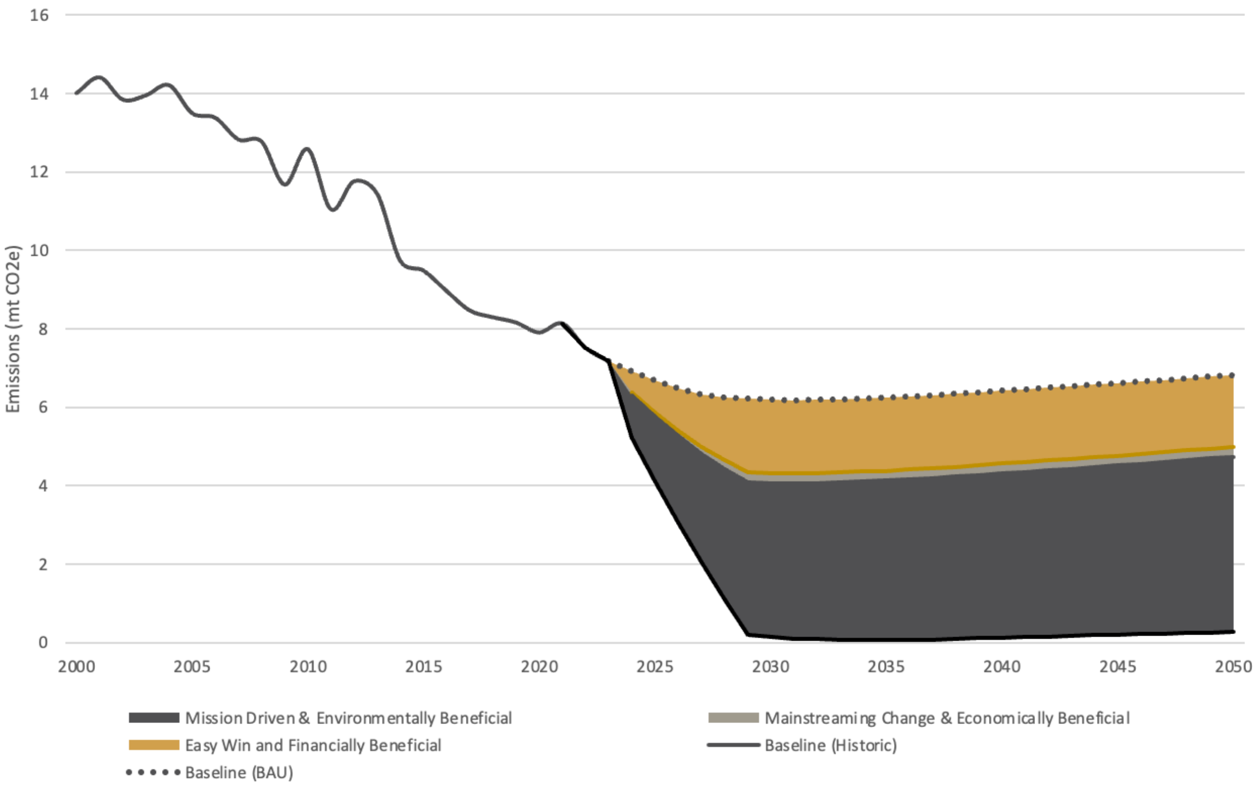

Figure 9: Yorkshire and the Humber's Carbon Reduction Potential: Housing

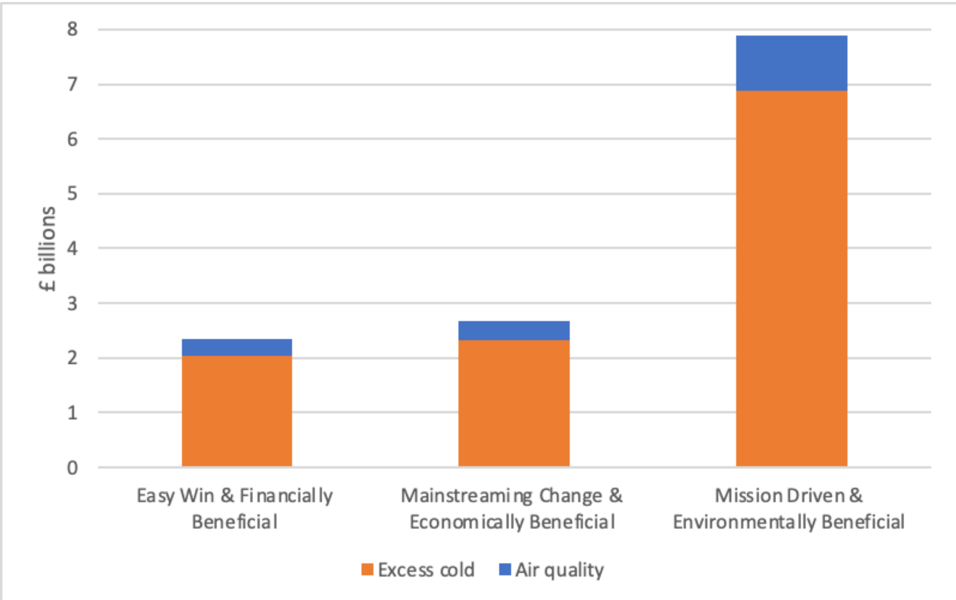

Figure 10: Yorkshire and the Humber's Social Benefits: Domestic Sector

Results by Sector: Public and Commercial Buildings

Achieving net zero emissions from public and commercial buildings in Yorkshire and the Humber presents a significant challenge. The majority of buildings in Yorkshire and the Humber (56%) hold an EPC rating of D or below while only 28% of non-domestic properties across England hold an EPC rating of D or below. Therefore, the buildings stock in Yorkshire and the Humber requires immediate attention not only to meet carbon targets, but to catch up with the national standard. Similar patterns exist across the different geographic boundaries, with the anomaly of North Yorkshire where 69% of properties hold a rating of C or above (compared to the rest of the region's average of 44%).

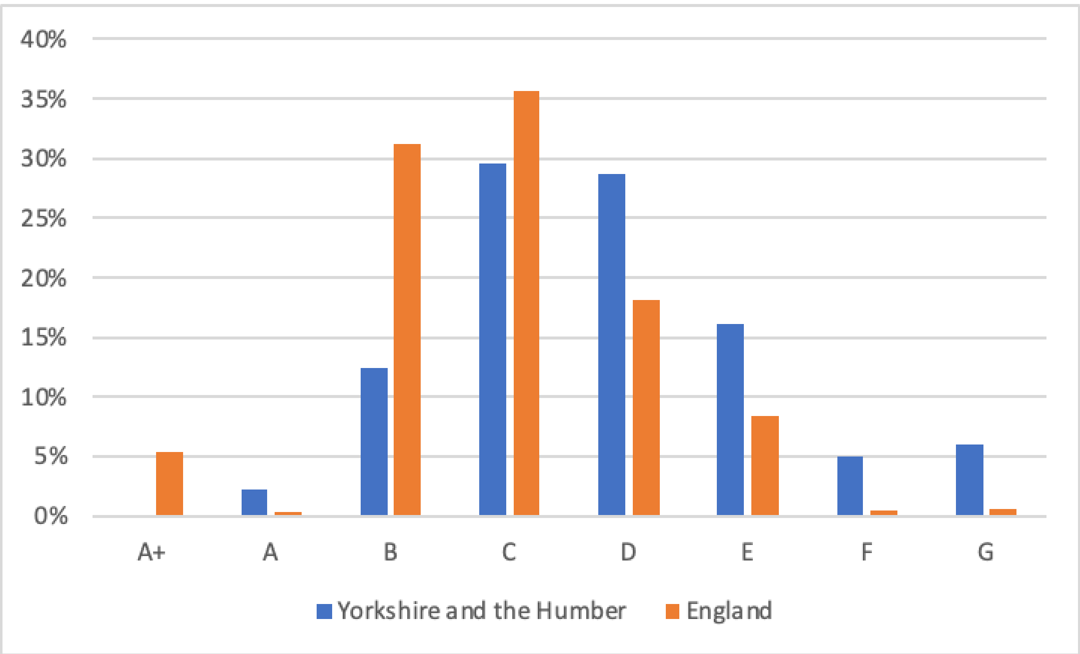

Figure 111: Comparison between England and Yorkshire and the Humber's Non-Domestic EPC ratings[19]

[19] https://www.gov.uk/government/statistical-data-sets/live-tables-on-energy-performance-of-buildings-certificates#epcs-for-non-domestic-properties

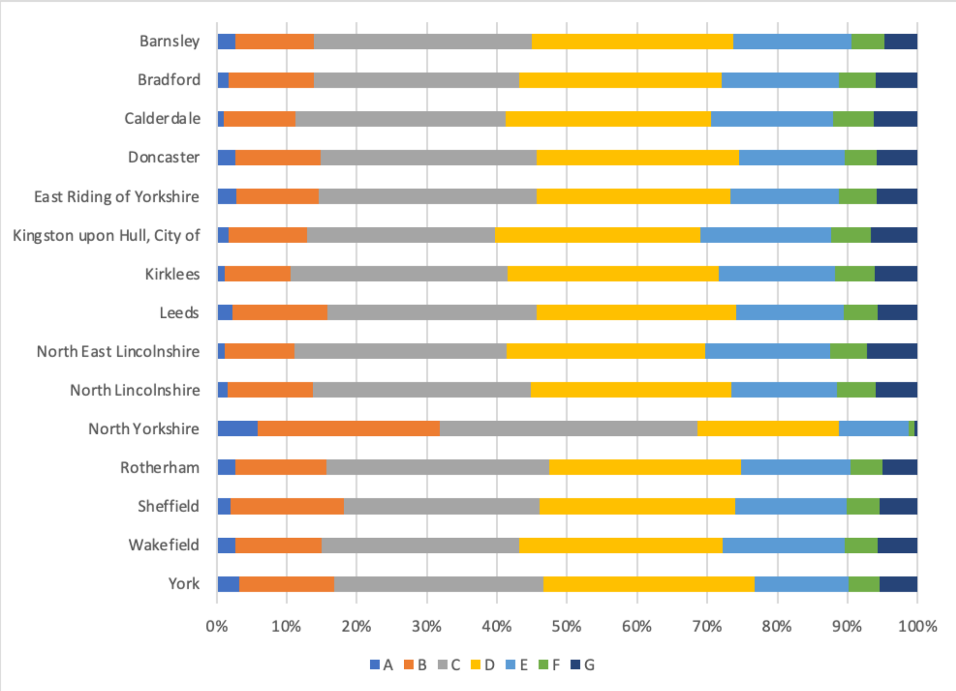

Figure 12: Comparison of Non-Domestic EPC ratings across geographic boundaries in Yorkshire and the Humber[20]

[20] https://www.gov.uk/government/statistical-data-sets/live-tables-on-energy-performance-of-buildings-certificates#epcs-for-non-domestic-properties

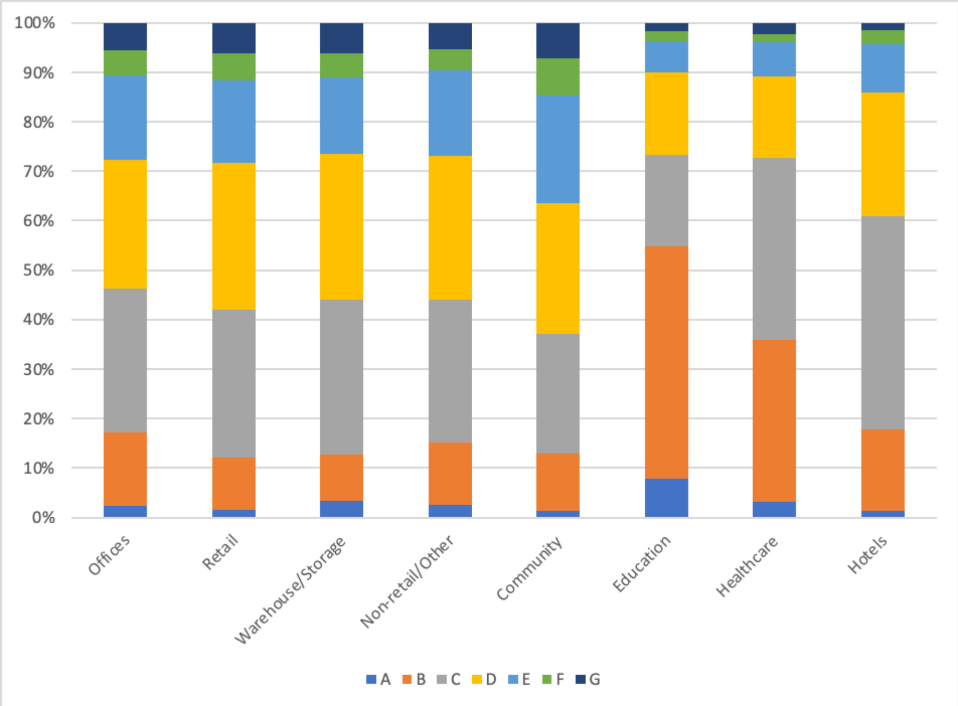

Figure 123: Comparison of Non-Domestic EPC ratings across Archetypes in Yorkshire and the Humber[21]

Similar to the domestic sector, analysis of the public and commercial buildings sector considers building archetypes by age. Limitations in the availability of data, however, and around the known floor area of commercial buildings require additional assumptions for the development of a model of decarbonisation. Further information on the approach and data sources can be found in the appendix.

Under a business-as-usual scenario, including ongoing decarbonisation of the energy supply emissions from the public and commercial sector will remain at 1.7 Mt CO_2e in 2038, only 29% below 2024 levels.

The following scenarios demonstrate how net zero can be achieved by 2038:

» Easy Win & Financially Beneficial

[21] https://www.gov.uk/government/statistical-data-sets/live-tables-on-energy-performance-of-buildings-certificates#epcs-for-non-domestic-properties

With investments of £147 million a year for the next 15 years, emissions from public and commercial buildings in the area could be reduced by 27% by 2038. These investments would reduce the total energy bill for public and commercial buildings in the area by £107 million a year by 2038.

» Mainstreaming Change & Economically Beneficial

With investments of £824 million a year for the next 15 years, emissions from public and commercial buildings in the area could be reduced by 34% by 2038. These investments would reduce the total energy bill for public and commercial buildings in the area by £207 million a year by 2038.

» Mission Driven & Environmentally Beneficial

With investments of £1.7 billion a year for the next 15 years, emissions from public and commercial buildings in the area could be reduced by 100% by 2038. These investments would reduce the total energy bill for public and commercial buildings in the area by £297 million a year by 2038.

Table 6: Most Carbon-Effective Options in Public and Commercial Buildings

Measure	Mt CO_2e	Floorspace applied to (km^2)
Insulation improvements in industrial/warehouse buildings	4.4	7.3
Draught reduction (air tightness) in retail buildings	2.5	5.7
Heat pumps (air source) in retail buildings	2.4	3.4
Solar PV installations in industrial/warehouse buildings	2.4	23.5
More efficient heating (warm air blowers) in industrial/warehouse buildings	0.9	10.6
High-efficiency boilers in industrial/warehouse buildings	0.9	23.3
Heat recovery (MVHR) in retail buildings	0.7	2.6
Improved heating controls in industrial/warehouse buildings	0.7	21.3
Highly efficient new build standards in industrial/warehouse buildings	0.6	-
Draught reduction (air tightness) in industrial/warehouse buildings	0.6	23.7

Table 7: Most Cost-Effective Options in Public and Commercial Buildings

Measure	Cost per tonne (£)
High efficiency electrical systems (0.95 Power Factor) in retail buildings	-938
High efficiency cooling systems in retail buildings	-874
Improved efficiency in ventilation systems (variable speed pumps) in retail buildings	-851
Optimised fan power for ventilation systems in retail buildings (SFP 2.0/l/s)	-850
Energy-saving fluorescent lighting (T5 bulbs) in office buildings	-736
High efficiency electrical systems (0.95 Power Factor) in industrial/warehouse buildings	-656
Office 3T5 conversions	-348
Heat recovery (MVHR) in retail buildings	-237
Upgrading lighting systems (LED) in non-retail buildings	-226
Smart lighting (daylight sensing) installations in community centres	-174

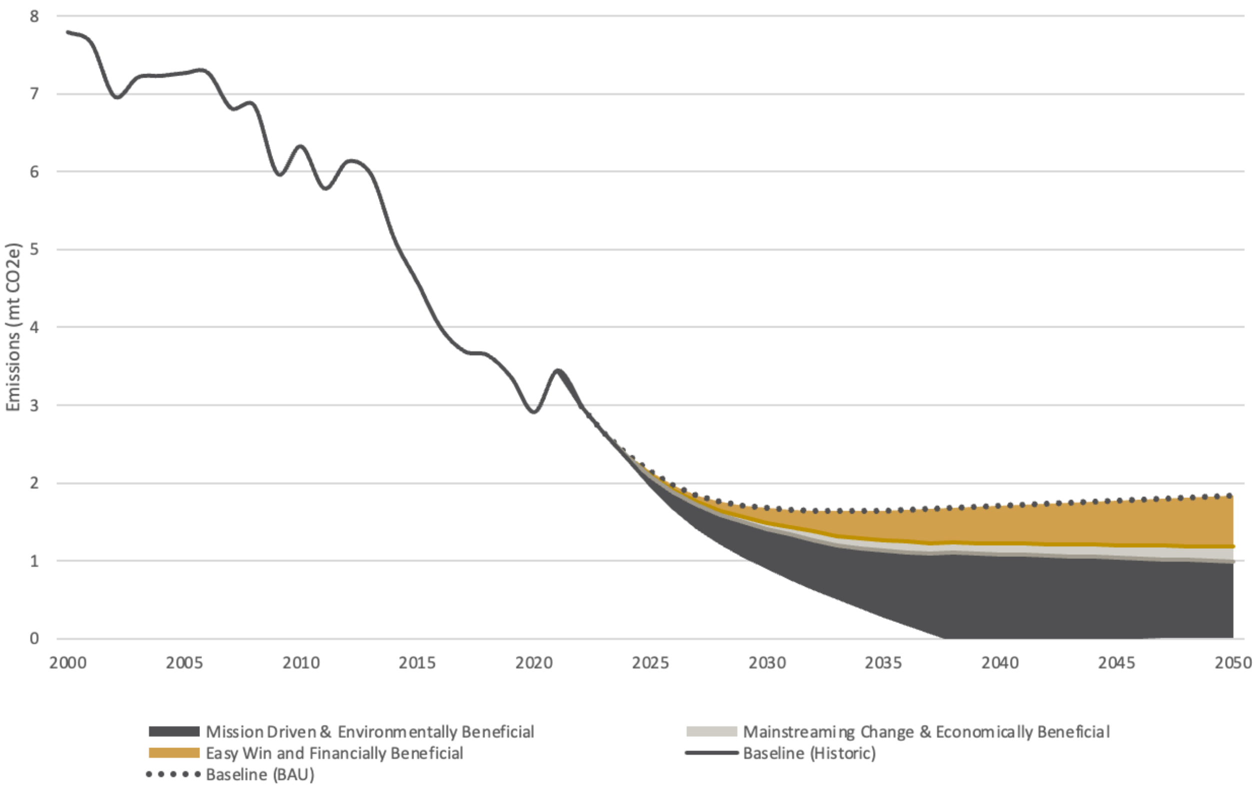

Figure 134: Yorkshire and the Humber's Carbon Reduction Potential: Public and Commercial Buildings

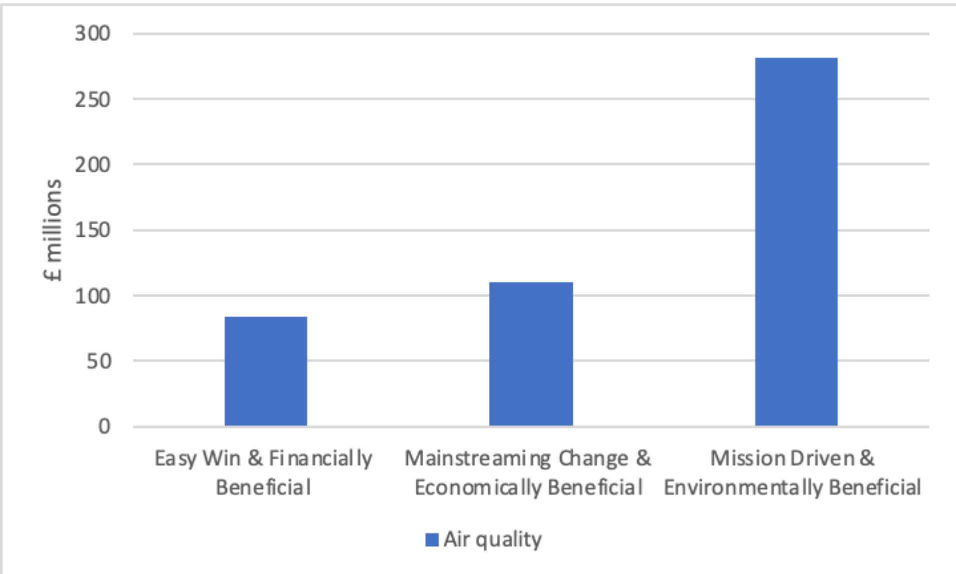

Figure 14: Yorkshire and the Humber's Social Benefits: Public and Commercial Sector

Results by Sector: Transport

As a diverse region with large urban centres and low-density rural areas, low-carbon and zero carbon transport will require locally tailored solutions. Bradford's per capita emissions in 2021 from transport, for example, were 0.9 t CO_2e while North Yorkshire's were 3.1 t CO_2e. This suggests that North Yorkshire has a much higher dependency on private vehicle transport (as a consequence of geography) and will require a different approach from urban centres in the region such as Bradford. 57% of journeys in the region are currently taken by private transport and public transport currently represents only 5% of journeys.

Figure 16 shows that decarbonisation of the transport sector has been limited across the region from 2000, with temporary reductions visible during the COVID-19 pandemic. Looking forward, significant decarbonisation is forecast through to 2050, primarily due to national policies around the ban of ICE vehicles. In order to eliminate remaining emissions and meet its net zero goal of 2038, Yorkshire and the Humber will need to implement further policies to reduce the carbon intensity of travel across the region. Significant interventions are already underway, with large-scale investment in the region through the West Yorkshire mass-transit system, and expansion of the Northern Powerhouse rail network[22].

[22] https://www.gov.uk/government/news/yorkshire-and-the-humber-to-benefit-from-198-billion-transport-investment

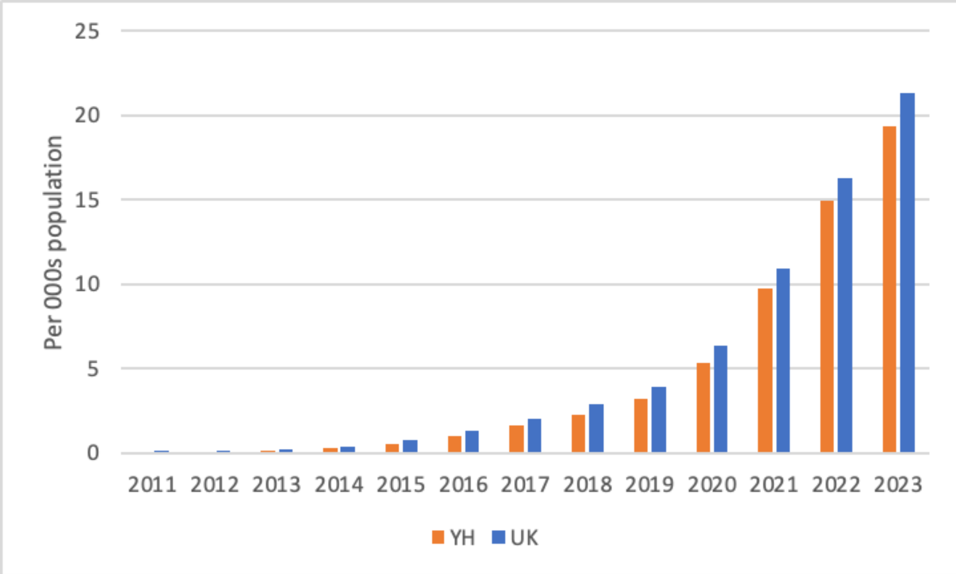

Figure 156: Comparison of Electric Vehicle uptake in Yorkshire and the Humber and the UK[23]

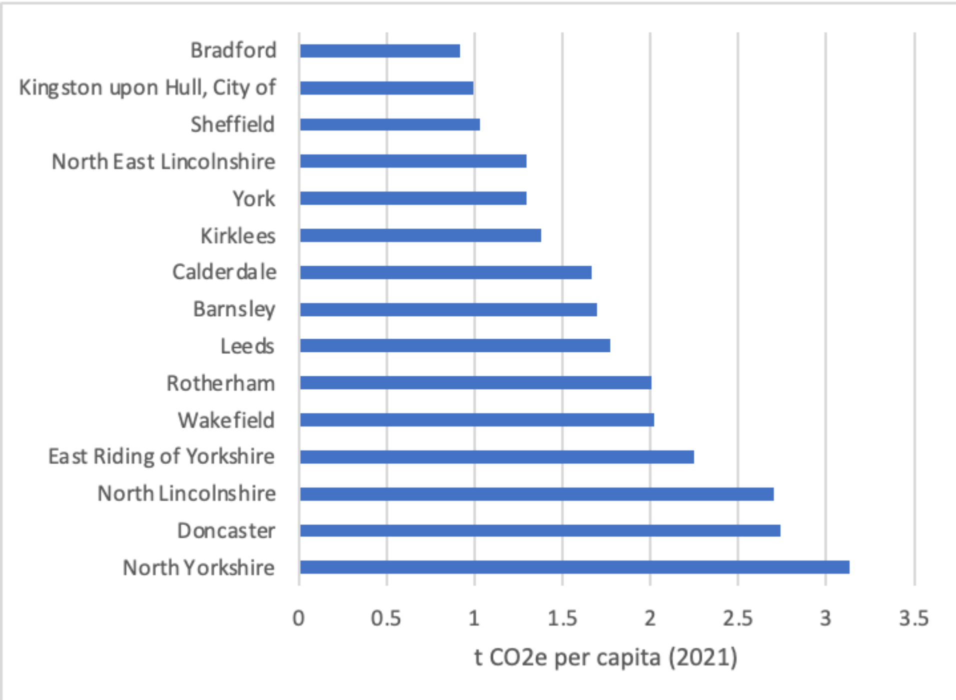

Figure 167: Carbon Footprint of Travel per capita across geographic boundaries in Yorkshire and the Humber[24]

[23] https://www.gov.uk/government/statistical-data-sets/vehicle-licensing-statistics-data-tables
[24] https://www.gov.uk/government/collections/uk-local-authority-and-regional-greenhouse-gas-emissions-national-statistics

Analysis here assumes that the number of trips taken within Yorkshire and the Humber is the same in all scenarios presented. The way trips are made, however, is changed based on the interventions applied. Trips that were previously taken by car, for example, are shifted to public transport or walking and cycling. Where trips are shifted to walking and cycling the analysis also assumes that the destination of trips can be changed. A trip to collect groceries from a large store on the edge of a city, for example, is shifted to a store within cycling distance. These are the same assumptions as have been applied in a large set of literature on transport and decarbonisation ().

Analysis is ambitious in its targets for non-motorised transport and public transport, assuming that approximately 40% of trips currently made by cars can be shifted to walking, cycling and public transport. This 40% shift assumes that adults can walk up to 2.7kms per day and cycle up to 2.5kms per day.

Under a business-as-usual scenario, which includes on-going decarbonisation of grid electricity, a continuation of background trends that are gradually improving the energy efficiency of the transport sector in Yorkshire and the Humber, we project that the transport sector's carbon emissions will decrease by 35% by 2038 compared with 2024 levels.

The following scenarios demonstrate how net zero can be achieved by 2038:

» Easy Win & Financially Beneficial

With investments of £262 million a year for the next 15 years, emissions from the transport sector in the area could be reduced by 78% by 2038. These investments would reduce the total energy bill for the transport sector by £1.7 billion a year by 2038.

» Mainstreaming Change & Economically Beneficial – As transport includes some measures that over their lifetimes are highly cost-effective (e.g. mode shift and EVs) and some that generate significant wider benefits but are not directly cost-effective (e.g. many public transport measures generate substantial economic benefits but require subsidies from public bodies to cover their financial costs), there are no cost-neutral measures included in the analysis.

» Mission Driven & Environmentally Beneficial

With investments of £1.1 billion a year for the next 15 years, emissions from the transport sector in the area could be reduced by 96% by 2038. These investments would reduce the total energy bill for the transport sector by £2 billion a year by 2038.

Table 8: Aggregated List of Most Carbon-Effective Options for the Transport Sector[25]

Measure	Mt CO_2e	Context
ICE goods vehicles to EVs	39.7	24.7 billion km (average of 0.91 billion km per annum)
Car journeys to walking journeys	37.3	19.4 billion km shifted from 2024 - 2050 (weekly per capita average of 2.5 km)
Car journeys to bike journeys	26.4	13 billion km shifted (average of 1.7 km per person per week)
ICE buses to EVs	9.3	6.2 billion km shifted (average of 3.5 km travelled per person per month by EV bus).

Table 9: Most Cost-Effective Options for the Transport Sector

Measure	Cost per tonne (£)
Large car (Petrol) to EV	-2168
Medium car (Petrol) to EV	-2049
Medium car (Diesel) to Bicycle	-1951
Small car (Diesel) to Bicycle	-1929
Large car (Diesel) to Bicycle	-1913
Small car (Petrol) to EV	-1899
Medium car (Petrol) to Walk	-1862

[25] *Measures in table combined across related deployments (for example car size, fuel type) for readability.*

Small car (Petrol) to Walk	-1851
Medium car (Petrol) to Bicycle	-1838
Large car (Petrol) to Walk	-1828

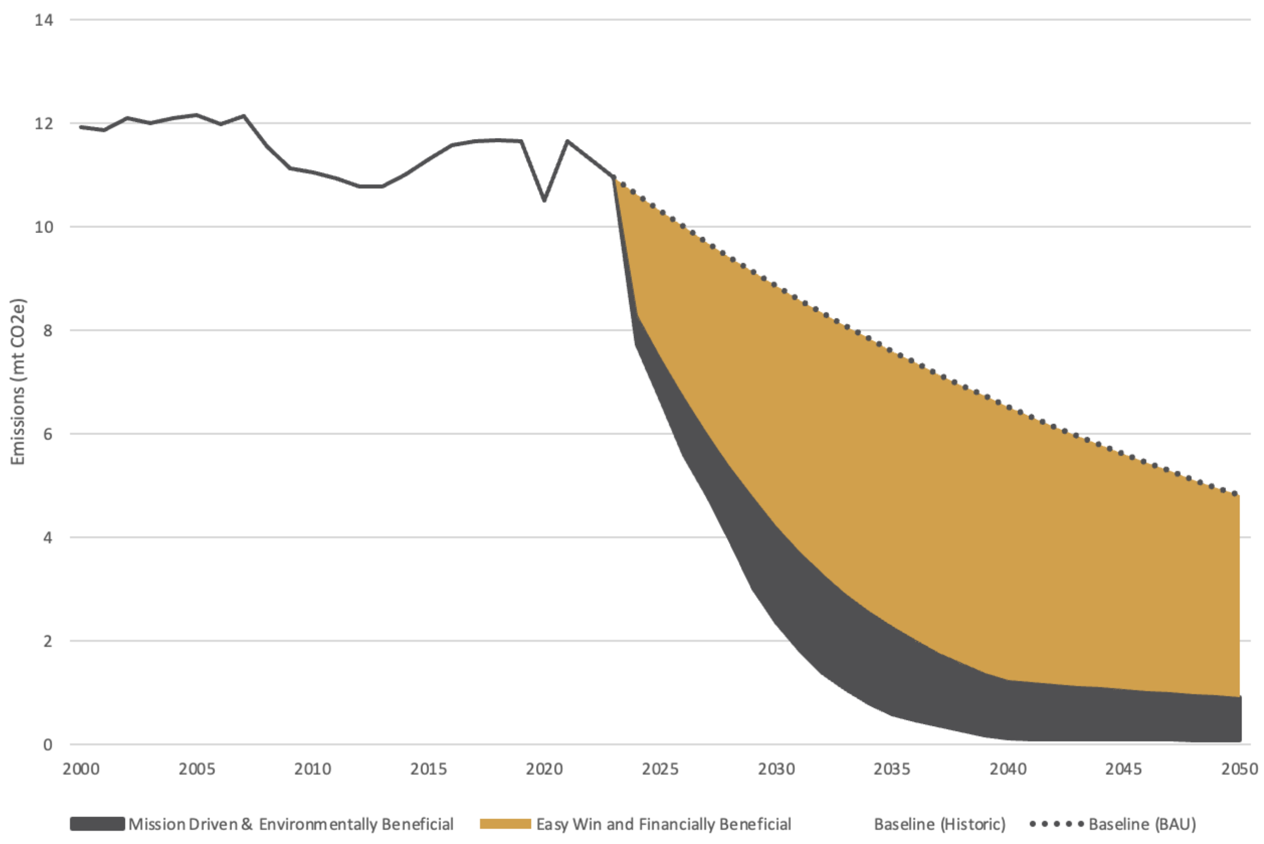

Figure 178: Yorkshire and the Humber's Carbon Reduction Potential: Transport

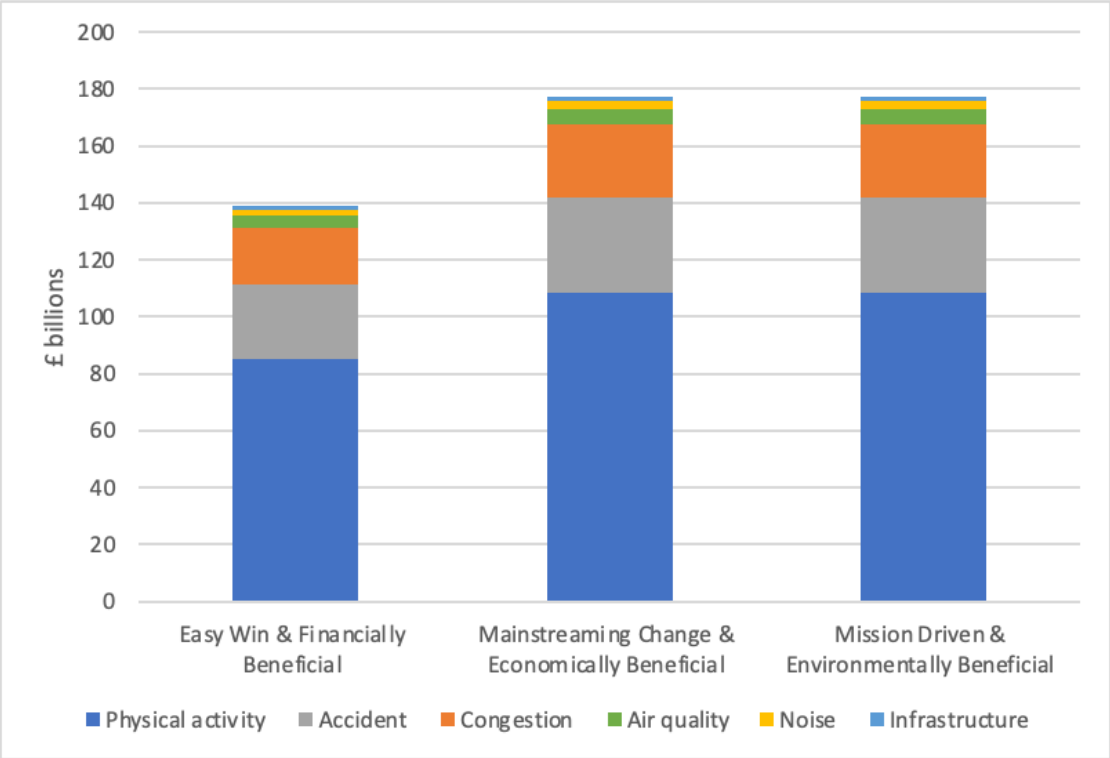

Figure 19: Yorkshire and the Humber's Social Benefits by Scenario: Transport Sector

Results by Sector: Industry

Yorkshire and the Humber has a large industrial sector that contributes 33% of the region's 2024 emissions. Within this sector, the Humber Industrial Cluster is both the highest GHG emitting industrial cluster in the UK and the second highest GHG emitting cluster in Western Europe[26]. The cluster was responsible for 97% of all industrial emissions in the region in 2021[27].

The Humber Industrial Cluster Plan (HICP) was launched in 2023 and is the most recent strategic roadmap for the decarbonisation of the Humber Industrial Cluster. This work supercedes previous work such as The Humber Estuary Plan and the Zero Carbon Humber Plan which were launched in 2021 and 2020[28]. HICP sets out the strategic roadmap for the decarbonisation of the Humber Cluster, with the target of achieving net zero emissions by 2040.

Analysis here applies many of the same interventions as the HICP. Key conclusions between this analysis and the HICP also align, including the need for significant coordinated investment from industrial actors, support and investment from government and policy direction around the development of carbon capture, utilisation and storage.

A key difference between HICP analysis and analysis here lies in the extent that carbon capture, utilisation and storage (CCUS) is relied upon to achieve net zero emissions. While CCUS is highlighted by the HICP as having the capacity to reduce emissions 35-56%, in this analysis it is estimated to reduce emissions by 30%. Two factors contribute to the difference.

First, analysis here covers emissions from the wider Yorkshire and Humber region as well as the emissions from the Humber Cluster. While emissions outside of the Humber cluster

[26] **https://heylep.com/wp-content/uploads/2021/05/Humber-Estuary-Plan-final-draft-Jan-2021.pdf**
[27] https://www.weforum.org/agenda/2021/07/net-zero-carbon-humber-uk-industry/
[28] **https://www.zerocarbonhumber.co.uk/wp-content/uploads/2019/11/HUMBER-DIGITAL-V4.6-reduced.pdf**

are generally less energy intensive, the dispersion of these emissions across the region make them a challenge for decarbonisation, and leads to more interventions (where possible) that rely on alternatives to CCUS. Second, within the Humber Cluster analysis utilises CCUS only where alternatives to CCUS are not available or do not achieve zero emissions. This approach is taken to reduce the level of technological and policy risk embedded in the net zero scenario produced by this analysis.

Under a business-as-usual scenario, which includes on-going decarbonisation of grid electricity, a continuation of background trends that are gradually improving the energy efficiency of the industrial sector in Yorkshire and the Humber, and forecasted growth in the sector, we project that this sector's carbon emissions will decrease by 18% by 2038 compared with 2024 levels. Compared with other sectors these figures contain significantly higher uncertainty. For example, recent plans to reduce or close steel production at Scunthorpe could reduce emissions significantly much earlier[29].

Interventions in the industry sector are complex and interdependent. Investments in carbon capture, utilisation and storage (CCUS), for example, could improve the case for some investments in hydrogen while negatively impacting the case for some investments in electrification. In the following section we present four key areas of measures that collectively allow Yorkshire and the Humber to meet its GHG targets.

» Efficiency Measures

With investment of £226 million annually for 15 years investments in efficiency measures could reduce emissions from the industry sector by 24% in 2038. These investments could save £493 million annually in 2038. Efficiency measures are important to decarbonisation across processes in the industrial sector with particular opportunities in the chemical and refining subsectors.

[29] https://www.bbc.co.uk/news/business-67332093

» Electrification

With investment of £340 million annually for 15 years in efficiency measures could reduce emissions from the industry sector by 27% in 2038. These investments would save £260 million annually in 2038. Electrification can help to decarbonise a wide range of processes in the industrial sector, including an increasing share of high-heat processes as large-scale high temperature heat pumps are developed.

» Green Hydrogen

With investment of £180 million annually for 15 years in efficiency measures could reduce emissions from the industry sector by 26% in 2038. These investments would save £488 million annually in 2038. Green hydrogen can help to decarbonise processes in refining, chemicals and fertiliser production.

» Carbon Capture, Utilisation and Storage (CCUS).

Investment of £217 million annually for 15 years in carbon capture, utilisation and storage could reduce emissions from the industry sector by 18% in 2038. These investments would save £113 million annually in 2038. Investments in CCUS in Yorkshire and the Humber could help to decarbonise hard to abate industrial processes, including cement production and refining and chemical production.

Case studies from Trafford and Devon demonstrate that local governments can play a leading role supporting decarbonisation of the industry sector.

Table 10: Most Carbon-Effective Options in Industry

Process	Mt CO_2e
Primary Iron Production - A - HiSarna + CCS - Calcium Looping	11
Primary Iron Production - B - HiSarna + CCS - Calcium Looping	10.1
CHP (Non BECCS allowed) - Green hydrogen	5.7
CHP (Non BECCS allowed) - Electrification	5.4
CHP (Non BECCS allowed) - Blue hydrogen	5.3
Furnace - Refinery - Biomass	3.2
Furnace - Refinery - Blue hydrogen	2.4
Furnace - Refinery - Electrification	2.5
Furnace - Refinery - Heat pumps, microwaves and infra-red	3.3
Furnace - Refinery - Green hydrogen	3.4

Table 11: Most Cost-Effective Options in Industry

Process	Cost per tonne
Compressed Air Systems efficiency	-603
Pump Upgrades, Repairs and Maintenance	-575
Flaring - Gas recovery for sales (bio or fossil)	-457
Fan Correction, Repairs, & Upgrades	-314
Compressors and Variable Speed Systems	-212
Improving Efficiency of Boilers and Steam Piping	-69
Methane Leakage - FFP - LDAR (Leak Detection and repair)	-38
Methane Leakage - Distribution - LDAR (Leak Detection and repair)	-38
Refrigeration Efficiency and Technical Upgrades	3
Venting - Reduce vent and flare where needed	5

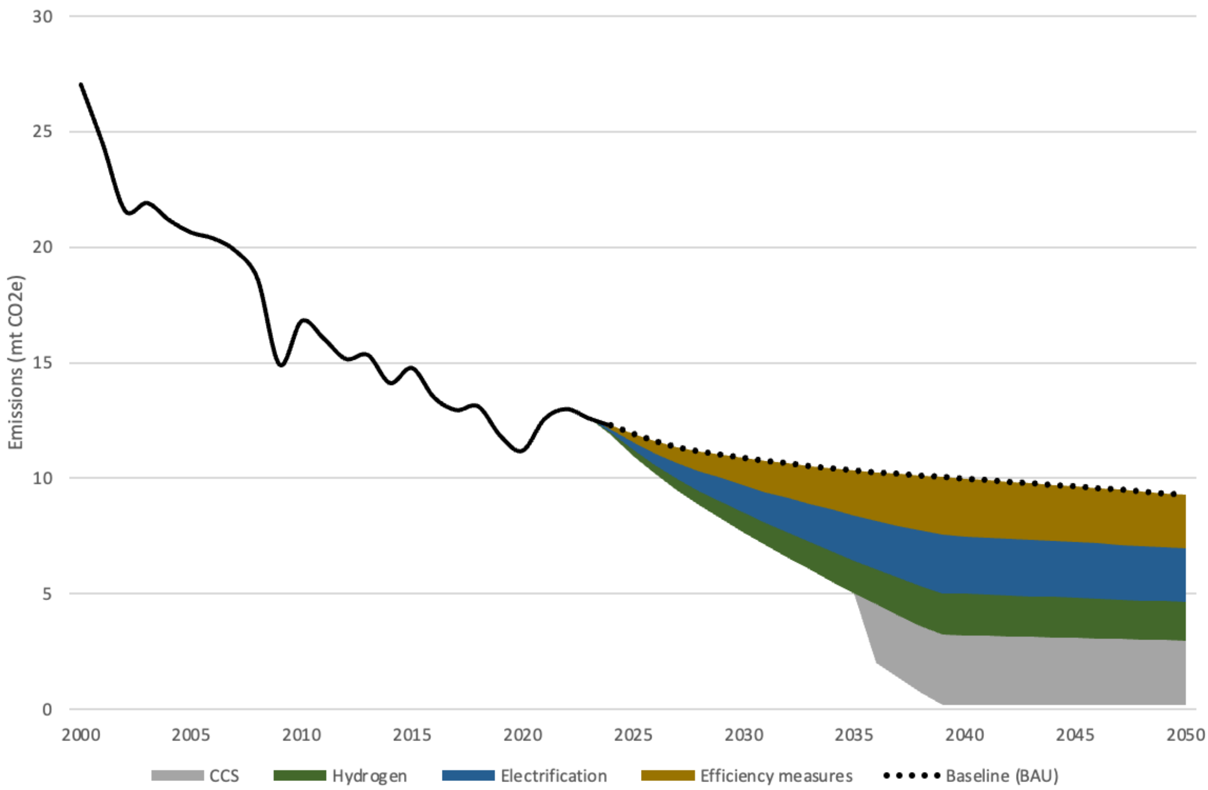

Figure 18: Yorkshire and the Humber's Carbon Reduction Potential: Industry

Results by Sector: Agriculture and Land-use

Land-uses in Yorkshire and the Humber are diverse, ranging from major urban centres and large-scale farming to peat bogs, forestry and coastal areas. Crucial considerations within this sector include food security, biodiversity protection, flood defence and long-standing farming traditions which contribute significantly to the regional and national economy.

This sector also contributes heavily to the region's carbon footprint, primarily through animal agriculture emissions. Significant carbon sinks also exist, with forestry sequestering 746 kt CO_2e in 2021. Figure 22's geographic boundary breakdowns highlight that it's important to consider not only emission sources, but also carbon sinks in order to fully understand the overall carbon profile of land-use in the region.

While considerable afforestation efforts are ongoing across the region, such as White Rose Forest, Humber Forest and the Yorkshire Forest Plans[30], it's clear from the scale of emissions in Figure 26 that progress will be limited without sizeable reductions in agricultural emissions. Fig 26 shows that overall land-use emissions are likely to increase slightly in the future, caused by increasing agricultural output and soil degradation. Changing climatic conditions could further exacerbate this trend, with increased temperatures and unpredictable precipitation patterns leading to an increase in carbon emissions from soil organic matter.

Addressing land-use emissions is an issue which, despite the keystone role it holds on our net zero targets, does not receive a great deal of public scrutiny or policy attention. Introducing net zero policies in the agricultural sector has caused friction with the farming community (visible in recent protests across Europe[31]) and is a topic which many authorities are only beginning to grapple with[32]. Recent publications by the YHCC highlight the importance of implementing a sustainable, profitable and nature-positive farming economy[33], for example through initiating a study on Maximum Sustainable

[30] https://www.humberforest.org/
[31] https://www.theguardian.com/world/2024/jan/30/belgian-port-blockaded-as-farmer-protests-spread-across-europe
[32] https://www.nature.com/articles/d41586-023-03960-0
[33] https://eprints.whiterose.ac.uk/204854/1/YHCC%20Sustainable%20Food%20Systems.pdf

Outputs for farms in the region. While the success of previous schemes such as ELMS (Environmental Land Management Schemes) have so far been mixed, recent studies have highlighted the economic benefits of more sustainable food production systems[34].

In addition to the economic positives, the wider social and environmental benefits are abundant. Shifts to a more plant-based diet have clear health and carbon benefits compared to animal agriculture, require less water and result in lower levels of runoff pollution. Increased afforestation improves soil health and increases lag-time during heavy rainfall episodes, which could prove immensely beneficial given Yorkshire and the Humber's flood risks.

[34] https://www.ft.com/content/e8ddbfe3-6036-4151-88da-431442c181a9?accessToken=zwAGECcSASXQkdPo3b_jYDZBUdOI2kMUQsGBqQ.MEYCIQD-uV2QoeQoUpFp3tgEPoJUr9S8WahcyIWRBDVqo1D8KwIhAIXlv0q2obyBiyamSVymeT2ze5ejuORk7aYBWGN53IbP&sharetype=gift&token=6cdf8479-4dda-4c94-b2c9-ad19db670e01

Low carbon policies within this sector often include the restoration of wetlands, reductions in urban encroachment on natural land and a range of improvements to improve farm-level carbon intensity.

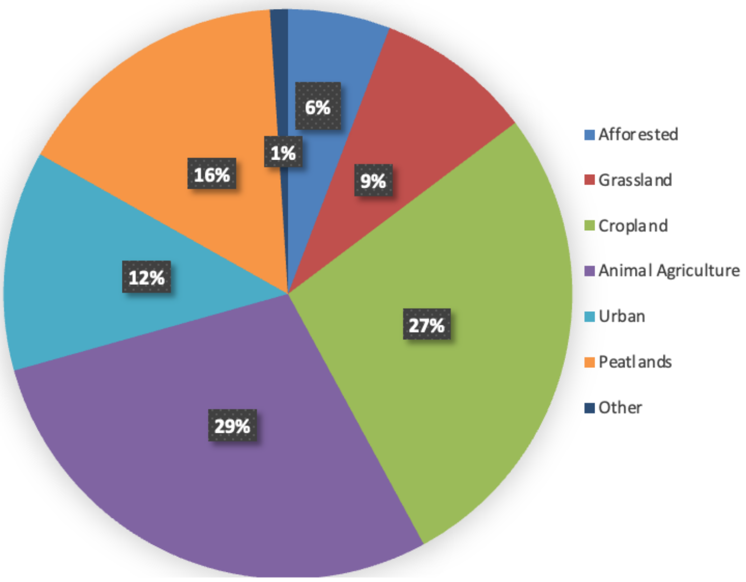

Figure 21: Yorkshire and the Humber's Simplified Estimated Land-Use Area Breakdowns, 2024

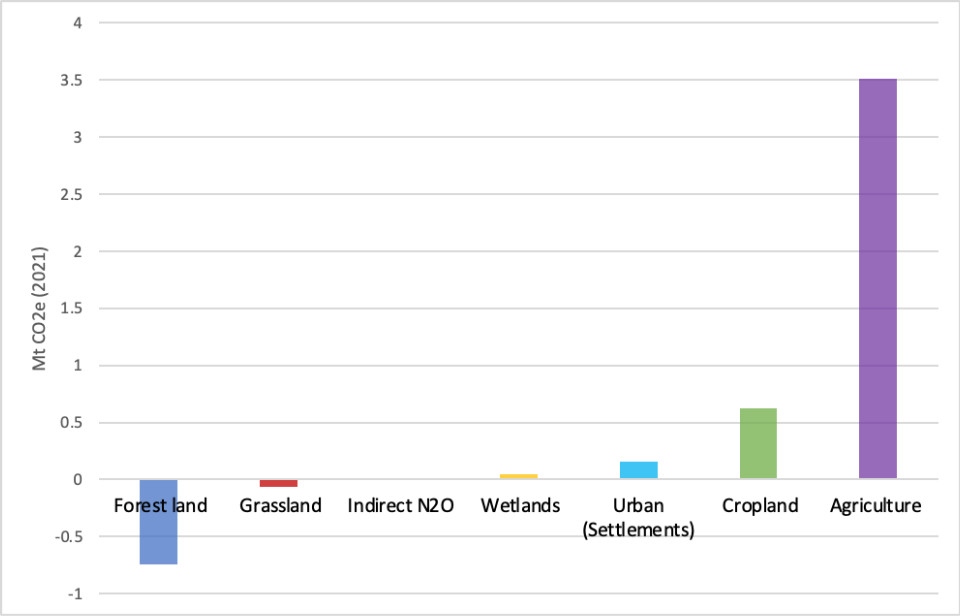

Figure 22: Yorkshire and the Humber's Land-Use Emissions Breakdown by Sub-Sector, 2021[35] *(note: some wetlands emissions fall under different categories under reporting guidelines; eg cropland on peat soils is*

[35] https://www.gov.uk/government/collections/uk-local-authority-and-regional-greenhouse-gas-emissions-national-statistics

attributed to cropland emissions).

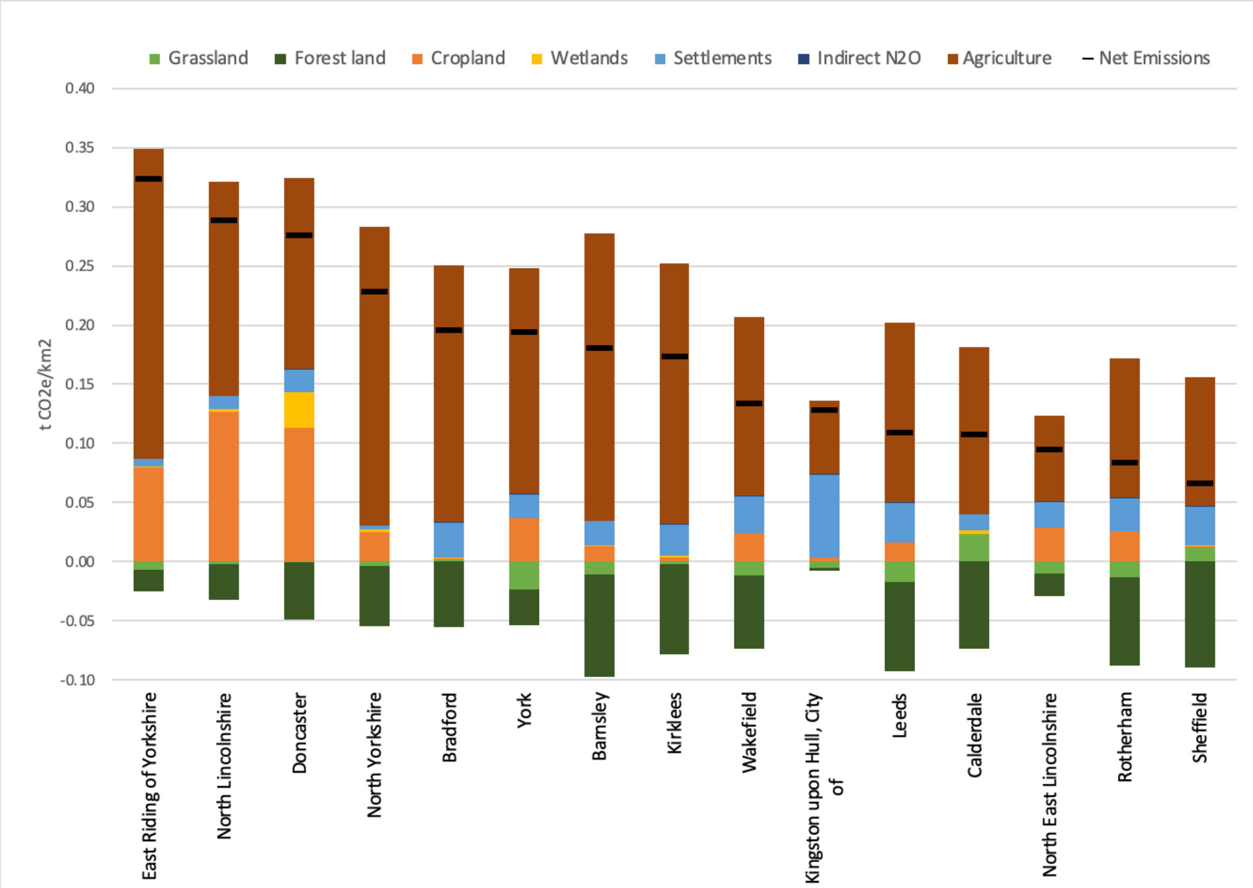

Figure 23: Yorkshire and the Humber's Land-Use Emissions by Geographic Boundary and Sub-Sector[36]

However, it's clear that the climate actions presented in this analysis could have wider social, economic and environmental implications that need to be explored before any policies or investments are made. In agriculture and land-use these considerations may be particularly acute. Changes to farming practices could affect not only households and communities but longstanding ways of life in rural Yorkshire. The analysis that follows should therefore be seen as a contribution to a wider conversation that needs to take place by adding insight into the challenge of this sector achieving Net Zero emissions. Owing to these considerations, two scenarios unique to this sector are presented and no costs have been considered.

Under a business-as-usual scenario, which includes no significant policy intervention and forecasted increased agricultural production, we project that the sector's carbon emissions will increase by 7% by 2038 compared with 2024 levels.

[36] https://www.gov.uk/government/collections/uk-local-authority-and-regional-greenhouse-gas-emissions-national-statistics

» ***Maintaining farming practices***

This scenario consists of improvements to cropland and animal farming practices including reducing tilling, use of cover crops and hedgerow expansion (among a wider set interventions). With a comprehensive set of investments over the next 15 years, emissions from the land-use sector across the area could be reduced by 13% by 2038 through these actions.

To put these figures in context, a report by Centre for Innovation Excellence in Livestock[37] found that, with 100% uptake across the UK, agricultural emissions could be reduced by 23% with no loss the productivity through a similar set of inventions. The UK Committee on Climate Change, applying a less ambitious set of assumptions for the deployment of similar measures, found that emissions could be reduced by 15% without changing land uses.

These figures suggest that changes in farming practices could substantially reduce agricultural GHG emissions. However, these findings also emphasise the need for other kinds of interventions. These could include new measures that reduce the emissions of existing farming practices, interventions such as forest generation that offset the emissions of agriculture, and measures that change farming practices, for example shifting animal agriculture to crop-based agriculture.

» ***Achieving 30x30 in Yorkshire and the Humber***

This scenario is designed to meet the UK's commitment to protect 30% of all land and water by 2030. To meet this challenge we assume forest cover in Yorkshire and the Humber increases from 4% to 16.5% (in line with the UK's forest cover targets). In addition, we assume

[37] https://cielivestock.co.uk/expertise/net-zero-carbon-uk-livestock/report-april-2022/

that all peatlands/wetlands[38] are protected. The marine area considered extends to 12 miles off the Yorkshire and Humber coast. This scenario for achieving 30x30 is, of course, just one representation of how this target could be achieved among many possible options.

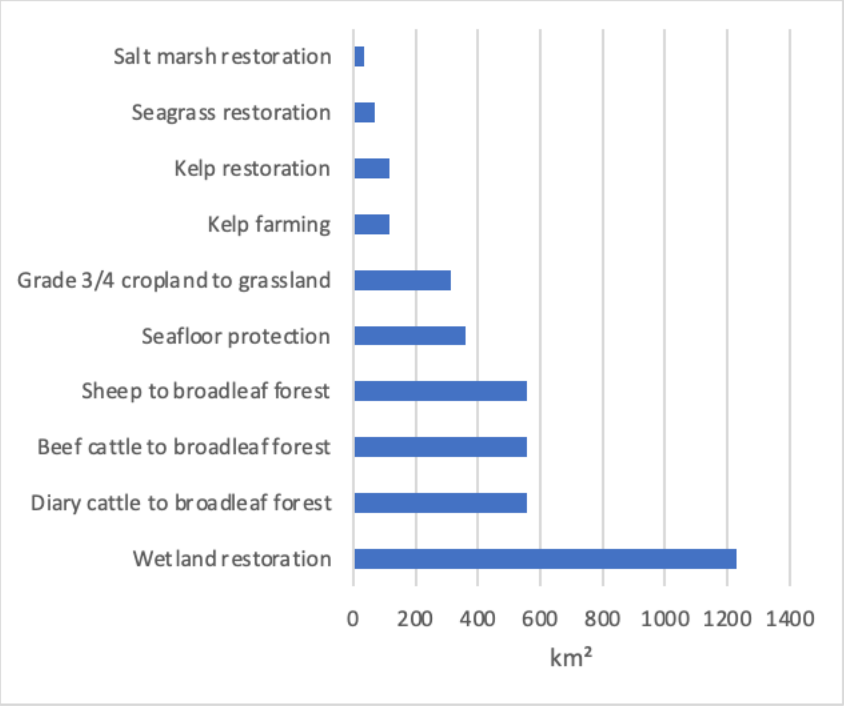

Figure 19: Total Area Improved by New Protections under the 'Achieving 30x30' Scenario in Yorkshire and the Humber

With a comprehensive set of policies and interventions, analysis finds that meeting 30x30 could help Yorkshire and the Humber exceed its GHG targets by turning the land-use and agriculture sector net negative in emissions by the early 2030s. As shown in figure 26, the majority of GHG savings result from shifting animal agriculture to broadleaf forest. These shifts would affect approximately 37% of the land currently covered by animal agriculture in Yorkshire and the Humber.

[38] Clarification regarding terminology - while often used interchangeably all peatlands are wetlands, and the term wetlands is used to include other submerged soils like bogs and marshes, as well as peatlands.

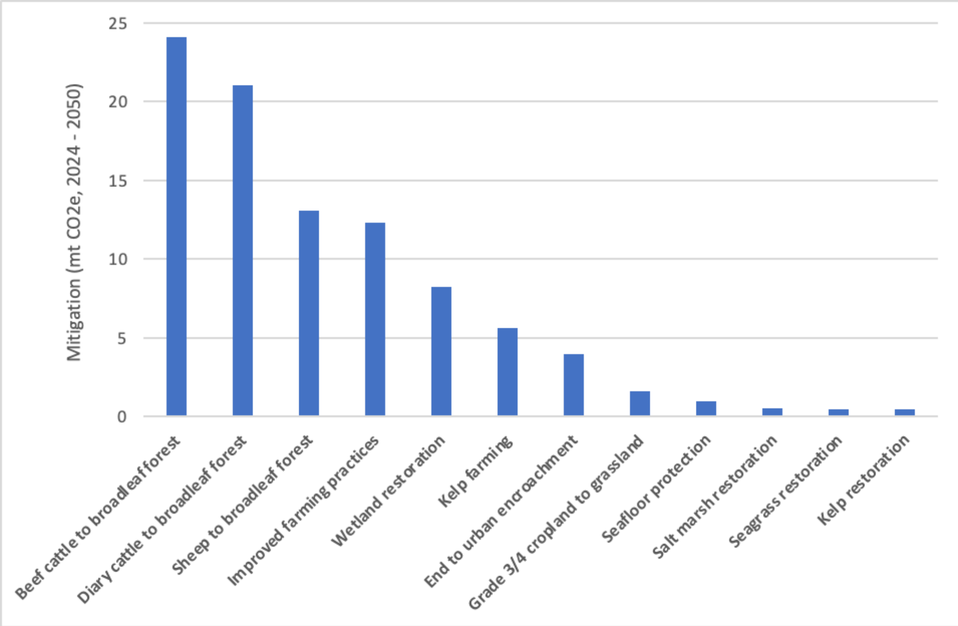

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Figure 25: Greenhouse Gas Savings by Measure in the 'Achieving 30x30' Scenario in Yorkshire and the Humber

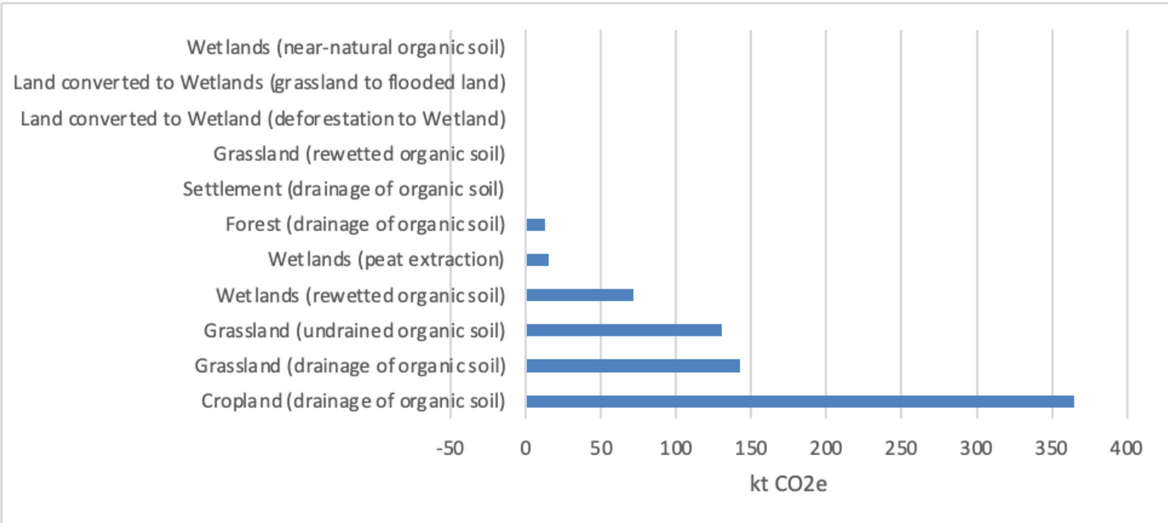

Figure 26: Reported emissions for different wetlands categories for Yorkshire and the Humber (2020), highlighting the overlap of wetlands on other land-use sectors and resulting soil emissions

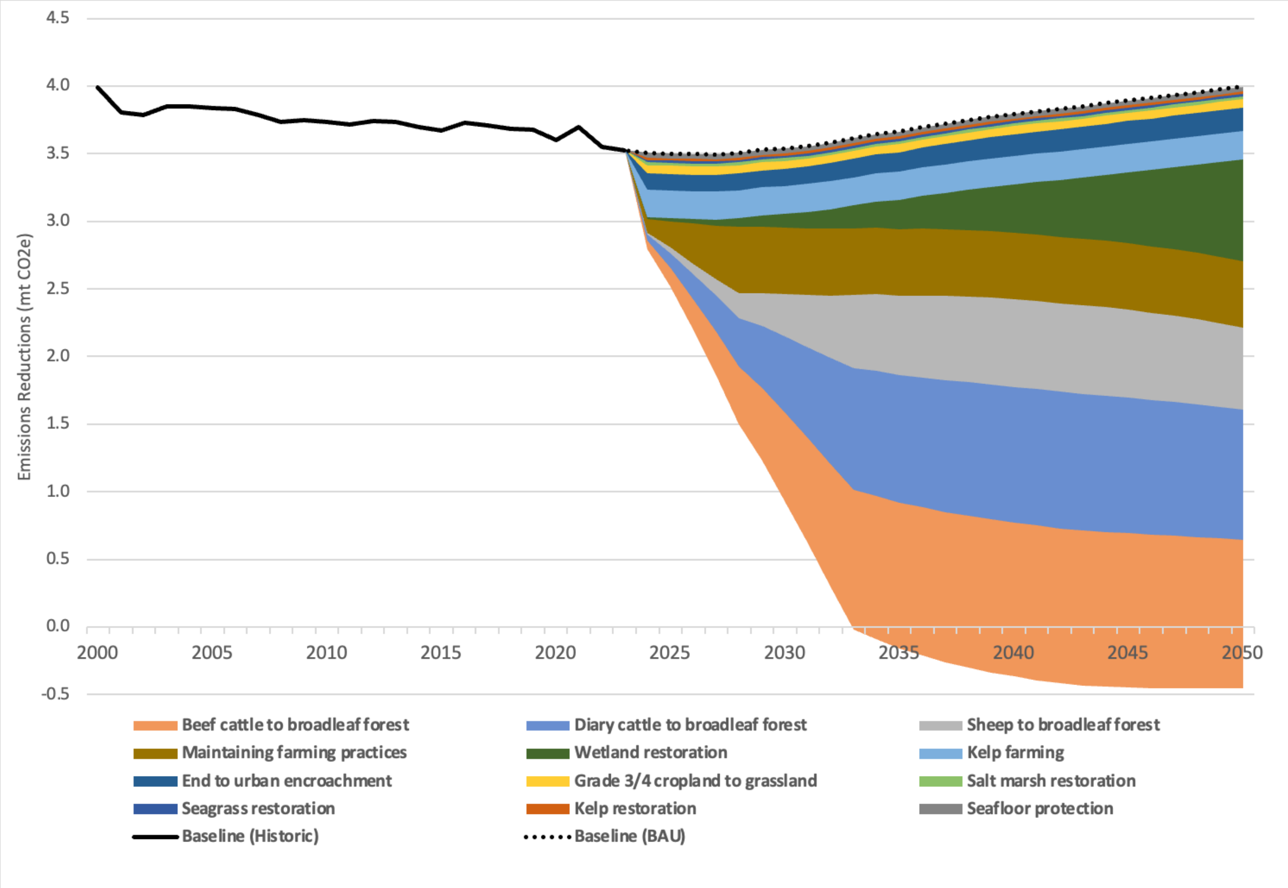

Figure 207: Components of a '30x30' Scenario for Yorkshire and the Humber

Case studies from County Antrim and Arc-Zero Farming demonstrate the wide range of interventions available to mitigate carbon from this sector.

Under a business-as-usual scenario, which doesn't involve significant policy interventions across the land-use sector, we project that this sector's carbon emissions will increase by 7% by 2038 compared with 2024 levels.

» Maintaining Farming Practices

Without any major changes to land-use practices, emissions from the sector in the area could be reduced by 13% by 2038. This interventions include improved animal feed, agroforestry, soil additives and tilling reductions among other improvements.

» 30 x 30 –

This scenario encompasses ambitious biodiversity and carbon-friendly land-use initiatives, resulting in an overall reduction of 108% in carbon emissions; ie turning this sector from a carbon source into a carbon sink. The bulk of reductions come from the afforestation of agricultural land, improved farming practices and wetlands restoration, alongside marine habitat improvements.

Table 12: Most Carbon-Effective Options in Land-Use

Measure	Mt CO_2e	Metric
Beef cattle to broadleaf forest	24.1	56,000 ha shifted to forestry; 111,000 fewer beef cows (35% reduction)
Dairy cattle to broadleaf forest	21.1	56,000 ha shifted to forestry; 83,000 fewer dairy cows (43% reduction)
Sheep to broadleaf forest	13.1	56,000 ha shifted to forestry; 222,000 fewer sheep (11% reduction)
Improved farming practices	12.3	340,000 ha (80% of total cropland improved)
Wetland restoration	8.3	123,000 ha (50% of total wetlands)
Kelp restoration	5.6	12,000 ha (20% of total kelp area)
End to urban encroachment	4	Reduction of projected encroachment on natural areas - 70%
Ruminant feed additive 3NOP - beef cows	3.3	100% application to remaining beef cows
Ruminant feed additive 3NOP - dairy cows	3	100% application to remaining dairy cows

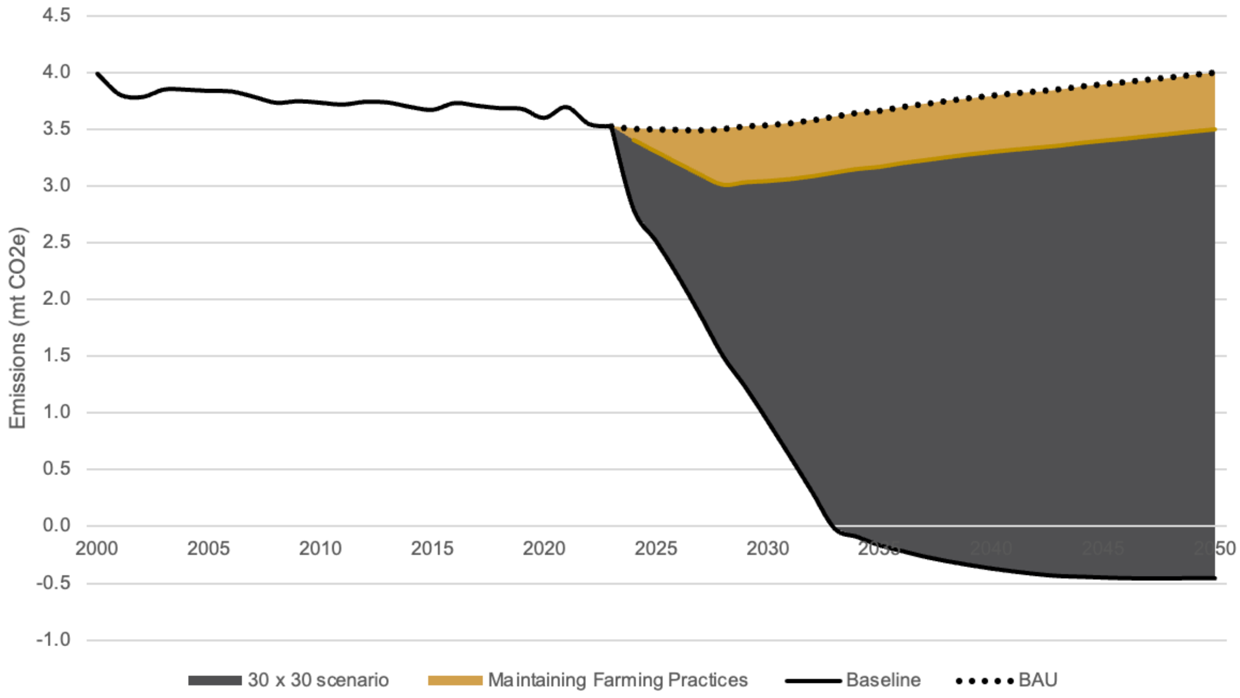

Figure 28: Yorkshire and the Humber's Carbon Reduction Potential: Land-Use and Management

Seizing the Opportunity:

What these results mean for Climate Action in Yorkshire and the Humber

Yorkshire and the Humber has reduced its direct carbon emissions by 44% since 2000, with a projection to cut emissions by 56% by 2038 based on current trends. This progress is laudable; however, it is clear that without accelerated and more ambitious actions, the region is at risk of not meeting its net zero target. The need for a concerted effort to bridge this gap is more critical than ever.

Our investigation into approximately 700 decarbonisation options across various sectors—ranging from energy savings in residential and commercial buildings, to enhancements in transportation, industry, and land use—reveals a rich landscape of technical and economic opportunities. These options not only offer pathways to substantial emissions reductions but also present economically attractive investments that can yield broader social, economic, and environmental benefits for the region. The analysis underscores the technical feasibility and economic viability of these decarbonisation strategies, highlighting their potential to contribute meaningfully to the region's climate goals.

Yet, it is crucial to acknowledge the inherent challenges and obstacles to implementing these options. Despite the technical and economic viability of numerous decarbonisation strategies, the transition requires overcoming significant barriers, including the need for enhanced capacities, supportive policies, and societal buy-in. The analysis identifies where building new capacities for change could have the most significant impact, emphasizing the importance of a multi-faceted approach that includes not only technological innovation but also behavioral change, policy reform, and investment in infrastructure.

As we look to the future, the report makes it evident that achieving net zero by 2038 is within reach, provided there is a collective and intensified effort to adopt the identified decarbonisation options. This will necessitate not only significant investments but also a holistic consideration of broader social, environmental, and political factors that influence the desirability and adoption of different decarbonisation pathways. The Yorkshire and Humber Climate Commission, along with its partners and stakeholders, is thus called upon to evaluate progress, prioritize actions, and accelerate the transition towards a sustainable, low-carbon future.

While the path to net zero is fraught with challenges, the opportunities for transformational change are immense. The region has a unique opportunity to lead by example, demonstrating how ambitious climate targets can be met through a combination of technological innovation, policy leadership, and community engagement. By prioritizing those options with the largest potential for decarbonisation and addressing the barriers to change, Yorkshire and Humber can not only meet its climate targets but also pave the way for a resilient, sustainable, and economically vibrant future.

Appendices:

Appendix 1: Breakdown of most carbon-effective land-use mitigation options

Low-Carbon Measure	Mitigation (Mt CO_2e)	% of Total Reduction
Beef cattle to broadleaf forest	24.1	26%
Dairy cattle to broadleaf forest	21.1	23%
Sheep to broadleaf forest	13.1	14%
Maintaining farming practices	12.3	13%
Wetland restoration	8.3	9%
Kelp farming	5.6	6%
End to urban encroachment	4.0	4%
Grade 3/4 cropland to grassland	1.6	2%
Seafloor protection	1.0	1%
Salt marsh restoration	0.6	1%
Seagrass restoration	0.5	1%
Kelp restoration	0.5	0%

Appendix 2: Age Bands Definitions for Archetypes in the Domestic Sector by Year of Construction and Region

Age band (Year of Construction)	England & Wales	Scotland	Northern Ireland
A	before 1900	before 1919	before 1919
B	1900-1929	1919-1929	1919-1929
C	1930-1949	1930-1949	1930-1949
D	1950-1966	1950-1964	1950-1973
E	1967-1975	1965-1975	1974-1977
F	1976-1982	1976-1983	1978-1985
G	1983-1990	1984-1991	1986-1991
H	1991-1995	1992-1998	1992-1999
I	1996-2002	1999-2002	2000-2006
J	2003-2006	2003-2007	(not applicable)
K	2007 onwards	2008 onwards	2007 onwards

Appendix 3: Most cost-effective mitigation options across Yorkshire and the Humber

Sector	Low-Carbon Measure	Cost per tonne (£)
Transport	Large car (Petrol) to EV	-2168
Transport	Medium car (Petrol) to EV	-2049
Transport	Medium car (Diesel) to Bicycle	-1951
Transport	Small car (Diesel) to Bicycle	-1929
Transport	Large car (Diesel) to Bicycle	-1913
Transport	Small car (Petrol) to EV	-1899
Transport	Medium car (Petrol) to Walk	-1862
Transport	Small car (Petrol) to Walk	-1851
Transport	Medium car (Petrol) to Bicycle	-1838
Transport	Large car (Petrol) to Walk	-1828
Transport	Small car (Petrol) to Bicycle	-1823
Transport	Large car (Petrol) to Bicycle	-1811
Transport	Medium car (Diesel) to Walk	-1781
Transport	Small car (Diesel) to Walk	-1769
Transport	Large car (Diesel) to Walk	-1743
Transport	Large car (Diesel) to train (electric)	-1695
Transport	Large car (Diesel) to EV	-1556
Transport	Medium car (Diesel) to train (electric)	-1500
Transport	Large car (Petrol) to Bus (electric)	-1485
Transport	Medium car (Diesel) to EV	-1460
Transport	Small car (Diesel) to EV	-1339
Transport	Bus (Diesel) to Bus (electric)	-1316
Transport	Medium car (Petrol) to Bus (electric)	-1267
Transport	Small car (Diesel) to train (electric)	-1254
Transport	Light goods vehicle (Diesel) to Light goods vehicle (electric)	-1154
Transport	Small car (Petrol) to train (electric)	-1151
Transport	Small car (Petrol) to Bus (electric)	-1081
Transport	OGV1 (Diesel) to OGV (electric)	-1012
Transport	OGV2 (Diesel) to OGC (electric)	-1005
Public & Commercial	Insulation improvements in industrial/warehouse buildings	-938
Public & Commercial	Draught reduction (air tightness) in retail buildings	-928
Public & Commercial	Heat pumps (air source) in retail buildings	-922
Public & Commercial	Solar PV installations in industrial/warehouse buildings	-920
Public & Commercial	More efficient heating (warm air blowers) in industrial/warehouse buildings	-918

Public & Commercial	High-efficiency boilers in industrial/warehouse buildings	-913
Public & Commercial	Heat recovery (MVHR) in retail buildings	-913
Public & Commercial	Improved heating controls in industrial/warehouse buildings	-913
Public & Commercial	Highly efficient new build standards in industrial/warehouse buildings	-909
Public & Commercial	Draught reduction (air tightness) in industrial/warehouse buildings	-906
Public & Commercial	Heat pumps (air source) in office (age band 3) buildings	-900
Public & Commercial	Highly efficient new build standards in retail buildings	-874
Public & Commercial	Heat pumps (air source) in non-retail buildings	-864
Public & Commercial	Heat pumps (air source) in office (age band 2) buildings	-851
Public & Commercial	High-efficiency boilers in retail buildings	-850
Transport	Large car (Diesel) to Bus (electric)	-831
Public & Commercial	Solar PV installations in retail buildings	-822
Public & Commercial	Energy-saving fluorescent lighting (T5 bulbs) in industrial/warehouse buildings	-803
Public & Commercial	T5 conversions in industrial/warehouse buildings	-736
Public & Commercial	Double-glazed windows in office (age band 1) buildings	-725
Public & Commercial	Improved heating controls in retail buildings	-721
Public & Commercial	LED lighting upgrades in non-retail buildings	-719
Public & Commercial	Heat pumps (air source) in office (age band 1) buildings	-693
Public & Commercial	Solar PV installations in non-retail buildings	-692
Public & Commercial	Draught reduction (air tightness) in office (age band 2) buildings	-692
Public & Commercial	LED lighting upgrades in office (age band 3) buildings	-668
Public & Commercial	T5 conversions in non-retail buildings	-667
Public & Commercial	Highly efficient new build standards in office (age band 3) buildings	-657

Public & Commercial	Heat pumps (air source) in community centres	-656
Public & Commercial	Heat pumps (air source) in healthcare buildings	-653
Public & Commercial	T5 conversions in office (age band 3) buildings	-649
Public & Commercial	Heat pumps (air source) in office (age band 4) buildings	-614
Public & Commercial	Solar PV installations in office (age band 3) buildings	-605
Public & Commercial	Insulation improvements in retail buildings	-604
Industry	Compressed Air Systems efficiency	-603
Public & Commercial	Highly efficient new build standards in non-retail buildings	-577
Public & Commercial	Optimised fan power for ventilation systems (SFP 2.0/l/s) in retail buildings	-577
Public & Commercial	Heat pumps (air source) in education buildings	-577
Public & Commercial	Movement sensing lighting systems in industrial/warehouse buildings	-576
Industry	Pump Upgrades, Repairs and Maintenance	-575
Public & Commercial	Energy-saving fluorescent lighting (T5 bulbs) in office (age band 3) buildings	-568
Public & Commercial	High efficiency electrical systems (0.95 Power Factor) in industrial/warehouse buildings	-568
Transport	Medium car (Diesel) to Bus (electric)	-550
Public & Commercial	Heat recovery (MVHR) in non-retail buildings	-537
Public & Commercial	T5 conversions in retail buildings	-534
Public & Commercial	LED lighting upgrades in education buildings	-523
Public & Commercial	High efficiency electrical systems (0.95 Power Factor) in retail buildings	-516
Public & Commercial	LED lighting upgrades in community centres	-478
Public & Commercial	Heat pumps (air source) in hotels	-474
Public & Commercial	High-efficiency boilers in non-retail buildings	-459
Industry	Flaring - Gas recovery for sales (bio or fossil)	-457
Public & Commercial	High-efficiency boilers in office (age band 3) buildings	-435

Public & Commercial	High efficiency cooling systems in retail buildings	-401
Public & Commercial	External shading in office (age band 2) buildings	-348
Public & Commercial	Highly efficient new build standards in healthcare buildings	-315
Industry	Fan Correction, Repairs, & Upgrades	-314
Transport	Small car (Diesel) to Bus (electric)	-312
Public & Commercial	Heat recovery (MVHR) in office (age band 2) buildings	-312
Public & Commercial	Energy-saving fluorescent lighting (T5 bulbs) in non-retail buildings	-279
Public & Commercial	LED lighting upgrades in office (age band 2) buildings	-237
Public & Commercial	Solar PV installations in healthcare buildings	-226
Industry	Compressors and Variable Speed Systems	-212
Public & Commercial	Solar thermal installation in retail buildings	-174
Public & Commercial	Highly efficient new build standards in hotels	-155
Public & Commercial	Highly efficient new build standards in office (age band 4) buildings	-147
Public & Commercial	Solar PV installations in office (age band 2) buildings	-146
Public & Commercial	T5 conversions in office (age band 4) buildings	-133
Public & Commercial	LED lighting upgrades in healthcare buildings	-125
Transport	Large car (Petrol) to train (diesel)	-115
Public & Commercial	Solar PV installations in community centres	-112
Public & Commercial	T5 conversions in healthcare buildings	-106
Public & Commercial	Highly efficient new build standards in education buildings	-105
Public & Commercial	Smart lighting (daylight sensing) installations in office (age band 2) buildings	-102
Public & Commercial	LED lighting upgrades in hotels	-97
Domestic	End Terrace (B) - Shallow retrofit	-87
Domestic	Mid Terrace (D) - Shallow retrofit	-85
Public & Commercial	Highly efficient new build standards in office (age band 2) buildings	-85

Domestic	End Terrace (A) - Shallow retrofit	-84
Public & Commercial	Improved heating controls in office (age band 2) buildings	-72
Public & Commercial	Solar PV installations in office (age band 4) buildings	-72
Public & Commercial	Energy-saving fluorescent lighting (T5 bulbs) in retail buildings	-72
Industry	Improving Efficiency of Boilers and Steam Piping	-69
Domestic	Bungalow (B) - Shallow retrofit	-69
Domestic	Semi Detached (B) - Shallow retrofit	-67
Domestic	Bungalow (A) - Shallow retrofit	-66
Domestic	Mid Terrace (E) - Shallow retrofit	-66
Domestic	Purpose Built Flat (C) - Shallow retrofit	-65
Domestic	End Terrace (D) - Shallow retrofit	-63
Domestic	Semi Detached (A) - Shallow retrofit	-63
Public & Commercial	High efficiency cooling system (passive chilled beams) in non-retail buildings	-62
Domestic	End Terrace (H) - Shallow retrofit	-61
Domestic	End Terrace (E) - Shallow retrofit	-60
Public & Commercial	Draught reduction (air tightness) in office (age band 1) buildings	-60
Domestic	End Terrace (C) - Shallow retrofit	-60
Domestic	End Terrace (G) - Shallow retrofit	-56
Domestic	Mid Terrace (G) - Shallow retrofit	-55
Domestic	Detached (B) - Shallow retrofit	-54
Public & Commercial	High efficiency cooling system (passive chilled beams) in office (age band 3) buildings	-53
Public & Commercial	Highly efficient new build standards in community centres	-53
Domestic	Purpose Built Flat (A) - Shallow retrofit	-53
Domestic	Detached (A) - Shallow retrofit	-52
Domestic	Semi Detached (D) - Shallow retrofit	-50
Public & Commercial	Improved heating controls in office (age band 3) buildings	-48
Domestic	Detached (E) - Shallow retrofit	-47
Domestic	Mid Terrace (A) - Shallow retrofit	-46
Domestic	Semi Detached (C) - Shallow retrofit	-46
Domestic	Purpose Built Flat (D) - Shallow retrofit	-45
Domestic	Semi Detached (E) - Shallow retrofit	-45
Domestic	Mid Terrace (H) - Shallow retrofit	-44
Domestic	Detached (D) - Shallow retrofit	-43
Domestic	Mid Terrace (B) - Shallow retrofit	-42

Domestic	Semi Detached (G) - Shallow retrofit	-42
Domestic	Purpose Built Flat (G) - Shallow retrofit	-42
Domestic	Purpose Built Flat (E) - Shallow retrofit	-42
Domestic	Detached (C) - Shallow retrofit	-41
Domestic	Mid Terrace (F) - Shallow retrofit	-41
Domestic	Semi Detached (H) - Shallow retrofit	-39
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Industry	Boiler - Steam (Non BECCS allowed) - Green hydrogen	50
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Industry	Boiler - Steam (Non BECCS allowed) - Green hydrogen	50
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Domestic	Purpose Built Flat (J) - Deep retrofit	1253
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Domestic	Purpose Built Flat (K) - Deep retrofit	1288
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Domestic	End Terrace (I) - Deep retrofit	1323
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Domestic	End Terrace (J) - Deep + appliances retrofit	1353
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Domestic	Semi Detached (J) - Deep + appliances retrofit	1394
Domestic	End Terrace (L) - Deep + appliances retrofit	1401
Domestic	End Terrace (K) - Deep retrofit	1411
Domestic	Semi Detached (K) - Deep + appliances retrofit	1417
Domestic	Semi Detached (I) - Deep + appliances retrofit	1429
Domestic	Semi Detached (J) - Deep retrofit	1430
Domestic	Detached (J) - Medium retrofit	1434
Domestic	End Terrace (L) - Deep retrofit	1439
Domestic	Semi Detached (L) - Deep + appliances retrofit	1443
Domestic	Detached (K) - Medium retrofit	1452
Domestic	Semi Detached (K) - Deep retrofit	1454
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Domestic	Detached (L) - Medium retrofit	1474
Domestic	Semi Detached (J) - Medium retrofit	1478
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Public & Commercial	Improved heating controls in hotels	1609
Public & Commercial	Improved efficiency in ventilation systems (variable speed pumps) in office (age band 2) buildings	1644
Public & Commercial	Movement sensing lighting systems in non-retail buildings	1689
Public & Commercial	Optimised fan power for ventilation systems (SFP 2.0/l/s) in non-retail buildings	1719
Public & Commercial	External shading in hotels	1728
Public & Commercial	High efficiency cooling system (active chilled beams) in hotels	1737
Public & Commercial	Movement sensing lighting systems in office (age band 1) buildings	1758
Public & Commercial	Efficient AC system (DC fan coils) in office (age band 3) buildings	1773
Public & Commercial	Solar thermal installation in hotels	1776
Public & Commercial	Smart lighting (daylight sensing) installations in hotels	1832

Public & Commercial	Solar thermal installation in office (age band 1) buildings	1886
Public & Commercial	High efficiency cooling systems in office (age band 2) buildings	1913
Public & Commercial	Efficient AC system (DC fan coils) in healthcare buildings	1967
Public & Commercial	Optimised fan power for ventilation systems (SFP 2.0/l/s) in healthcare buildings	1990
Public & Commercial	Efficient AC system (DC fan coils) in community centres	2075
Public & Commercial	High efficiency cooling systems in community centres	2138
Public & Commercial	Optimised fan power for ventilation systems (SFP 2.0/l/s) in office (age band 4) buildings	2178
Public & Commercial	Optimised fan power for ventilation systems (SFP 2.0/l/s) in education buildings	2219
Public & Commercial	Efficient AC system (DC fan coils) in education buildings	2406
Transport	Medium car (Diesel) to train (diesel)	2679
Public & Commercial	Movement sensing lighting systems in office (age band 4) buildings	2917
Public & Commercial	Optimised fan power for ventilation systems (SFP 2.0/l/s) in community centres	3051
Public & Commercial	Optimised fan power for ventilation systems (SFP 2.0/l/s) in office (age band 2) buildings	3139
Public & Commercial	Efficient AC system (DC fan coils) in office (age band 4) buildings	3206
Public & Commercial	Movement sensing lighting systems in healthcare buildings	3367
Transport	Small car (Diesel) to train (diesel)	3454
Public & Commercial	High efficiency cooling systems in healthcare buildings	3649
Public & Commercial	Movement sensing lighting systems in education buildings	3734
Public & Commercial	Movement sensing lighting systems in community centres	3806
Public & Commercial	High efficiency electrical systems (0.95 Power Factor) in office (age band 1) buildings	4274
Public & Commercial	Efficient AC system (DC fan coils) in office (age band 2) buildings	5330
Public & Commercial	Efficient AC system (DC fan coils) in hotels	6794
Public & Commercial	Optimised fan power for ventilation systems (SFP 2.0/l/s) in hotels	9053

Public & Commercial	High efficiency electrical systems (0.95 Power Factor) in office (age band 2) buildings	16604
Public & Commercial	High efficiency cooling systems in education buildings	17822
Public & Commercial	High efficiency cooling systems in office (age band 4) buildings	18542
Public & Commercial	Movement sensing lighting systems in hotels	18891
Public & Commercial	High efficiency cooling systems in hotels	20273
Public & Commercial	Improved efficiency in ventilation systems (variable speed pumps) in office (age band 1) buildings	21902

Appendix 4: Most carbon-effective mitigation options across Yorkshire and the Humber

Sector	Low-Carbon Measure	Mitigation (kt)
Transport	Light goods vehicle (Diesel) to Light goods vehicle (electric)	29681
Land-Use	Beef cattle to broadleaf forest	24137
Land-Use	Diary cattle to broadleaf forest	21068
Domestic	Semi Detached (C) - Deep + appliances retrofit	13842
Domestic	Semi Detached (C) - Deep retrofit	13656
Land-Use	Sheep to broadleaf forest	13090
Domestic	Semi Detached (C) - Medium retrofit	12906
Land-Use	Improved farming practices	12291
Domestic	Mid Terrace (B) - Deep + appliances retrofit	11140
Domestic	Mid Terrace (B) - Deep retrofit	10967
Industry	Primary Iron Production - A - HiSarna + CCS - Calcium Looping	10934
Domestic	Mid Terrace (B) - Medium retrofit	10413
Industry	Primary Iron Production - B - HiSarna + CCS - Calcium Looping	10109
Domestic	Semi Detached (D) - Deep + appliances retrofit	9985
Domestic	Semi Detached (D) - Deep retrofit	9837
Domestic	Semi Detached (D) - Medium retrofit	9268
Transport	Bus (Diesel) to Bus (electric)	9246
Land-Use	Wetland restoration	8270
Domestic	Mid Terrace (A) - Deep + appliances retrofit	7537
Domestic	Mid Terrace (A) - Deep retrofit	7433
Domestic	Mid Terrace (A) - Medium retrofit	7089
Transport	Small car (Petrol) to Bicycle	7036
Transport	Small car (Petrol) to Walk	6936

Transport	Large car (Petrol) to Walk	6713
Transport	Large car (Petrol) to Bicycle	6409
Transport	Medium car (Petrol) to Walk	6360
Transport	Medium car (Petrol) to Bicycle	6315
Transport	Small car (Diesel) to Walk	6260
Domestic	Detached (A) - Deep + appliances retrofit	5985
Domestic	Detached (A) - Deep retrofit	5947
Industry	Generators - CCS (low CO2)	5730
Industry	Generators - CCS (low CO2)	5730
Domestic	Detached (A) - Medium retrofit	5658
Land-Use	Kelp farming	5634
Industry	Generators - Blue hydrogen	5580
Transport	Large car (Diesel) to Walk	5535
Transport	Small car (Diesel) to EV	5494
Transport	Medium car (Diesel) to Walk	5463
Industry	CHP (Non BECCS allowed) - Electrification	5433
Industry	CHP (Non BECCS allowed) - Electrification	5433
Industry	CHP (Non BECCS allowed) - Electrification	5433
Industry	CHP (Non BECCS allowed) - Electrification	5433
Industry	CHP (Non BECCS allowed) - Electrification	5433
Industry	CHP (Non BECCS allowed) - Electrification	5433
Industry	CHP (Non BECCS allowed) - Electrification	5433
Industry	Generators - Electricity grid connection	5175
Industry	Generators - Electricity grid connection	5175
Transport	OGV1 (Diesel) to OGV (electric)	5172
Transport	Medium car (Diesel) to EV	5038
Transport	Large car (Diesel) to EV	5011
Industry	Generators - Wind power and battery storage	4965
Domestic	Semi Detached (C) - Shallow retrofit	4941
Transport	Small car (Diesel) to Bicycle	4900
Transport	Medium car (Petrol) to EV	4813
Transport	Small car (Petrol) to EV	4812
Transport	OGV2 (Diesel) to OGC (electric)	4794
Transport	Large car (Petrol) to EV	4782
Domestic	End Terrace (B) - Deep + appliances retrofit	4708
Domestic	End Terrace (B) - Deep retrofit	4648
Domestic	Bungalow (D) - Deep + appliances retrofit	4478
Domestic	End Terrace (B) - Medium retrofit	4439
Transport	Large car (Diesel) to Bicycle	4431
Domestic	Bungalow (D) - Deep retrofit	4414

Public & Commercial	Insulation improvements in industrial/warehouse buildings	4380
Transport	Medium car (Diesel) to Bicycle	4361
Domestic	Semi Detached (B) - Deep + appliances retrofit	4118
Domestic	Semi Detached (B) - Deep retrofit	4072
Domestic	End Terrace (A) - Deep + appliances retrofit	4051
Domestic	End Terrace (A) - Deep retrofit	4007
Land-Use	End to urban encroachment	3997
Domestic	Bungalow (D) - Medium retrofit	3987
Domestic	Semi Detached (B) - Medium retrofit	3876
Domestic	End Terrace (A) - Medium retrofit	3840
Domestic	Semi Detached (D) - Shallow retrofit	3833
Industry	Kiln - Other - Electrification	3773
Domestic	Bungalow (E) - Deep + appliances retrofit	3639
Domestic	Bungalow (E) - Deep retrofit	3581
Industry	Oven - F&D - Blue hydrogen	3531
Industry	Kiln - Other - Green hydrogen	3473
Industry	Furnace - Refinery - Green hydrogen	3445
Industry	Kiln - Other - Blue hydrogen	3368
Domestic	Detached (I) - Deep + appliances retrofit	3358
Industry	Oven - F&D - Green hydrogen	3351
Domestic	Detached (I) - Deep retrofit	3302
Land-Use	Ruminant feed additative 3NOP - beef cows	3298
Industry	Furnace - Refinery - Heat pumps, microwaves and infra-red	3250
Domestic	Mid Terrace (B) - Shallow retrofit	3247
Domestic	Semi Detached (E) - Deep + appliances retrofit	3211
Domestic	Bungalow (E) - Medium retrofit	3190
Domestic	Semi Detached (A) - Deep + appliances retrofit	3187
Domestic	Semi Detached (E) - Deep retrofit	3161
Domestic	Semi Detached (A) - Deep retrofit	3158
Industry	Furnace - Refinery - Biomass	3145
Industry	Oven - F&D - Heat pumps, microwaves and infra-red	3111
Land-Use	Ruminant feed additative 3NOP - dairy cows	3031
Domestic	Mid Terrace (C) - Deep + appliances retrofit	3027
Domestic	Semi Detached (A) - Medium retrofit	3020
Domestic	Detached (E) - Deep + appliances retrofit	3017
Domestic	Detached (E) - Deep retrofit	2986
Domestic	Mid Terrace (C) - Deep retrofit	2975
Domestic	Semi Detached (E) - Medium retrofit	2973
Industry	Compressor - H2 Compressor (green)	2967
Domestic	Detached (I) - Medium retrofit	2966

Domestic	Detached (G) - Deep + appliances retrofit	2879
Domestic	Detached (F) - Deep + appliances retrofit	2845
Domestic	Detached (G) - Deep retrofit	2836
Domestic	Detached (F) - Deep retrofit	2810
Domestic	Mid Terrace (C) - Medium retrofit	2804
Domestic	Detached (E) - Medium retrofit	2799
Industry	Oven - F&D - Electrification	2796
Domestic	Mid Terrace (D) - Deep + appliances retrofit	2749
Industry	Furnace - Glass - Green hydrogen	2744
Domestic	Mid Terrace (D) - Deep retrofit	2700
Domestic	Purpose Built Flat (D) - Deep + appliances retrofit	2686
Domestic	Purpose Built Flat (B) - Deep + appliances retrofit	2670
Industry	Methane Leakage - Distribution - Strong LDAR	2661
Domestic	Purpose Built Flat (D) - Deep retrofit	2606
Domestic	Purpose Built Flat (B) - Deep retrofit	2602
Domestic	Detached (F) - Medium retrofit	2600
Domestic	Purpose Built Flat (E) - Deep + appliances retrofit	2588
Domestic	Detached (G) - Medium retrofit	2588
Industry	Furnace - Glass - Electrification	2549
Industry	Dryer - Chemicals - Biomass	2547
Industry	Dryer - Chemicals - Biomass	2547
Public & Commercial	Draught reduction (air tightness) in retail buildings	2529
Domestic	Mid Terrace (D) - Medium retrofit	2527
Industry	Furnace - Refinery - Electrification	2515
Domestic	Purpose Built Flat (E) - Deep retrofit	2504
Domestic	Purpose Built Flat (B) - Medium retrofit	2485
Domestic	Purpose Built Flat (D) - Medium retrofit	2480
Public & Commercial	Heat pumps (air source) in retail buildings	2448
Industry	Furnace - Refinery - Blue hydrogen	2425
Public & Commercial	Solar PV installations in industrial/warehouse buildings	2419
Domestic	Purpose Built Flat (E) - Medium retrofit	2388
Industry	Kiln - Lime - Blue hydrogen	2377
Domestic	Detached (H) - Deep + appliances retrofit	2364
Domestic	End Terrace (C) - Deep + appliances retrofit	2334
Domestic	Detached (H) - Deep retrofit	2330
Industry	Compressor - CCS (low CO2)	2322
Industry	Compressor - CCS (low CO2)	2322
Domestic	Purpose Built Flat (A) - Deep + appliances retrofit	2311

Domestic	End Terrace (C) - Deep retrofit	2301
Domestic	Detached (B) - Deep + appliances retrofit	2289
Domestic	Detached (B) - Deep retrofit	2273
Industry	Compressor - Electric compressor - grid electricity	2262
Industry	Compressor - Electric compressor - grid electricity	2262
Domestic	Purpose Built Flat (A) - Deep retrofit	2258
Industry	Methane Leakage - Distribution - LDAR (Leak Detection And Repair)	2196
Domestic	End Terrace (C) - Medium retrofit	2181
Domestic	Purpose Built Flat (A) - Medium retrofit	2179
Domestic	Detached (B) - Medium retrofit	2164
Industry	Methane Leakage - Distribution - Continuous monitoring	2136
Domestic	Detached (H) - Medium retrofit	2125
Industry	Kiln - Cement - Blue hydrogen	2107
Domestic	Detached (D) - Deep + appliances retrofit	2090
Domestic	Bungalow (D) - Shallow retrofit	2082
Domestic	Detached (D) - Deep retrofit	2071
Industry	Compressor - H2 Compressor (blue)	2052
Domestic	Mid Terrace (A) - Shallow retrofit	1992
Domestic	Bungalow (F) - Deep + appliances retrofit	1978
Domestic	Detached (C) - Deep + appliances retrofit	1961
Domestic	Detached (D) - Medium retrofit	1952
Domestic	Detached (C) - Deep retrofit	1944
Domestic	Bungalow (F) - Deep retrofit	1943
Industry	Metal Rolling - Blue hydrogen	1924
Industry	Metal Rolling - Blue hydrogen	1924
Industry	Metal Rolling - Blue hydrogen	1924
Land-Use	Cover crops	1894
Domestic	Bungalow (E) - Shallow retrofit	1888
Domestic	Detached (C) - Medium retrofit	1839
Industry	Kiln - Cement - Green hydrogen	1807
Industry	Compressor - Electric compressor - wind power & battery storage	1782
Domestic	Detached (A) - Shallow retrofit	1765
Industry	Kiln - Cement - Electrification	1762
Industry	Furnace - Glass - Blue hydrogen	1754
Domestic	End Terrace (D) - Deep + appliances retrofit	1739
Domestic	Purpose Built Flat (F) - Deep + appliances retrofit	1713
Domestic	End Terrace (D) - Deep retrofit	1711
Industry	Furnace - Glass - Biomass	1709
Domestic	Bungalow (F) - Medium retrofit	1701
Industry	Kiln - Lime - Green hydrogen	1672
Domestic	Purpose Built Flat (F) - Deep retrofit	1644

Land-Use	Grade 3/4 cropland to grassland	1641
Land-Use	Manure Spreading	1637
Industry	Boiler - Steam - Electrification	1637
Industry	Dryer - Paper - Electrification	1637
Transport	Small car (Petrol) to train (electric)	1629
Industry	CHP - Biomass	1622
Domestic	End Terrace (D) - Medium retrofit	1612
Domestic	Detached (J) - Deep + appliances retrofit	1607
Industry	Boiler - Steam - Blue hydrogen	1607
Domestic	Detached (J) - Deep retrofit	1583
Domestic	End Terrace (B) - Shallow retrofit	1577
Industry	CHP - Blue hydrogen	1577
Domestic	Mid Terrace (E) - Deep + appliances retrofit	1562
Domestic	Mid Terrace (E) - Deep retrofit	1530
Domestic	Semi Detached (F) - Deep + appliances retrofit	1517
Domestic	Purpose Built Flat (F) - Medium retrofit	1517
Domestic	Bungalow (C) - Deep + appliances retrofit	1511
Domestic	Bungalow (C) - Deep retrofit	1490
Domestic	Semi Detached (F) - Deep retrofit	1489
Industry	Pumps - Electrification	1478
Domestic	Detached (J) - Medium retrofit	1438
Industry	Dryer - Chemicals - Blue hydrogen	1422
Industry	Dryer - Chemicals - Blue hydrogen	1422
Domestic	Mid Terrace (E) - Medium retrofit	1420
Industry	Metal Melting - Green hydrogen	1399
Industry	Metal Melting - Green hydrogen	1399
Domestic	Bungalow (G) - Deep + appliances retrofit	1398
Domestic	Semi Detached (F) - Medium retrofit	1386
Domestic	Bungalow (G) - Deep retrofit	1368
Industry	Boiler - Steam - Heat pumps, microwaves and infra-red	1367
Domestic	Bungalow (C) - Medium retrofit	1344
Domestic	Semi Detached (B) - Shallow retrofit	1331
Domestic	Purpose Built Flat (G) - Deep + appliances retrofit	1321
Industry	Dryer - Paper - Green hydrogen	1292
Domestic	Purpose Built Flat (G) - Deep retrofit	1261
Domestic	Semi Detached (E) - Shallow retrofit	1252
Domestic	Detached (E) - Shallow retrofit	1234
Domestic	Detached (L) - Deep + appliances retrofit	1228
Domestic	Semi Detached (G) - Deep + appliances retrofit	1220
Industry	Venting - Reduce vent and flare where needed	1217
Domestic	Detached (L) - Deep retrofit	1209

Domestic	End Terrace (A) - Shallow retrofit	1209
Domestic	Semi Detached (G) - Deep retrofit	1191
Domestic	Detached (G) - Shallow retrofit	1188
Domestic	Purpose Built Flat (J) - Deep + appliances retrofit	1183
Domestic	Detached (I) - Shallow retrofit	1161
Domestic	Purpose Built Flat (G) - Medium retrofit	1161
Industry	Metal Rolling - Electrification	1159
Industry	Metal Rolling - Electrification	1159
Industry	Metal Rolling - Electrification	1159
Domestic	Bungalow (G) - Medium retrofit	1159
Industry	Pump Upgrades, Repairs and Maintenance	1154
Industry	Dryer - Chemicals - Electrification	1137
Industry	Dryer - Chemicals - Electrification	1137
Domestic	Purpose Built Flat (J) - Deep retrofit	1109
Domestic	Semi Detached (G) - Medium retrofit	1095
Domestic	Detached (L) - Medium retrofit	1095
Industry	Dryer - Paper - Blue hydrogen	1082
Industry	Dryer - Chemicals - Green hydrogen	1062
Industry	Dryer - Chemicals - Green hydrogen	1062
Domestic	Semi Detached (H) - Deep + appliances retrofit	1060
Land-Use	Optimal pH Lining	1044
Domestic	Semi Detached (H) - Deep retrofit	1035
Domestic	Mid Terrace (D) - Shallow retrofit	1017
Domestic	Purpose Built Flat (J) - Medium retrofit	1011
Domestic	End Terrace (E) - Deep + appliances retrofit	997
Industry	Metal Melting - Electrification	994
Industry	Metal Melting - Electrification	994
Domestic	Mid Terrace (C) - Shallow retrofit	992
Industry	Boiler - Steam - Biomass	992
Domestic	Purpose Built Flat (D) - Shallow retrofit	987
Domestic	Detached (F) - Shallow retrofit	986
Domestic	End Terrace (E) - Deep retrofit	980
Land-Use	Seafloor protection	970
Domestic	Detached (H) - Shallow retrofit	964
Domestic	Purpose Built Flat (C) - Deep + appliances retrofit	960
Domestic	Purpose Built Flat (E) - Shallow retrofit	958
Domestic	Semi Detached (H) - Medium retrofit	951
Industry	Boiler - Steam (Non BECCS allowed) - Green hydrogen	947
Industry	Boiler - Steam (Non BECCS allowed) - Green hydrogen	947
Industry	Boiler - Steam (Non BECCS allowed) - Green hydrogen	947
Industry	Boiler - Steam (Non BECCS allowed) - Green hydrogen	947

Industry	Boiler - Steam (Non BECCS allowed) - Green hydrogen	947
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Industry	Boiler - Steam (Non BECCS allowed) - Green hydrogen	947
Industry	Boiler - Steam (Non BECCS allowed) - Green hydrogen	947
Industry	Boiler - Steam (Non BECCS allowed) - Green hydrogen	947
Domestic	Purpose Built Flat (C) - Deep retrofit	933
Domestic	Purpose Built Flat (B) - Shallow retrofit	920
Domestic	End Terrace (E) - Medium retrofit	916
Domestic	Semi Detached (A) - Shallow retrofit	907
Public & Commercial	More efficient heating (warm air blowers) in industrial/warehouse buildings	906
Domestic	Semi Detached (I) - Deep + appliances retrofit	899
Public & Commercial	High-efficiency boilers in industrial/warehouse buildings	898
Domestic	Purpose Built Flat (C) - Medium retrofit	889
Industry	Refrigeration Efficiency and Technical Upgrades	888
Domestic	Bungalow (F) - Shallow retrofit	886
Domestic	Semi Detached (I) - Deep retrofit	873
Industry	Boiler - Steam (Non BECCS allowed) - Heat pumps, microwaves and infra-red	872
Industry	Boiler - Steam (Non BECCS allowed) - Heat pumps, microwaves and infra-red	872
Industry	Boiler - Steam (Non BECCS allowed) - Heat pumps, microwaves and infra-red	872
Industry	Boiler - Steam (Non BECCS allowed) - Heat pumps, microwaves and infra-red	872
Industry	Boiler - Steam (Non BECCS allowed) - Heat pumps, microwaves and infra-red	872
Industry	Boiler - Steam (Non BECCS allowed) - Heat pumps, microwaves and infra-red	872
Industry	Boiler - Steam (Non BECCS allowed) - Heat pumps, microwaves and infra-red	872
Industry	Boiler - Steam (Non BECCS allowed) - Heat pumps, microwaves and infra-red	872
Industry	Boiler - Steam (Non BECCS allowed) - Heat pumps, microwaves and infra-red	872
Industry	Furnace - Vehicles - Electrification	853
Industry	Metal Rolling - Green hydrogen	844
Industry	Metal Rolling - Green hydrogen	844
Industry	Metal Rolling - Green hydrogen	844
Domestic	End Terrace (C) - Shallow retrofit	838
Transport	Small car (Diesel) to train (electric)	831
Domestic	Semi Detached (I) - Medium retrofit	789

Industry	Metal Melting - Blue hydrogen	784
Industry	Metal Melting - Blue hydrogen	784
Domestic	Detached (D) - Shallow retrofit	780
Industry	Dryer - F&D - Electrification	777
Domestic	Purpose Built Flat (I) - Deep + appliances retrofit	771
Industry	Dryer - Rotary - Biomass	747
Industry	Dryer - Rotary - Electrification	732
Domestic	Purpose Built Flat (I) - Deep retrofit	728
Public & Commercial	Heat recovery (MVHR) in retail buildings	724
Industry	Furnace - Vehicles - Green hydrogen	718
Domestic	Semi Detached (L) - Deep + appliances retrofit	714
Domestic	Detached (B) - Shallow retrofit	706
Domestic	Bungalow (C) - Shallow retrofit	705
Domestic	Bungalow (G) - Shallow retrofit	703
Domestic	Semi Detached (L) - Deep retrofit	695
Domestic	Detached (C) - Shallow retrofit	694
Public & Commercial	Improved heating controls in industrial/warehouse buildings	689
Domestic	End Terrace (D) - Shallow retrofit	687
Domestic	Bungalow (H) - Deep + appliances retrofit	680
Domestic	Purpose Built Flat (I) - Medium retrofit	671
Domestic	Mid Terrace (F) - Deep + appliances retrofit	665
Domestic	Bungalow (H) - Deep retrofit	664
Industry	Boiler - Steam - Green hydrogen	662
Industry	Furnace - Vehicles - Blue hydrogen	658
Domestic	Mid Terrace (F) - Deep retrofit	649
Domestic	Purpose Built Flat (A) - Shallow retrofit	649
Industry	CHP - Electrification	632
Domestic	Semi Detached (L) - Medium retrofit	632
Industry	Dryer - Rotary - Blue hydrogen	612
Public & Commercial	Highly efficient new build standards in industrial/warehouse buildings	608
Transport	Large car (Diesel) to train (electric)	599
Domestic	Mid Terrace (F) - Medium retrofit	595
Land-Use	Hedgerow Expansion	593
Transport	Medium car (Diesel) to train (electric)	593
Domestic	Mid Terrace (E) - Shallow retrofit	581
Public & Commercial	Draught reduction (air tightness) in industrial/warehouse buildings	578
Industry	Oven - Vehicles - Green hydrogen	572

Domestic	End Terrace (F) - Deep + appliances retrofit	564
Land-Use	Salt marsh restoration	563
Domestic	Bungalow (H) - Medium retrofit	559
Domestic	End Terrace (F) - Deep retrofit	553
Transport	Small car (Petrol) to Bus (electric)	541
Domestic	Purpose Built Flat (F) - Shallow retrofit	536
Transport	Large car (Diesel) to Bus (electric)	528
Domestic	End Terrace (F) - Medium retrofit	512
Domestic	Semi Detached (F) - Shallow retrofit	506
Domestic	Semi Detached (G) - Shallow retrofit	506
Domestic	Semi Detached (J) - Deep + appliances retrofit	504
Transport	Large car (Petrol) to Bus (electric)	502
Domestic	Purpose Built Flat (G) - Shallow retrofit	499
Industry	CHP - Green hydrogen	497
Domestic	Semi Detached (J) - Deep retrofit	491
Public & Commercial	Heat pumps (air source) in office (age band 3) buildings	474
Land-Use	Seagrass restoration	469
Domestic	Mid Terrace (J) - Deep + appliances retrofit	464
Industry	Dryer - F&D - Green hydrogen	462
Land-Use	Kelp restoration	460
Domestic	Detached (J) - Shallow retrofit	453
Industry	Dryer - Paper - Biomass	452
Industry	Boiler - Steam (Non BECCS allowed) - Electrification	452
Industry	Boiler - Steam (Non BECCS allowed) - Electrification	452
Industry	Boiler - Steam (Non BECCS allowed) - Electrification	452
Industry	Boiler - Steam (Non BECCS allowed) - Electrification	452
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Industry	Boiler - Steam (Non BECCS allowed) - Electrification	452
Industry	Boiler - Steam (Non BECCS allowed) - Electrification	452
Industry	Boiler - Steam (Non BECCS allowed) - Electrification	452
Industry	Boiler - Steam (Non BECCS allowed) - Electrification	452
Domestic	Mid Terrace (J) - Deep retrofit	451
Domestic	Semi Detached (J) - Medium retrofit	448
Domestic	Purpose Built Flat (J) - Shallow retrofit	448
Domestic	Semi Detached (H) - Shallow retrofit	443
Transport	Medium car (Petrol) to Bus (electric)	440
Industry	Furnace - Vehicles - Biomass	437
Industry	Oven - Vehicles - Blue hydrogen	437
Industry	Oven - Vehicles - Heat pumps, microwaves and infra-red	433

Public & Commercial	Highly efficient new build standards in retail buildings	433
Domestic	End Terrace (E) - Shallow retrofit	429
Domestic	End Terrace (J) - Deep + appliances retrofit	424
Transport	Medium car (Diesel) to Bus (electric)	420
Domestic	Mid Terrace (J) - Medium retrofit	413
Domestic	End Terrace (J) - Deep retrofit	413
Industry	Dryer - Rotary - Green hydrogen	402
Public & Commercial	Heat pumps (air source) in non-retail buildings	398
Domestic	Detached (L) - Shallow retrofit	396
Domestic	Mid Terrace (G) - Deep + appliances retrofit	392
Land-Use	Low tilling	389
Industry	Dryer - F&D - Blue hydrogen	387
Domestic	Mid Terrace (G) - Deep retrofit	381
Domestic	Purpose Built Flat (K) - Deep + appliances retrofit	381
Domestic	Purpose Built Flat (L) - Deep + appliances retrofit	379
Industry	Boiler - Steam (Non BECCS allowed) - Blue hydrogen	377
Industry	Boiler - Steam (Non BECCS allowed) - Blue hydrogen	377
Industry	Boiler - Steam (Non BECCS allowed) - Blue hydrogen	377
Industry	Boiler - Steam (Non BECCS allowed) - Blue hydrogen	377
Industry	Boiler - Steam (Non BECCS allowed) - Blue hydrogen	377
Industry	Boiler - Steam (Non BECCS allowed) - Blue hydrogen	377
Industry	Boiler - Steam (Non BECCS allowed) - Blue hydrogen	377
Industry	Boiler - Steam (Non BECCS allowed) - Blue hydrogen	377
Industry	Boiler - Steam (Non BECCS allowed) - Blue hydrogen	377
Domestic	End Terrace (I) - Deep + appliances retrofit	376
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