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Zero carbon pathway for council assets: Work Package 3.2

Report for Sheffield City Council

Report for Sheffield City Council - [Zero Carbon Commission DN461793]

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Executive summary

Sheffield City Council declared a Climate Emergency and has set a target for the city to be zero carbon by 2030. The City Council commissioned Arup and Ricardo to support them in developing a plan to achieve the goal.

Sheffield's zero carbon goal is defined as: *Net zero carbon dioxide, defined as a 95% reduction in net emissions.*

This report sets out recommended measures for Sheffield City Council's assets. It establishes a strategic pathway and indicates what will need to be delivered in order to meet the goals the council has set itself.

The council has adopted a bold emissions goal and rightly intends to lead from the front by decarbonising its own estate. Not only does it present an opportunity to reduce Sheffield's carbon emissions, it can spur action across the city by creating a robust local supply chain, supporting new businesses and leading to retraining in net zero skills and technology.

It provides an evidence base which can be used to support investment in new technology, changes in operating practices and strengthened discussions with its strategic partners.

A zero carbon pathway for the council's assets creates a strong basis for decision making. The analysis and subsequent recommendations will require new governance arrangements and internal policy, which is covered in detail as part of *Work Package 4: Governance Structures.*

The report sets out the baseline emissions inventory and projections to 2030 for council assets. The assessment of options for reducing emissions is undertaken for the following sectors:

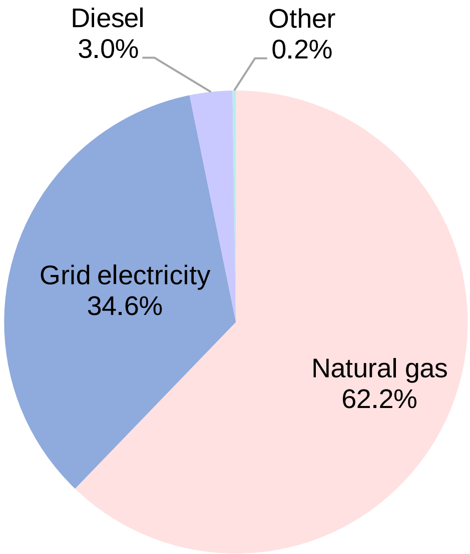
1. Domestic buildings owned by the council
2. Non-domestic buildings, such as schools and libraries
3. Council and key contractor fleet vehicles
4. Street lighting

The pathway to achieving net zero in each of these sectors translated into the following ways:

Emissions baseline

Baseline emissions were 162,700 tonnes CO_2/year in 2019. Natural gas accounts for 62.2% of the emissions inventory, with 34.6% from electricity. Vehicle fuels account for around 3% and all other sources account for smaller fractions, adding to around 0.2%.

Baseline carbon emissions by fuel 2019

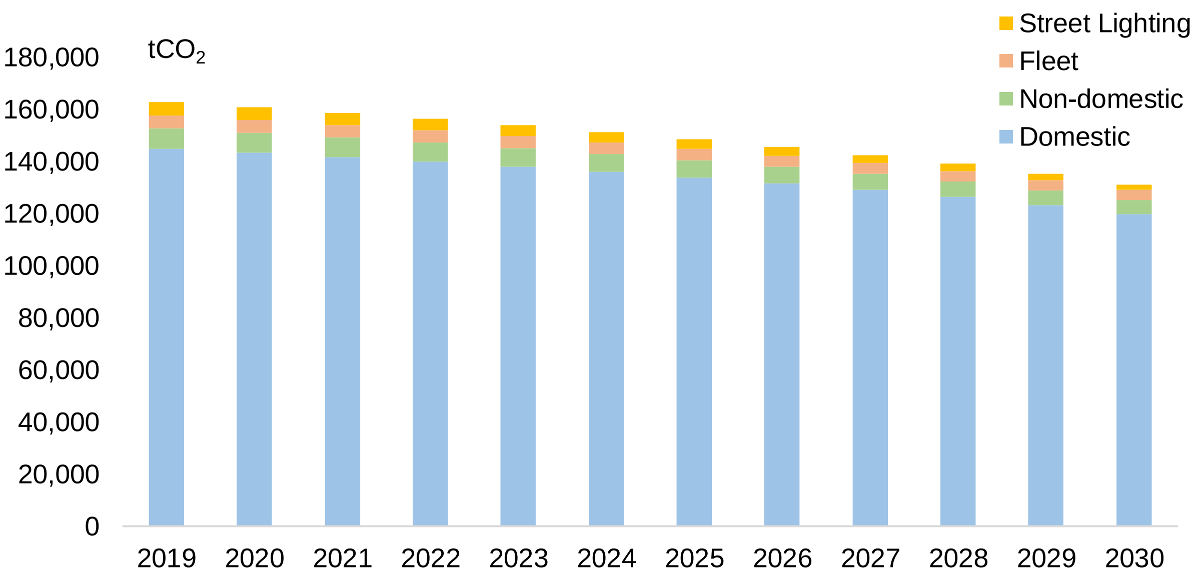


The baseline emissions inventory is dominated by domestic buildings, accounting for 89% of the total. This is a product of the larger number of homes owned by the council. Non-domestic buildings, schools, offices, cultural and civic buildings together account for 4.9% of emissions. Street lighting accounts for 3.1% of all emissions.

Emissions projections

The emissions projection forecasts emissions to 2030 under business as usual assumptions. This is used to understand the scale of the net zero challenge.

Baseline emissions projections to 2030 by sector



It illustrates that there remains a significant gap to net zero without further action by the council, with 80% of 2019 emissions still to be addressed in 2030.

Proposed actions

The net zero measures that are proposed are summarised below by sector.

Domestic

The key measures that the council should take to decarbonise social housing fall into the following categories:

- Improve the fabric of homes
- Reduce energy consumption in homes
- Remove fossil fuels
- Generate renewable electricity
- Directly deliver zero carbon new builds

Non-domestic

The key measures that the council should take to decarbonise its non-domestic building stock fall into the following categories:

- Reduce energy consumption through energy management, low energy lighting & controls.
- Adopt a heat-led approach by identifying the most cost effective and least disruptive low carbon heating source available. This means connecting to an existing district heating network where available. The primary alternative is an individual heat pump.
- Improve building fabric and air tightness. Fabric measures which are likely to be cost effective should be undertaken across the stock.
- A whole building fabric approach should be considered for the least efficient buildings. Addressing heat loss and air tightness are essential for the effective operation of heat pumps. These should be installed as part of a wider refurbishment as changes to internal pipework and emitters is likely.
- Generate renewable electricity from roof top solar arrays

Fleet vehicles

The key measures that the council should take to decarbonise its vehicle fleet and those of its key strategic contractors fall into the following categories:

- Reduced mileage through driver behaviour, optimising route planning, journey consolidation and telematics. Together these can increase efficiency while reducing fuel costs. Shrinking the size of the fleet can also reduce the capital cost of vehicle replacement.
- Switching cars and vans to electric through fleet replacement programmes, investing in both the vehicles and supporting charging infrastructure
- Switching larger vehicles (i.e. large vans, trucks, buses and specialist heavy duty vehicles) to electric is a longer-term challenge but an increasing number of models are expected to become available before 2030.

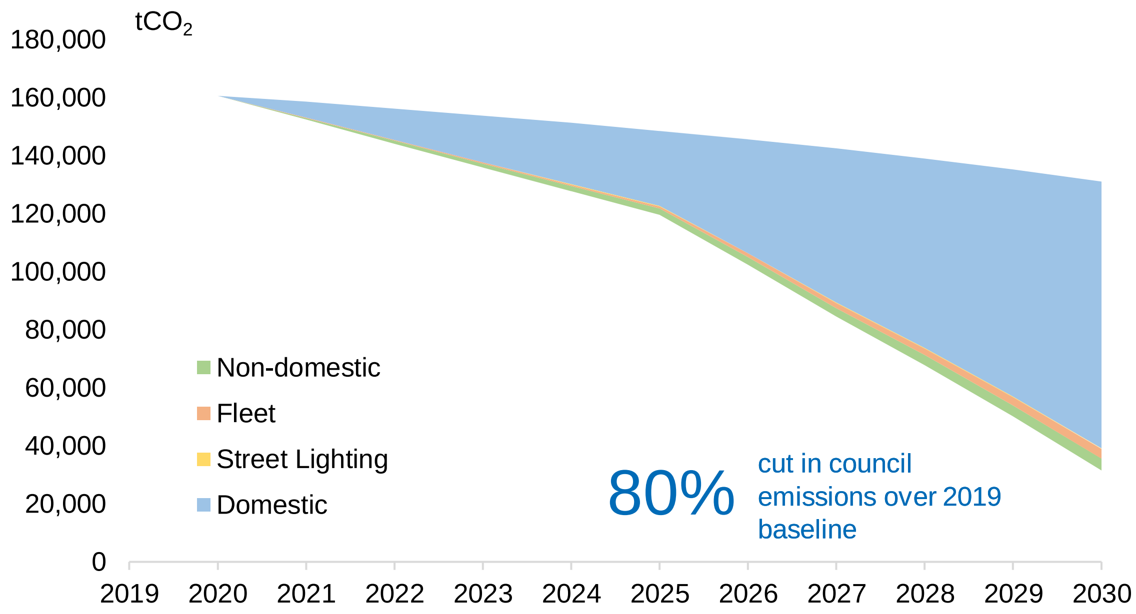
Street lighting

The council has already undertaken measures to significantly reduce emissions from street lighting. As a result of its trimming and dimming pilots, the council has decided it should be rolled out across the city. Street lighting should be kept under review with opportunities for further energy saving adopted in future.

2030 emissions pathway

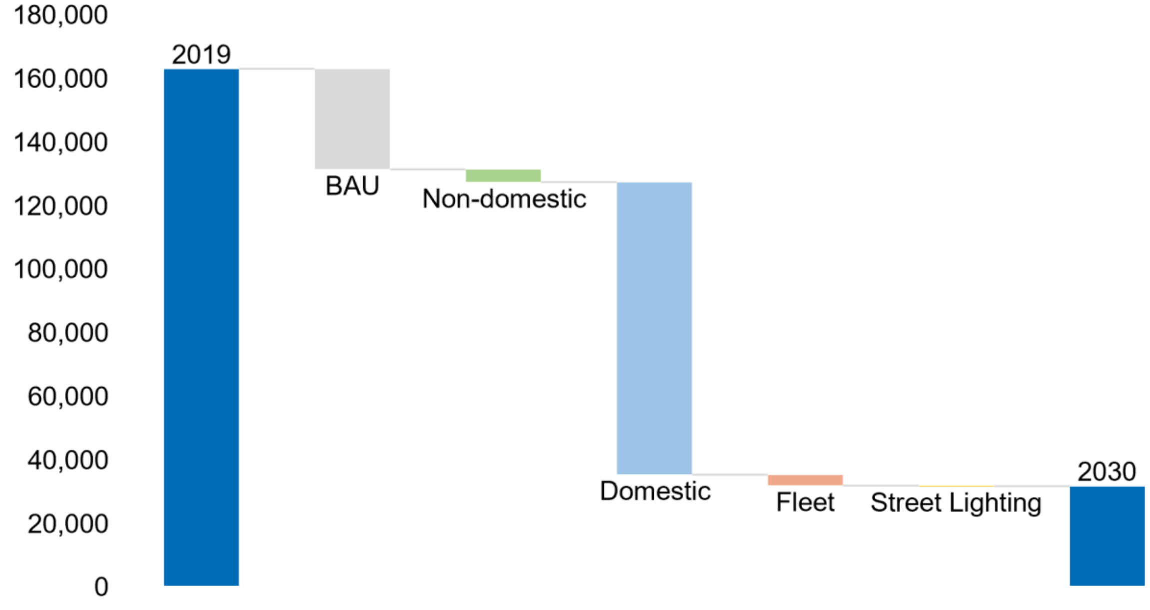
The measure proposed as part of the net zero strategy reduce emissions 76% below the baseline in 2030 to 31,498 tCO_2, an 80% overall cut from 2019.

Sheffield City Council net zero pathway



The waterfall chart below shows the contribution of each measure category to emissions reductions. Measures to council homes account for 92% of the emissions savings beyond the BAU baseline achieved, with around 4% from non-domestic and fleet vehicles. This reflects the size of domestic emissions, rather than the potential to achieve reductions. Street lighting measures at 0.1% reflects the substantial investments already made in LED lighting.

Overall emissions reduction by sector



Residual emissions in 2030 are 31,498 tCO_2 after all proposed measures have been applied. While this represents an 80.6% reduction in 2019 baseline emissions, it fails to meet the 95% net zero criteria. That this ambitious and wide-ranging package of measures is not sufficient highlights the importance of carbon positive measures and energy exports in meeting the goal.

Analysis of solar generation potential and land use measures within the city's boundary indicates that the council must seek offsets from further afield. For these to be viewed as both credible and additional, they should be sourced from as close to the city as possible, such as peatland restoration or afforestation within the city region.

Recommendations

All of the interventions described need to be carried out in order for Sheffield to reach its zero carbon goal. Below are overarching recommendations for the council along with priority actions that create a strong platform for the transition to net zero. Additional sectoral recommendations are included in the report.

A net zero plan for the council's assets

Adopt a net zero policy for the council. It should establish a series of targets which together meet the net zero 2030 goal. It must be endorsed by council leaders with clear lines of responsibility and ownership.

Targets should identify the destination, such as a fully zero or low emissions vehicle fleet in 2030, supported by interim and subsidiary targets that ensure progress is made rapidly. In the case of fleet, a 2024 target could be set for passenger EVs could be set for example.

It would provide the framework for the decision-making, coordination and investment required to meet the targets, with a set of actions that are funded with ambitious delivery timelines agreed. This should include a review of on-going and planned projects and programmes which could also enable the net zero measures identified to be deployed.

The team's responsible for implementing the net zero plan should prepare a pipeline of projects and investments. Resources should be deployed up front on priority projects and critical enabling investments in advance of full funding being secured. Having plans, supporting evidence and partnerships in place creates a strong platform for successful funding applications.

A transparent monitoring and evaluation process would help ensure that it stays on track.

1.1 Governance

Reaching net zero for council assets will need the sustained support and engagement of officers from across the council, including housing, property, facilities and service delivery.

Net zero should be integrated into decision-making at every level. This should include day-to-day and delegated decisions for tasks like refurbishment, building change of use or parking are taken as opportunities to incorporate energy measures and do not create new barriers to net zero.

The net zero plan for the council's assets should be institutionalised within the corporate plan, financial strategy and departmental delivery. For example, net zero should be incorporated into the council's property strategy. The opportunities and challenges of making buildings net zero should be used as a 'lens' to inform decisions about property investment priorities, planned refurbishments and any disposals of existing buildings. Specific governance proposals are presented in Work Package 4.

1.2 Skills and supply chain

Local supply chains will need to strengthen their ability to meet the new investment and service demand implied by the proposed measures. The council can work with local industries and suppliers to develop a recommended and trusted list of local installers and maintenance companies in areas such as general building and/or fabric energy efficiency specialists along with installers of technological solutions such as heat pumps, smart meters and EV charging

In-house operations and maintenance teams may benefit from undergoing additional training to familiarise themselves with new technologies. Having MCS certified installers is especially important for buildings heating systems, as we begin to move away from gas-based heating systems to heat pumps. This would also present an opportunity to develop and train in-house apprentices.

1.3 Communication with users and tenants

Some of the interventions could be disruptive to tenants and buildings users during the installation process. New systems such as heat pumps, electric car charging and smart metering may be unfamiliar and could lead to discomfort, inefficiencies and potentially distress if they are not taught how to use them correctly. Getting buy in from user groups is critical to long term success.

This challenge will be most acute with measures in council housing. To deal with this, it is recommended that the council engage with tenants in particular to bring them on board with the changes required to their homes and provide appropriate training and support with using any new technologies. To deliver this, there will need to be sufficient internal resource and training programmes in place.

Empowering tenants and supporting tenant champions could help to create buy-in and trust amongst tenants so they have a higher level of confidence and understanding about the interventions and the changes that will be needed to their homes.

Priority actions

Below are actions that the council should take as a priority and begin without delay to create a strong platform for the transition to net zero.

Overarching priority actions	**Short** Up to 2022	**Medium** 2023-2026	**Long** 2027-2030
Adopt a net zero plan for the council's assets with a funded action plan to kick off its implementation	●		
Institutionalise the net zero plan for the council's assets into city planning, operations and budgeting	●	●	
Training and skills for in-house operations and maintenance teams for are being asked to implement it	●	●	
Communication with users and tenants in order to gain buy in and manage the change and disruption to come	●	●	●

Domestic priority actions	**Short** Up to 2022	**Medium** 2023-2026	**Long** 2027-2030
Launch a programme of detailed energy surveys and technical studies to underpin the zero carbon retrofit measures.	●	●	
Develop an intensive programme of works on Council-owned domestic properties to kick-start an increased local delivery pipeline.	●	●	
Require that all new social homes are zero carbon	●	●	
All Council acquisitions to be brought up to zero carbon standards		●	●
Secure funding from BEIS via innovation and/or energy programmes, such as the Social Housing Fund, Whole House Retrofit Programme, and the forthcoming and Net Zero Innovation Programme.	●		
Scale-up a whole house approach to net zero retrofits, delivering a comprehensive package of measures together.		●	

Initiate discussion with local electrical infrastructure providers to understand how capacity impacts on meeting zero carbon target (such as electrified heating) and develop a programme of strengthening works.	●	●	
Work with commercial partners in district heating sector to develop a detailed heat study for expanding heat networks	●	●	

Non-domestic priority actions	**Short** Up to 2022	**Medium** 2023-2026	**Long** 2027-2030
Deploy BEMS, AMR, permanent submetering and temporary energy loggers on all buildings. Use data analysis to target energy management and low-cost building energy measures.	●		
Develop an intensive programme of works on Council-managed non-domestic properties to kick-start an increased local delivery pipeline.	●	●	
Pilot whole building net zero retrofits, delivering a comprehensive package of measures together.		●	
Develop a long-term energy masterplan that integrates heat, power and transport energy vectors for a building or cluster of buildings with large or complex energy needs.	●	●	
Scale-up the existing revolving energy efficiency fund and align it with the approach to net zero buildings. This could include grant funding from Public Sector Decarbonisation Scheme and the city's investment budget.	●	●	

Fleet priority actions	**Short** Up to 2022	**Medium** 2023-2026	**Long** 2027-2030
Build the evidence base for action - Undertake a fleet consolidation and electrification feasibility assessment	●		
Roll out behaviour change programmes	●		
Begin to accelerate the electrification of all cars and vans	●		
Work with key contractors to align their vehicle policy with the council's zero carbon targets		●	
Commit to trialling low carbon large and specialist vehicles as they become available, in preparation for a complete switch away from diesel.		●	

1 Introduction

Sheffield City Council has declared a Climate Emergency and has set a target for the city to be zero carbon by 2030.

The council has been working with the Tyndall Centre for Climate Research to establish a carbon budget for the city. In their report of June 2019, the Tyndall Centre recommended that the city should stay within a cumulative CO_2 emissions budget of 16 Mt CO_2 for the period of 2020 to 2100, which would mean achieving near zero carbon emissions by no later than 2038[1].

The City Council commissioned Arup and Ricardo to support them in developing a plan to achieve their goal of being zero-carbon by the end of the decade.

This report sits within a wider suite of documents reflecting various stages of the overall project, being the output of *Work Package 3.2: Zero carbon pathway for council assets*. It was undertaken in parallel to *Work Package 3.1: City-wide zero carbon pathway*.

Work Package 3.2: Zero carbon pathway for council assets is one of a series of reports for Sheffield City Council have commissioned from Arup and Ricardo

WP1 Baseline emissions	**WP2** Business-as-usual projections	**WP3.1** City-wide zero carbon pathway **WP3.2** Zero carbon pathway for council assets	**WP4** Governance Structures
Establishing the current position	Predicting the effect of current policies	Setting out the actions that are needed to achieve zero carbon by 2030	How the council needs to organise itself to deliver the actions

1.1 Zero carbon pathway for council assets

This report sets out the measures that will be needed for Sheffield City Council's assets to be zero carbon by 2030. It establishes a strategic pathway and indicates the step change in delivery that will be needed in order to meet the goals the council has set itself.

The council has adopted a bold emissions goal and rightly intends to lead from the front by decarbonising its own estate. Not only does it present an opportunity to reduce Sheffield's carbon emissions, it can spur action across the city by creating a robust local supply chain, supporting new businesses and leading to retraining in net zero skills and technology.

A zero carbon pathway for the council's assets creates a strong basis for decision making. The analysis and subsequent recommendations will require new governance arrangements and internal policy, which is covered in detail as part of *Work Package 4: Governance Structures.*

This report provides an evidence base which can be used to support investment in new technology, changes in operating practices and strengthened discussions with its strategic partners.

[1] Tyndall Centre for Climate Change Research. [Online] June 2019. https://www.sheffield.gov.uk/content/dam/sheffield/docs/your-city-council/climate-change/Sheffield_Report_V1.3.1.pdf.

1.2 Approach to net zero carbon

There are many ways to reach zero carbon and even the definition of zero carbon is not universally agreed. For the purposes of this analysis, Sheffield's zero carbon goal is defined as:

Net zero carbon dioxide, defined as a 95% reduction in net emissions.

This follows the approach used by the Tyndall Centre, where they only considered energy-related CO_2 emissions (and not other GHGs such as CH_4 or N_2O) and used the 95% definition. This approach makes sense as CO_2 is the dominant GHG, as shown clearly in the WP1 analysis.

To translate the net zero carbon definition into a framework for exploring emissions pathways to 2030, a set of net zero principles have been established. These have been used to ensure the proposed mitigation measures and sectoral net zero strategy are established on a solid foundation. The principles are:

1.2.1 Energy efficiency to be prioritised and maximised

Irrespective of the future availability of near-zero carbon electricity from the grid (as it moves away from fossil fuels and towards renewables), there is a need to reduce the amount of energy used. Reducing energy will aid the transition to low carbon electricity as higher-emission sources can be phased out earlier.

1.2.2 Fuels are switched to low and zero carbon alternatives

Fossil fuels are completely eliminated in the 2030. Energy supply is switched to low and zero carbon alternatives, particularly electricity from the grid. The options proposed rely almost entirely on technologies which are available now. Technologies without a high degree of confidence in their immediate availability are excluded. This approach has been taken due to the relatively short timescales within which action must be taken to meet the 2030 target. The city does not have the luxury of waiting for technological solutions to appear.

1.2.3 Local zero carbon electricity generation can help to offset these residual emissions

While grid electricity continues to decarbonise, the power supply in 2030 is still expected to include a proportion of fossil fuelled generation. There will be some residual emissions resulting from its use.

Local zero carbon electricity generation can help to offset these residual emissions, although the net local benefit shrinks as the wider electricity system transforms.

1.2.4 Electrification of heat and transport

The electrification of heat and transport is a key mechanism for reaching net zero. Despite the residual carbon emissions of electricity in 2030, it is likely to be a cleaner option than most alternatives. As the amount of fossil fuels used to supply the grid falls, so do emissions associated with electricity use. It also has the benefit of continuing to be emissions free at the point of use.

Promising alternatives to electrification also tend to be less mature, with hydrogen unlikely to be ready for mass deployment in time to support Sheffield's goal. It is important to keep in mind the important role they could play in addressing hard to address applications as well as any residual emissions post 2030.

1.2.5 'Zero' in 2030 is taken as a 95% reduction

For the purposes of evaluating whether the target has been reached, a reduction of 95% from the baseline year is taken as meeting the definition of 'zero'. Whilst, mathematically speaking, it is not zero, it is felt that the overwhelming majority of the emissions will have been dealt with if a 95% reduction is met by 2030. The remaining 5% is assumed to tail off before the country achieves its goal of 100% reduction in 2050. This 'tail' of emissions will provide a way of balancing the need for drastic cuts with a small degree of pragmatism and reflects language and recommendations made in the Tyndall Centre report. The $16MtCO_2$ target is also considered.

1.2.6 No offsetting is considered

Offsetting is the reduction or avoidance of emissions outside of the geography being considered. Whilst in some circumstances it can be a valid way of reducing overall (global) emissions levels, it is not considered in this report. This is due to the fact that it is seen as preferable to reduce emission locally.

1.3 Net zero pathway framework

The approach set out above has been translated into each of the sectors in the following ways:

1.4 Report structure

The report sets out the baseline emissions inventory and projections to 2030 for council assets. The assessment of options for reducing emissions is undertaken for the following sectors:

5. Domestic buildings owned by the council
6. Non-domestic buildings, such as schools and libraries
7. Council and key contractor fleet vehicles
8. Street lighting

Energy & emissions modelling brings together the sector analysis in order to establish the emissions pathway for council assets.

2 Methodology

The council net zero pathway and recommendations were developed through the following tasks:

1. Council baseline: understanding how energy is used today and establishing an emissions inventory for 2019.
2. Gap analysis: projecting this baseline inventory forward under business as usual to assess the scale of the net zero challenge in 2030.
3. Options identification: developing a set of mitigation measures for the council's assets that can meet the net zero goal. These were identified using Arup-Ricardo expertise and validated in stakeholder workshops.
4. Impact and cost assessment: The impact of mitigation measures on emissions pathway was modelled using Ricardo's Net Zero Projection tool. It provides estimated costs for implementation.
5. Recommendations: The study has brought to light a number of recommendations which would help the council to meet its net zero goal.

2.1 Ricardo's Net Zero Projection tool

The Net Zero Projection tool enables users to model the impact of implementing mitigation measures on CO_2 emissions over time. The tool is designed to enable the development of pathways to net zero by a given target year. The tool allows the user to project CO_2 emissions forward for existing fuels and sectors based on assumptions on demand growth and energy efficiency improvements (both %/yr), as well as a consideration of options for fuel switching, for example switching from petrol/diesel cars to electric vehicles, or from gas boilers in buildings to heat pumps.

2.2 Boundary and scope

The boundary and scope establish the emissions that Sheffield City Council take responsibility for reducing to zero.

For Work Package 3.2, the boundary has been set to include emissions over which the council has direct or substantial control and where good quality baseline data has been collected. This comprises operational in use emissions from the following sectors:

1. Council owned domestic buildings
2. Council owned non-domestic buildings
3. Council and key contractor fleet vehicles
4. Street lighting
5. Renewable electricity generated on council owned land.

More details about each sector boundary is described in the results and analysis sections below.

Included are Scope 1 energy use and Scope 2 energy purchase emissions from within the boundary. Scope 3 supply chain emissions have not been accounted.

3 Energy and emissions projections

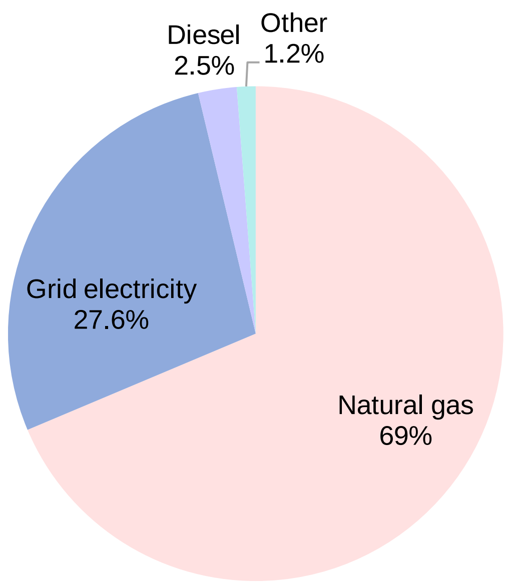
3.1 Introduction

2019 energy consumption data provided forms the baseline for the assessment and the basis for energy and emissions projections and measures impact assessment. The data covers the buildings in the council's control, including both domestic and non-domestic, its fleet vehicles and those of key contractors, and street lighting.

3.2 Energy baseline

Baseline energy demand was 803GWh/year in 2019. The largest energy requirement is for space heating and overall 68.7% of energy consumption from natural gas. Some heating demand is met by other fuels, including energy from waste (0.7%), via the district heating network and other fuels such as coal and biomass. Electricity accounts for 27.6% of energy demand in 2019, primarily from use in buildings. Energy for fleet vehicles represents approximately 2.5% of baseline energy use, primarily from diesel/petrol with negligible amounts of electricity and hydrogen consumed by vehicles.

Baseline energy consumption by fuel 2019

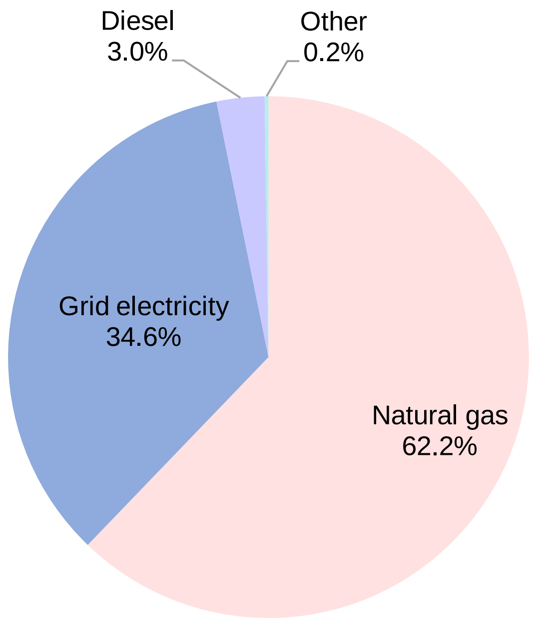


3.3 Emissions baseline

Converting baseline fuel consumption into carbon emissions helps us understand the starting point for the transition to net zero. It is also used as the basis for the business as usual emissions projections.

Within the scope and boundary of council assets defined for Work Package 3.2, the emissions baseline is 162,700 tonnes CO_2/year. The higher emissions factor for electricity over gas means it accounts for 34.6% of the baseline inventory. Natural gas accounts for 62.2% of the emissions inventory, with 0.1% from district heating. Vehicle fuels account for 3%. All other fuels account for smaller fractions, adding to around 0.1% together.

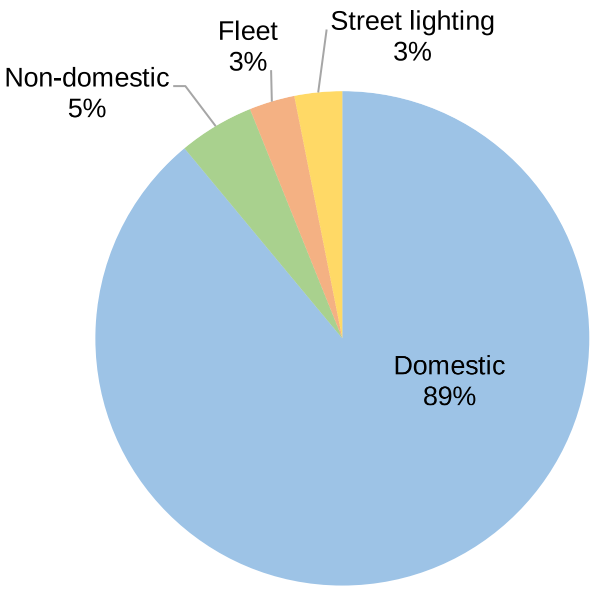
Baseline carbon emissions by fuel 2019



3.4 Emissions by sector

The baseline emissions inventory is dominated by domestic buildings, accounting for 89% of the total. This is a product of the larger number of homes owned by the council. Non-domestic buildings, schools, offices, cultural and civic buildings together account for 4.9% of emissions. Street lighting accounts for 3.1% of all emissions.

Baseline carbon emissions by sector



3.5 Baseline emissions projections

Understanding the likely sources of emissions in 2030 is central to developing a set of measures that can reduce those emissions to zero. An emissions pathway based on the 2019 baseline data has been developed. A series of assumptions are applied to reflect the key factors which will influence how the sector's emissions are expected to evolve in the absence of new energy measures.

3.5.1 Changes in the emissions intensity of electricity

The electricity supply in the UK has been decarbonising rapidly over the past 10 years and this trend is expected to continue. As a result the emissions associated with electricity consumption are modelled to fall from 0.254 to 0.107 kgCO_2/kWh by 2030 - an 58% reduction.

3.5.2 Changes in the scale of council assets and operations

The activities undertaken by the council, the number of assets in its ownership and how they are used all are all important underlying factors which influence its annual emissions. The baseline projection includes assumptions about how this could change over the next decade, such as the construction of new council houses.

3.5.3 Underlying energy efficiency improvements

Continual improvement in operational delivery as well the replacement of old heating systems and appliances with new more efficient models is likely to result in steadily improving energy efficiency over the last 10 years, without the need for any decarbonisation measures. Specific assumptions are described for each sector below.

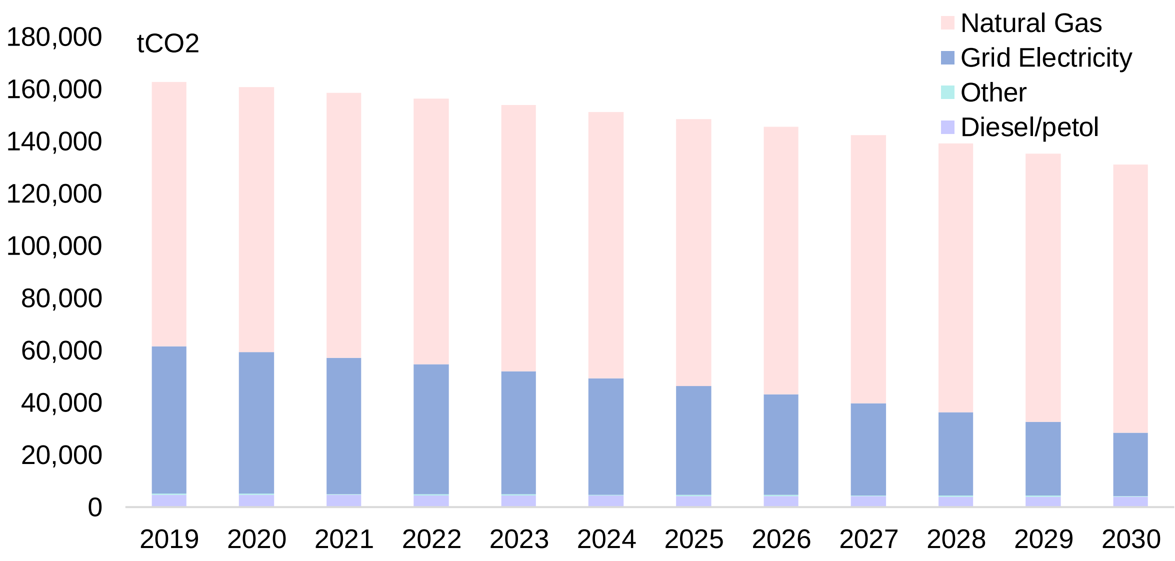
3.5.4 Planned measures

The council is already planning to undertake measures which will reduce electricity demand and will switch away from carbon intensive fossil fuels. It is assumed that these planned measures will be undertaken and form part of the business as usual baseline.

3.5.5 Baseline projection

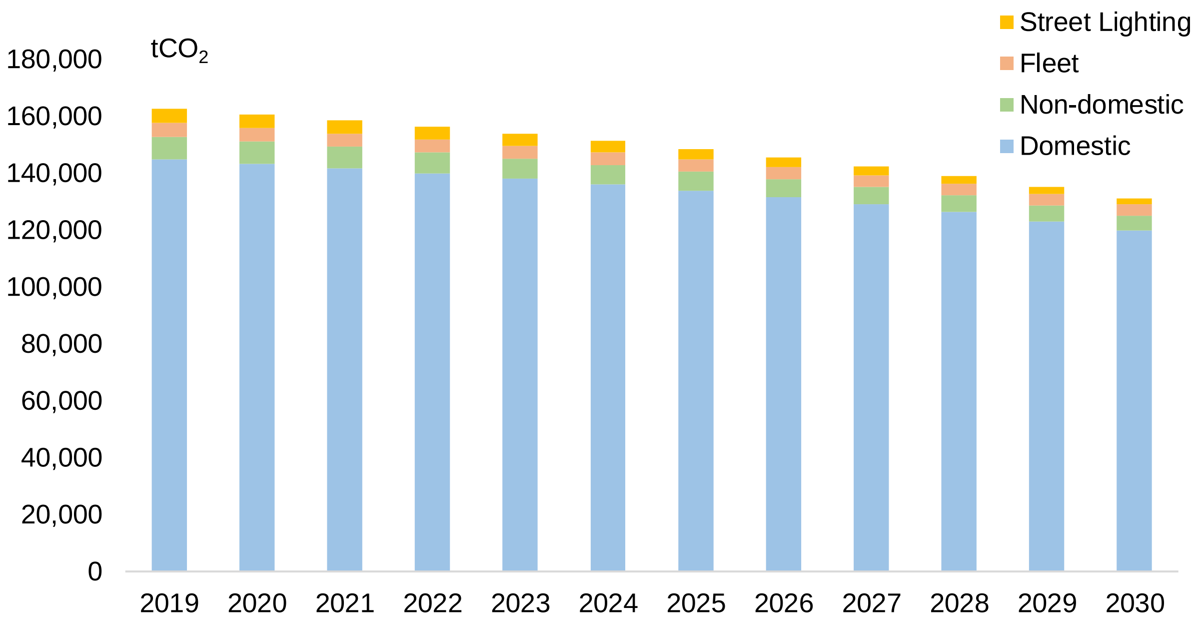
The baseline emissions projection is illustrated below. Taking into account the factors above, business as usual emissions in 2030 are estimated to be 131,175 tCO_2/year, a 20% reduction on 2019.

Baseline emissions projections to 2030 by fuel



The falling electricity emissions factor further increases the prominence of natural gas use in the emissions inventory, reflecting that around 80% of emission are related to meeting space heating and hot water demand in 2030.

Baseline emissions projections to 2030 by sector



Presenting the emissions projection by sector illustrates how the domestic sector remains the dominant component of the inventory over time. Baseline reductions in street lighting emissions are more substantial, linked to the falling emissions from grid electricity expected in future.

These charts illustrate that there remains a significant gap to net zero without further action by the council, with 80% of 2019 emissions still to be addressed.

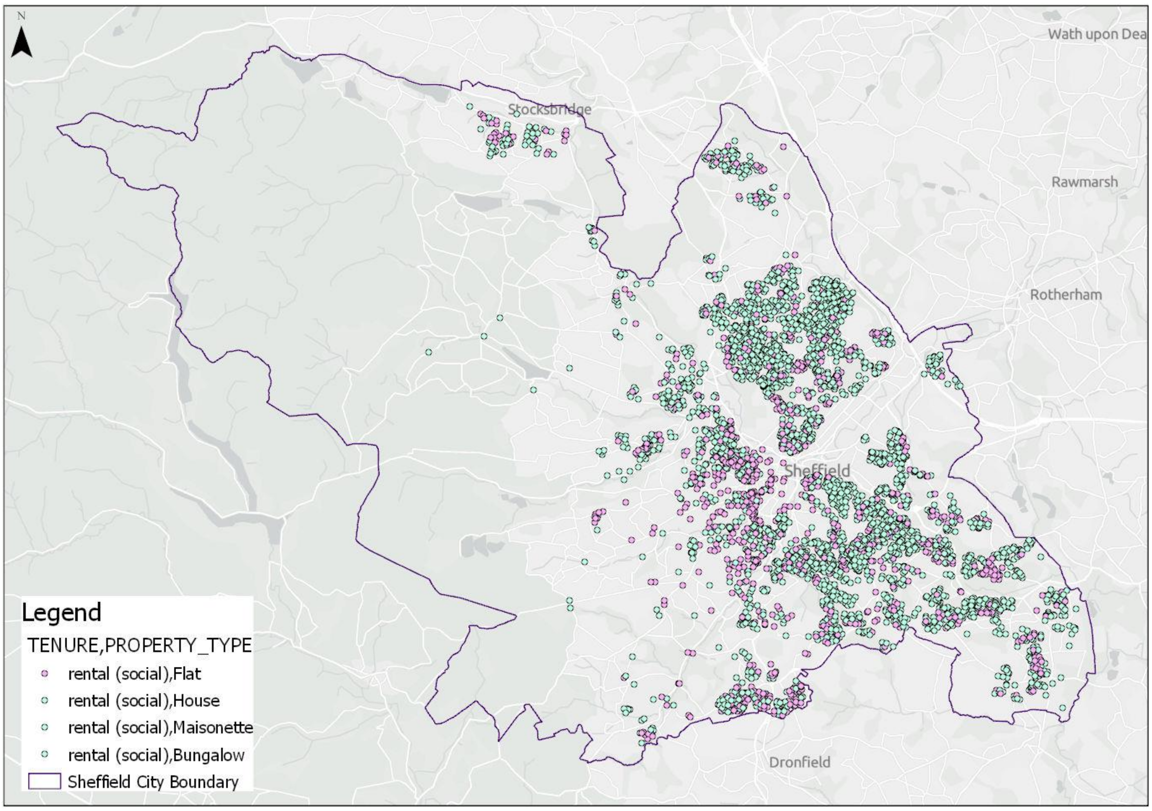
The next sections take each of the four sectors in turn and present further analysis of the energy & emissions modelling, propose a series of net zero interventions and an assessment of the impact on emissions.

4 Domestic

This section presents the results of energy & emissions modelling for domestic properties owned by the council. It includes an analysis of emissions projections, identification of net zero mitigation measures and an assessment of the impact on emissions.

4.1 Introduction

There are approximately 39,000 council owned domestic properties in Sheffield, consisting of 18,000 flats and 21,000 houses (including bungalows and maisonettes). Apex Energy Data for existing council homes has been used to estimate the carbon emissions and energy consumption. Publicly available Energy Performance Certificate (EPC) has been sourced to provide information on heating system and fabric energy efficiency.



Locations of council flats (pink) and council houses (green) in Sheffield
Based on EPC data

Metered gas and electricity data are not available for all existing council homes; therefore, assumptions of energy consumption have been made using EPC data where required.

4.2 Boundary and scope

The domestic analysis incorporates houses and flats that are owned and managed by the council. This is where the council has responsibility for building services and therefore has the ability to directly address emissions. The study covers the existing council homes within the data provided. It does not provide information on current occupancy, so it is assumed that all properties listed are occupied.

To align with the definition of zero carbon being targets, scope 1 and 2 emissions associated with the operational use of buildings will be included only. Scope 3, embedded construction and operational emissions are excluded (as are wider emissions sources such as emissions arising from the goods and services consumed by those occupying the homes).

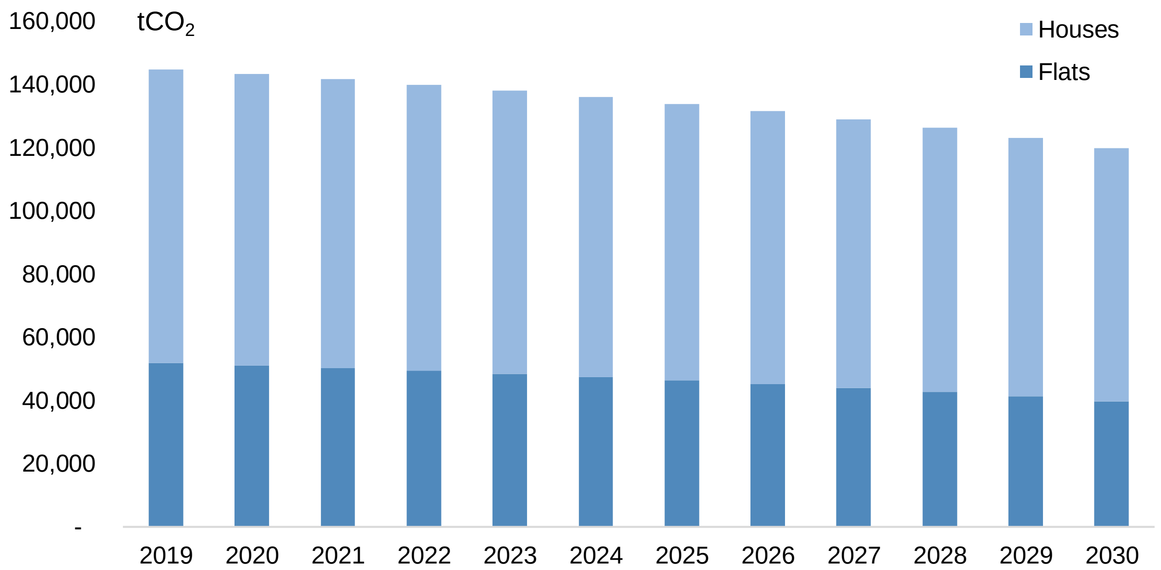
Some buildings within the council's control have also been excluded. These are properties provided by partnering bodies or housing associations. No specific consideration has been given to communal areas (e.g. outside of flats in apartment blocks) as these are anticipated to have minor emissions in comparison to the occupied areas.

4.3 Baseline projection

Carbon emissions in 2019 are estimated to be 144,777 tCO_2 with 51,749 tCO_2 attributed to flats and 93,028 tCO_2 to council houses. The baseline projection reflects reductions from general improvements and maintenance as well as replacing old appliances with more efficient models when they reach the end of life as wider trends in energy system decarbonisation.

It is understood from discussions with Sheffield City Council, that the main focus of current planned improvements to existing council homes is on hazard reduction. It is anticipated that some of these improvements will result in reductions in energy consumption. However, as it is understood that there are no concerted programmes aimed at energy/emissions reductions, it is assumed that the council homes will follow the national energy improvement trends. Overall, this means total emissions are projected to fall to 119,772 tCO_2 by 2030, a reduction of 17%.

Domestic emissions baseline, by building type



4.4 Options identification

Interventions are required to reduce emissions much further and much quicker in order to be on track to reach the zero carbon target. There are a series of interventions proposed for council homes in Sheffield to reach the net zero carbon target by 2030. The interventions include:

- Improve fabric of homes
- Reduce energy consumption in homes
- Remove fossil fuels
- Generate renewable electricity
- Directly deliver zero carbon new builds

4.4.1 Fabric improvements

66% of energy consumption within the domestic sector are attributed to space heating[2]. Improving the fabric of homes help to minimise the heat losses within the home thus helping to reducing the heating demand and emissions resulting from heating homes.

Sheffield City Council recognises the importance of fabric improvements and there are already programmes in place to maintain and improve the city's council housing stock. The Decent Homes programme has supported improvements to council housing in Sheffield, and high levels of the council's housing stock already have insulation to their walls and a further £250m has been agreed for further improvements to the building fabric, structure and safety.

Energy emissions modelling carried out as part of this study demonstrated that further improvements to the fabric of council homes are anticipated to help reduce emissions by 15,356 tCO_2 (with 27% attributed to flats and 73% attributed to houses). These fabric improvements will be a combination of the following measures:

- Solid wall insulation
- Cavity wall insulation
- Floor insulation
- Loft insulation
- Draught-proofing
- Replacing glazing

Assuming no change to the heat source, fabric improvement measure will also reduce the costs of heating the home. Some of the simpler interventions such as draught-proofing, loft insulation and cavity wall insulation are relatively low cost and low disruption and could be incorporated as part of regular maintenance work. Some of the more significant interventions have a much higher capital cost (e.g. glazing replacement) or can cause more disruption (e.g. floor insulation),), perhaps needing more planning to be able to implement them and a different funding route.

The costs associated with retrofitting and improving the fabric on homes could reduce over the next decade as the widescale uptake of retrofitting increases. In May 2019, BEIS launched a "Whole House Retrofit Innovation Competition", aimed at social landlords, exploring options to halve the cost of energy efficiency upgrades to homes. London Borough of Sutton, Nottingham City Council and Cornwall Council have been awarded funding as part of this competition and are tasked with demonstrating how to reduce domestic retrofit costs whilst improving the energy performance of the homes[3].

Irrespective of the capital costs, all of the fabric improvement measures reduce energy costs and can assist in tackling fuel poverty. It is also worth highlighting that a high level of fabric improvements will be necessary before heat pumps can be installed in homes that currently have poor fabric performance.

Fabric interventions can also provide improved thermal comfort for occupants. This can be as a result of occupants being able to more easily afford to heat their homes to a comfortable temperature after interventions or due to the fact that a well-insulated home will heat up more quickly to achieve a comfortable temperature. These more comfortable temperatures also bring health benefits from the avoidance of damp and mould.

The fabric improvement measures described in this section are stretching but are deemed to be what could be feasibly achieved in Sheffield within the 2030-time limit. The measures will not result in all homes achieving Passivhaus standards but will help to significantly reduce energy consumption and associated carbon emissions.

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[2] DECC Statistics. Estimates of heat use in the United Kingdom in 2013. 2014.

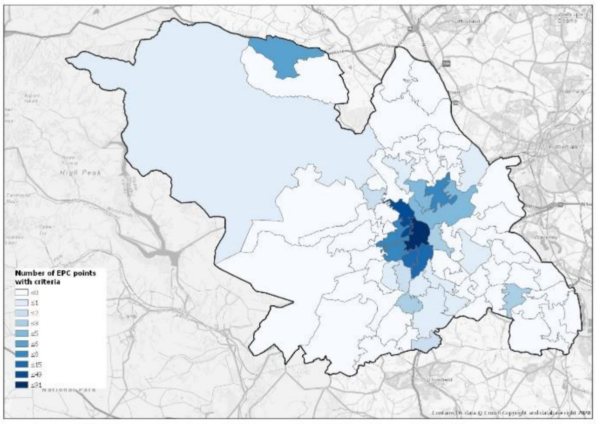
[3] https://www.gov.uk/government/publications/whole-house-retrofit-competition-successful-bids/whole-house-retrofit-grant-award-recipients-project-summaries

The scalability of the fabric improvement measures have been approximated based on Energy Performance Certificates (EPC) for domestic properties in Sheffield. Although EPC data is not available for every property and, for some, might be out of date, it is expected that it will still provide a good representation of the current fabric standards of domestic properties in Sheffield at present. Despite its limitations, it is the most complete data source available for the properties.

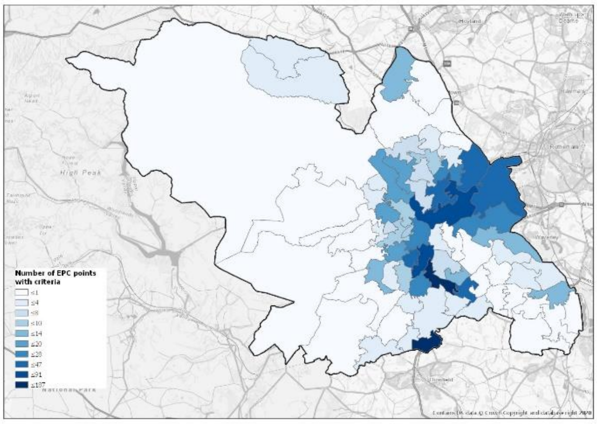
4.4.2 Solid wall insulation

Installing or improving solid wall insulation can reduce the amount of heat lost through the walls, reducing the heating demand of the building. Insulating solid walls is predicted to reduce the heating demand of a property by 13%[4].

Approximately 2% (~350) of council flats and 5% (~1,000) of council houses in Sheffield have solid walls that are currently uninsulated[5]. This is a much lower proportion compared with the 18% of homes within the whole of Sheffield that currently have uninsulated solid walls.



Locations of council flats in Sheffield with no solid wall insulation
Based on EPC data, scale ranging from 0 to over 91 points



Locations of council houses in Sheffield with no solid wall insulation
Based on EPC data, scale ranging from 1 to over 187 points

The cost of installing solid wall insulation is largely dependent on whether the walls are insulated externally or internally. The cost of installing solid wall insulation is expected to range between £6,800 to £15,000 per property[6]. Therefore, installing solid wall insulation across the council homes in Sheffield where it is currently not installed is expected to cost in the region of £15m. By installing solid wall insulation, household energy bills are expected to reduce by between £105 to £375 per year, leading to total savings of around £32k per annum if installed across all council homes[7].

This measure effectively needs to be instigated immediately, recognising that it will take to conduct a detailed survey on the properties and determine the most appropriate approach for installing solid wall insulation at scale. An average of round 200 properties per year will need to have solid wall insulation installed between now and 2027, at a cost of about £2.1 million annually. Lower numbers are expected in the initial years, but numbers should be increased as quickly as feasible. Opportunities to combine this work with other planned maintenance, such as structural improvements, should also be investigated.

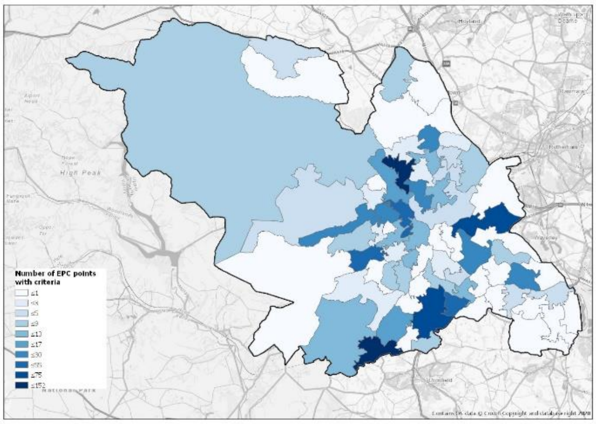
[4] Department for Business, Energy & Industrial Strategy. National Energy Efficiency Data-Framework (NEED): Summary of Analysis, Great Britain, 2019. [Online] 19 June 2019. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/812561/National_Energy_Efficiency_Data_Framework__NEED__report_summary_of_analysis_2019.pdf.
[5] Ministry of Housing, Communities & Local Government. Energy Performance of Buildings Data: England and Wales. [Online] 2020. https://epc.opendatacommunities.org/.
[6] Department for Business, Energy & Industrial Strategy. What does it cost to retrofit homes? [Online] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/656866/BEIS_Update_of_Domestic_Cost_Assumptions_031017.pdf.
[7] https://energysavingtrust.org.uk/home-insulation/solid-wall

There are a number of councils in the UK that are supporting solid wall insulation projects. Hull City Council are installing solid wall insulation in a selection of private homes in some priorities areas as part of a series of frontage improvement works[8]. Durham County Council have partnered with Durham University and European Regional Development Fund to install new and advanced solid wall insulation systems on over 200 stone and brick -built properties in towns and villages across County Durham[9]. Nottingham City Council and the Department of Business, Energy & Industrial Strategy (BEIS) are funding a deep retrofit of 76 solid wall properties with Nottingham City Homes[10]. These projects are on a smaller scale than what will be needed in Sheffield but provide great opportunities to learn from those trialling different approaches to solid wall insulation.

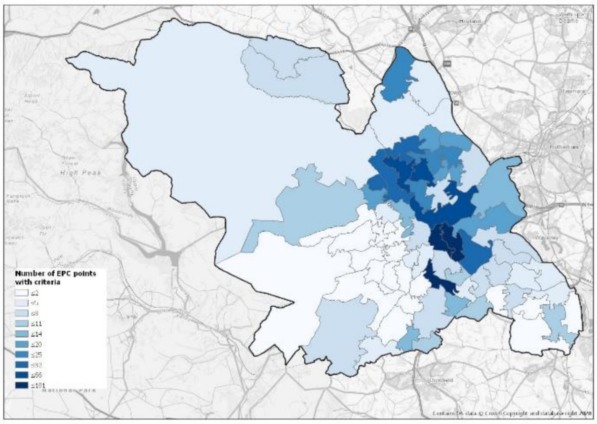
4.4.3 Cavity wall insulation

Installing or improving cavity wall insulation can reduce the amount of heat lost through the walls, reducing the heating demand of the building. Cavity wall insulation is usually easier to install than solid wall insultation, but the energy savings are slightly lower in comparison. Insulating cavity walls is predicted to reduce the heating demand of a property by 7%[11].

Approximately 9% (~1,500) of council flats and 7% (~1,500) of council houses in Sheffield have cavity walls that are currently uninsulated or partially insulated[12].



Locations of council flats in Sheffield with no cavity wall insulation
Based on EPC data, scale ranging from 1 to over 152 points



Locations of council houses in Sheffield with no cavity wall insulation
Based on EPC data, scale ranging from 2 to over 181 points

Installing cavity wall insulation is much less intrusive than sold wall insulation so is much cheaper in comparison. The cost of installing cavity wall insulation is expected to range between £480 to £660 per property[13]. Therefore, installing cavity wall insulation across the council homes in Sheffield where it is currently not installed is expected to cost in the region of £1.7m. The resulting energy savings are typically between £85 to £280 per year, which would be in the region of £550k per annum if installed across all properties[14].

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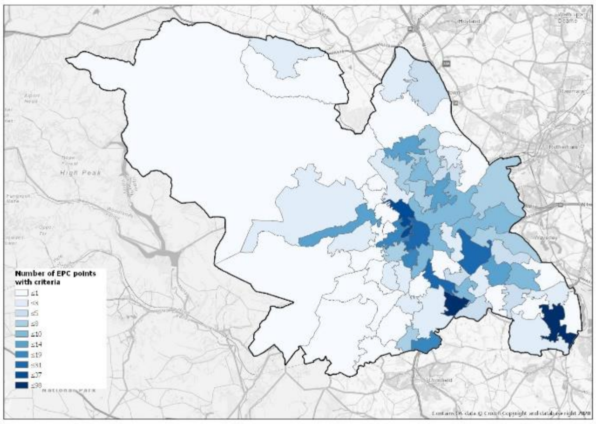
[8] http://www.hull.gov.uk/housing/private-tenants-and-homeowners/energy-efficiency-and-affordable-warmth
[9] https://swiiproject.co.uk/
[10] https://nottinghamcityhomes.org.uk/your-home/energy-and-sustainability/carbon-neutral-nottingham/whole-house-retrofit/
[11] Department for Business, Energy & Industrial Strategy. National Energy Efficiency Data-Framework (NEED): Summary of Analysis, Great Britain, 2019. [Online] 19 June 2019.
[12] Ministry of Housing, Communities & Local Government. Energy Performance of Buildings Data: England and Wales. [Online] 2020. https://epc.opendatacommunities.org/.
[13] Department for Business, Energy & Industrial Strategy. What does it cost to retrofit homes? [Online] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/656866/BEIS_Update_of_Domestic_Cost_Assumptions_031017.pdf.
[14] https://energysavingtrust.org.uk/home-insulation/cavity-wall

It is anticipated that the measure could start to be implemented immediately and will be delivered by 2027. This would mean that approximately 400 properties per year, at a cost of about £230k annually, between now and 2027 would need to have cavity wall insulation.

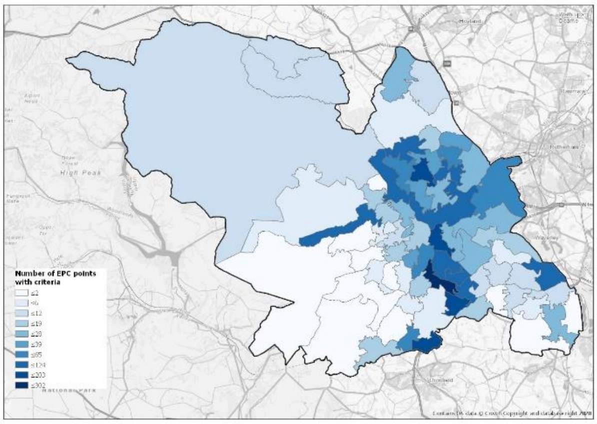
4.4.4 Loft/roof insulation

Installing or improving loft and roof insulation can reduce the amount of heat lost through the roof, reducing the heating demand of the building. Insulating lofts is predicted to reduce the heating demand of a property by 4%[15].

Approximately 12% (~2,100) of council flats and 18% (~4,000) of council houses in Sheffield have lofts or roof spaces that are currently uninsulated or have limited insulation. Over 60% of flats have other dwellings above them so do not require loft/roof insulation.



Locations of council flats in Sheffield with no loft/roof insulation
Based on EPC data, scale ranging from 1 to over 98 points



900 roofs Locations of council houses in Sheffield with no loft/roof insulation
Based on EPC data, scale ranging from 2 to over 302 points

The cost of installing loft insulation is expected to range between £230 to £395 per property[16]. Therefore, cost of installing loft insulation across the council homes in Sheffield where it is currently not installed is expected to cost in the region of £2m. The resulting energy savings are typically between £135 to £250 per year, which would be in the region of £1.2m per annum if installed across all properties[17].

It is anticipated that the measure could start to be implemented immediately and will be delivered by 2027. This would mean that approximately 900 properties per year between now and 2027 would need to have loft or roof insulation.

Roof renewal/roofline and roof repair work has been delivered on 9,000 roofs already and loft insulation was included as part of this work. Further roof repair and insulation is planned for approximately 66,000 homes as part of the housing improvement project. By combining these activities, the Council have helped to minimise disruption to tenants and resulted in cost savings by avoiding multiply visits.

4.4.5 Floor insulation

Installing or improving suspended floor insulation can reduce the amount of heat lost through the ground, reducing the heating demand of the building. Insulating floor insulation is predicted to reduce heating demand of a property by 7%[18].

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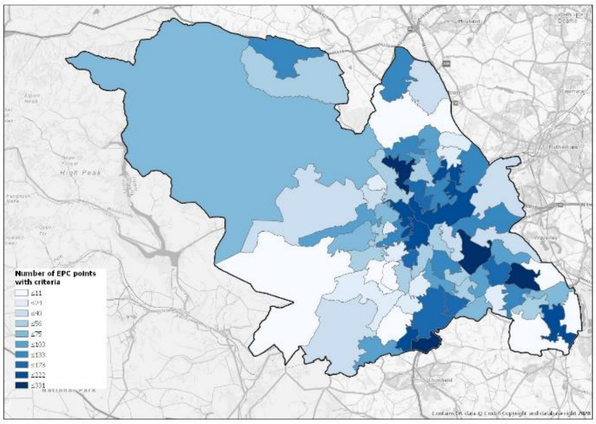
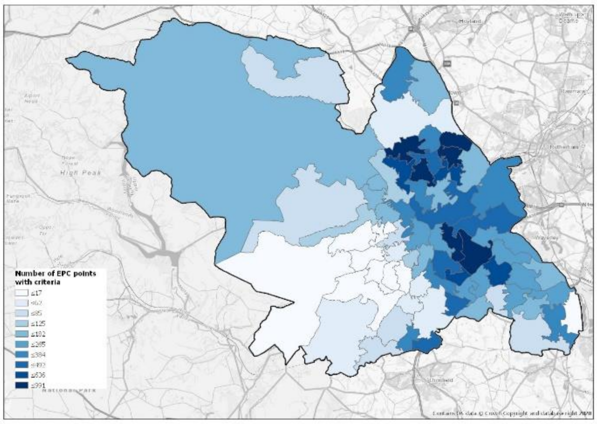
[15] Department for Business, Energy & Industrial Strategy. National Energy Efficiency Data-Framework (NEED): Summary of Analysis, Great Britain, 2019. [Online] 19 June 2019.
[16] Energy Saving Trust. [Online] https://energysavingtrust.org.uk/
[17] https://energysavingtrust.org.uk/home-insulation/roof-and-loft
[18] Energy Saving Trust. [Online] https://energysavingtrust.org.uk/

Approximately 36% (~6,000) of council flats and 84% (~18,000) of council houses in Sheffield have solid or suspended floors that are currently uninsulated[19].



Locations of council flats in Sheffield with no floor insulation
Based on EPC data, scale ranging from 11 to over 331 points



Locations of council houses in Sheffield with no floor insulation
Based on EPC data, scale ranging from 17 to over 991 points

The cost of installing floor insulation is expected to range between £520 to £1,300 per property[20]. Therefore, cost of installing floor insulation across the council homes in Sheffield where it is currently not installed is expected to cost in the region of £22m. By installing floor insulation, household energy bills are expected to reduce by between £30 to £75 per year, leading to total savings of around £1.3m per annum if installed across all council homes.

It is anticipated that the measure could start to be implemented immediately and will be delivered by 2027. This would mean that around 3,000 properties per year, at a cost of about £3m annually, between now and 2027 would need to have floor insulation.

Installing floor insulation can be very disruptive to tenants and needs to be carried out by professionals to ensure that it does not lead to condensation or cold spots. Technologies such as the Q-Bot, a robot that sprays insulation under floorboards, can help to minimise this disruption[21].

Installing floor insulation is one of the more challenging fabric improvements to implement and has comparatively small carbon savings for the disruption caused. Therefore, priority should be place on maximising the carbon savings from other fabric improvement measures before tackling floor insulation.

4.4.6 Draught-proofing

Draught-proofing measures can include sealing window frames, doors and adding draught excluders to letterboxes, doors and chimneys. Implementing draught-proofing measures increase air tightness and reduce unwanted air infiltration. This can lead to improve thermal comfort and help to reduce the heating demand. Installing draught-proofing is predicted to reduce the heating demand of a property by 5%[22].

Approximately 3% (~450) of council flats and 5% (~1,100) of council houses in Sheffield have an EPC rating of E or lower[23]. It is assumed these properties will benefit from draught-proofing.

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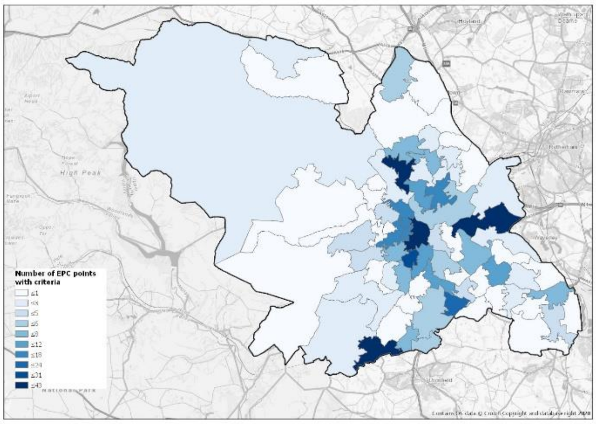
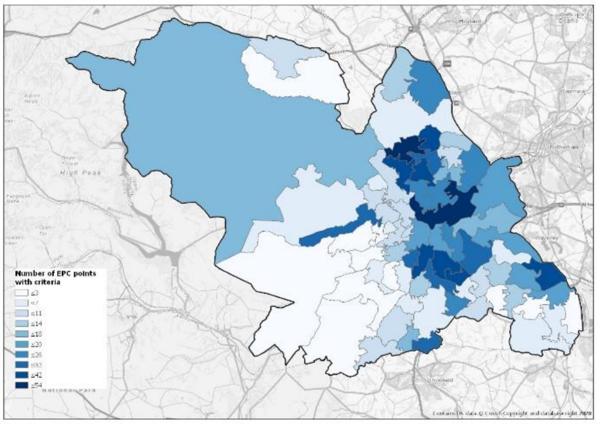
[19] Ministry of Housing, Communities & Local Government. Energy Performance of Buildings Data: England and Wales. [Online] 2020. https://epc.opendatacommunities.org/.
[20] Energy Saving Trust. [Online] https://energysavingtrust.org.uk/
[21] https://q-bot.co/
[22] Energy Saving Trust. [Online] https://energysavingtrust.org.uk/
[23] Ministry of Housing, Communities & Local Government. Energy Performance of Buildings Data: England and Wales. [Online] 2020. https://epc.opendatacommunities.org/.



Locations of council flats in Sheffield with EPC E or lower
Based on EPC data, scale ranging from 1 to over 43 points



Locations of council houses in Sheffield with EPC E or lower
Based on EPC data, scale ranging from 3 to over 54 points

The cost of installing draught stripping is expected to range between £85 to £275 per property[24]. Therefore, cost of installing draught stripping across the council homes in Sheffield with and EPC rating of E or lower is expected to cost in the region of £300k. Draught-proofing could reduce energy bills by between £20 per year, leading to total savings of around £30k per annum if installed across all council homes[25].

It is anticipated that the measure could start to be implemented immediately and will be delivered by 2027. This would mean that approximately 200 properties per year, at a cost of about £40k annually, between now and 2027 would need to have draught-proofing.

4.4.7 Replacing glazing

Replacing existing glazing with better performing glazing can reduce the amount of heat lost through the windows, reducing the heating demand of the building. Replacing glazing with high performance or triple glazing is predicted to reduce the heating demand of a property by approximately 10% and much higher savings are expected when replacing single glazing with triple.

Approximately 96% (~17,000) of council flats and 94% (~20,000) of council houses in Sheffield have double glazing and 4% (~1,000) of council flats and 6% (~1,000) of council houses have single glazing[26]. Although it is likely that all homes could benefit, it is assumed that 90% of properties will be applicable to take into account of localised constraints, such as listed status and conservation areas.

It is difficult to find robust benchmarks on the cost of installing triple glazing in homes as the uptake is still low and costs largely depend on the number of windows needing replacing. The cost is expected to range between £2000 to £7000 per property[27]. Therefore, cost of installing triple glazing across the council homes in Sheffield where it is currently not installed is expected to cost in the region of £160m. Improving glazing could reduce energy bills by between £30 to £120 per year, leading to total savings of around £3m per annum if installed across all council homes[28].

It is anticipated that the measure could start to be implemented immediately and will be delivered by 2027. This would mean that approximately 5,000 properties per year, at a cost of about £23m

[24] Department for Business, Energy & Industrial Strategy. What does it cost to retrofit homes? [Online] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/656866/BEIS_Update_of_Domestic_Cost_Assumptions_031017.pdf.
[25] Energy Saving Trust. [Online] https://energysavingtrust.org.uk/
[26] Ministry of Housing, Communities & Local Government. Energy Performance of Buildings Data: England and Wales. [Online] 2020. https://epc.opendatacommunities.org/.
[27] https://householdquotes.co.uk/how-much-does-triple-glazing-cost/
[28] Energy Saving Trust. [Online] https://energysavingtrust.org.uk/

annually, between now and 2027 would need to have high performance or triple glazing installed. Homes that have old or poor performing glazing should be prioritised.

Installing double glazing on homes that do not meet the Sheffield Standard is planned as part of the housing improvement project. It is recommended that the performance of the windows installed as part of these works is reviewed to ensure it is highly efficient and that upgrading to triple glazing is also considered as an option to avoid needing to replace the glazing again in the near future to meet the zero carbon targets. This approach is currently being considered as part of a tower block renewal scheme.

4.5 Reduce energy consumption in homes

Once the fabric of the building is as efficient as possible, additional measures can be installed to help reduce emissions even further. A combination of smart heating controls and LED lighting are anticipated to help reduce emissions by 11,224 tCO_2.

It has not been possible to accurately calculate the current uptake of both these energy reduction measures so assumptions have been made based on EPC data and through conversations with Sheffield City Council.

There are a number of other simple measures that could also help to reduce energy consumption, such as:

- Reducing the heating thermostat setpoint
- Upgrading to more energy efficient home appliances
- Switching appliances off standby
- Turning off lights when they are not in use
- Spending less time in the shower

Whilst these measures are important and combined could have a large impact, they have not been included in the carbon analysis as the impact from home to home is highly variable and it is difficult to estimate the proportion of homes they could be applied to. These interventions would need to take the form of a behaviour change communication campaign to residents.

4.5.1 Smart heating controls

Smart heating controls can help occupants have more advanced control over the heating system which can lead to a reduction in heating demand. Smart heating controls can also encourage occupants to reduce the heating set points through selecting eco-modes which can further reduce heating demand.

Installing smart heating controls is predicated to reduce the heating demand of a property by 7%. It is estimated that approximately 95% (~17,000) of council flats and 95% (~20,000) of council houses in Sheffield could benefit from installing smart heating controls[29].

The cost of installing or upgrading to smart heating controls is expected to range between £200 to £400 per property[30,31]. Therefore, cost of installing smart heating controls across the council homes in Sheffield is expected to cost in the region of £11m. The potential savings from installing smart metering systems and reducing setpoints by one degree are expected to range from £60 to £135 per year, which when applied across all properties could be over £3m per annum[32].

[29] Ministry of Housing, Communities & Local Government. Energy Performance of Buildings Data: England and Wales. [Online] 2020. https://epc.opendatacommunities.org/.
[30] Department for Business, Energy & Industrial Strategy. What does it cost to retrofit homes? [Online] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/656866/BEIS_Update_of_Domestic_Cost_Assumptions_031017.pdf.
[31] https://www.simpleenergyadvice.org.uk/
[32] Energy Saving Trust. [Online] https://energysavingtrust.org.uk/

It is anticipated that the measure could start to be implemented immediately and will be delivered by 2025. This would mean that around 7,000 properties per year, at a cost of about £2m annually, between now and 2025 would need to have smart heating controls installed.

Any future changes to the heating systems, such as switching to air source heat pumps, should be considered when selecting the most appropriate heating controls for the property. Whilst mart heating controls can bring immediate carbon savings, it might be more practical to install them as part of any other changes to the heating system. Ongoing support will also be needed to help tenants to transition to the new technologies installed and ensure they are being used correctly.

4.5.2 LED lighting

Light Emitting Diodes (LEDs) bulbs are more energy efficient than traditional incandescent lighting and Compact Fluorescent Lamps (CFLs). Replacing existing light fittings with LED bulbs reduces the electricity consumption associated with lighting a home. Replacing bulbs with LED lighting is predicted to reduce the electricity demand of a property by 20%[33].

In the past upgrading to LED lighting has not been a priority for council homes in Sheffield due to limited funding. As such, according the EPC data, approximately 80% (~14,000) of council flats and 91% (~19,000) of council houses in Sheffield have do not have low energy lighting for all fixed outlets[34]. However, given the lags within the data, it is not a true reflection of what is current installed as LED lighting has been installed in at least 25% of apartment blocks. Additionally, there are plans for LED lighting to be installed in 18,000 homes over the next 5/6 years as part of the electrical upgrades programme.

The cost of installing LED lighting is expected to range between £200 to £500 per property[35,36]. Therefore, cost of installing LED lighting across the council homes in Sheffield is expected to cost in the region of £10m. Costs will vary based on the number of light fittings needed replacing and the specification of the fittings themselves. Replacing bulbs with LED alternatives could save approximately £40 a year on electricity bill, so if adopted across all council homes it could result in a saving of over £1m per annum[37].

Although the costs of replacing lightbulbs when the break may typically sit with the tenant, upgrading to LEDs throughout an entire home can be expensive. The Council should look to provide additional funding support to help cover the upfront costs and make it accessible for tenants to upgrade. For example, Sri Lanka is providing over one million LED lights to low-income customers with zero-interest financing[38].

It is anticipated that the measure could start to be implemented immediately and will be delivered by 2025. This would mean that around 7,000 properties per year, at a cost of over £2m annually, between now and 2025 would need to have LED lighting installed. This installation programme aligns with the electrical upgrade programme, which includes for LED lighting to be installed within 18,000 homes in the next 5/6 years.

4.6 Remove fossil fuels

Fossil-fuel consumption from gas, coal and gas oil account for 67% of the total carbon from council homes in Sheffield. To be zero-carbon, Sheffield will need to eliminate all remaining fossil-fuels by 2030.

[33] Energy Saving Trust. [Online] https://energysavingtrust.org.uk/
[34] Ministry of Housing, Communities & Local Government. Energy Performance of Buildings Data: England and Wales. [Online] 2020. https://epc.opendatacommunities.org/.
[35] Department for Business, Energy & Industrial Strategy. What does it cost to retrofit homes? [Online]
[36] https://www.simpleenergyadvice.org.uk/
[37] Energy Saving Trust. [Online] https://energysavingtrust.org.uk/
[38] The Carbon-Free City Handbook, Rocky Mountain Institute

Measures to remove fossil-fuels are anticipated to help reduce emissions by 64,152 tCO_2. These measures will be a combination of the following:

- Switching to electric cooking
- Connecting to district heating networks
- Replacing boilers with heat pumps

As the grid decarbonises, removing the local emissions associated with burning fossil fuels not only helps to reduce carbon emissions but can also improve local air quality if heat sources are switched to cleaner technologies (such as heat pumps) rather than burning fuels locally..

In this report, hydrogen use has not been considered as a means to decarbonise heating within Sheffield's council homes - a position that is largely driven by the 2030 deadline within which zero carbon is being targeted. It is unclear how the infrastructure needed for hydrogen to meaningfully contribute to a broader solution could be designed and built in such a short space of time. However, this is not to say that it could not be a valid approach within the national government's 2050 timescales. Using hydrogen in place of natural gas is a fundamentally different approach to using heat pumps, as such, the approach taken now will determined whether hydrogen will be a suitable option for Sheffield in the future.

4.6.1 Electric cooking

Approximately 2% of gas use is associated with cooking in the domestic sector[39]. All gas cooking appliances are expected to be replaced with electric equivalents. Switching from gas to electric cooking appliances will increase the electricity demand on the grid. Whilst no direct energy savings have been accounted for in the carbon modelling it is anticipated that some energy saving measures will be seen if older ovens, cookers and hobs are replaced with higher efficient electric alternatives.

Switching from gas to electric cooking appliances helps support the long-term goal to eliminate fossil fuels. Whilst this switch may not bring immediate carbon savings, the carbon savings will become more prevalent as the grid decarbonises.

Approximately 15,000 council flats and 21,000 council houses have gas as the main heat source, and it is assumed that these properties also utilise gas for cooking[40].

The cost of installing electric cooking appliances is expected to range between £250 to £1000 per property[41]. Therefore, cost of installing electric cooking appliances across the council homes in Sheffield is expected to cost in the region of £22m. Costs will vary depending on the type of appliance needing the be replaced (hob, oven, cooker) and the specification level. This is a significant cost and, as appliances are not currently provided by the council, there will need to be careful consideration of how this could be funded.

Although this measure could start to be implemented immediately, it is anticipated that it will start to be implemented from 2025 and will be delivered by 2030. This would mean that around 8,000 properties per year between 2025 and 2030 would need to replace gas cooking appliances. The delay will allow for tenants and the council to prepare for replacing existing gas appliances when they reach the end of their service life. Where possible, it is recommended that gas cooking appliances are phased out when they reach their normal replacement cycle, which is typically 10-20 years, before being replaced. However, there is likely to a number of gas cooking appliances that are still fully functioning that would need to be replaced ahead to meet the net zero carbon target.

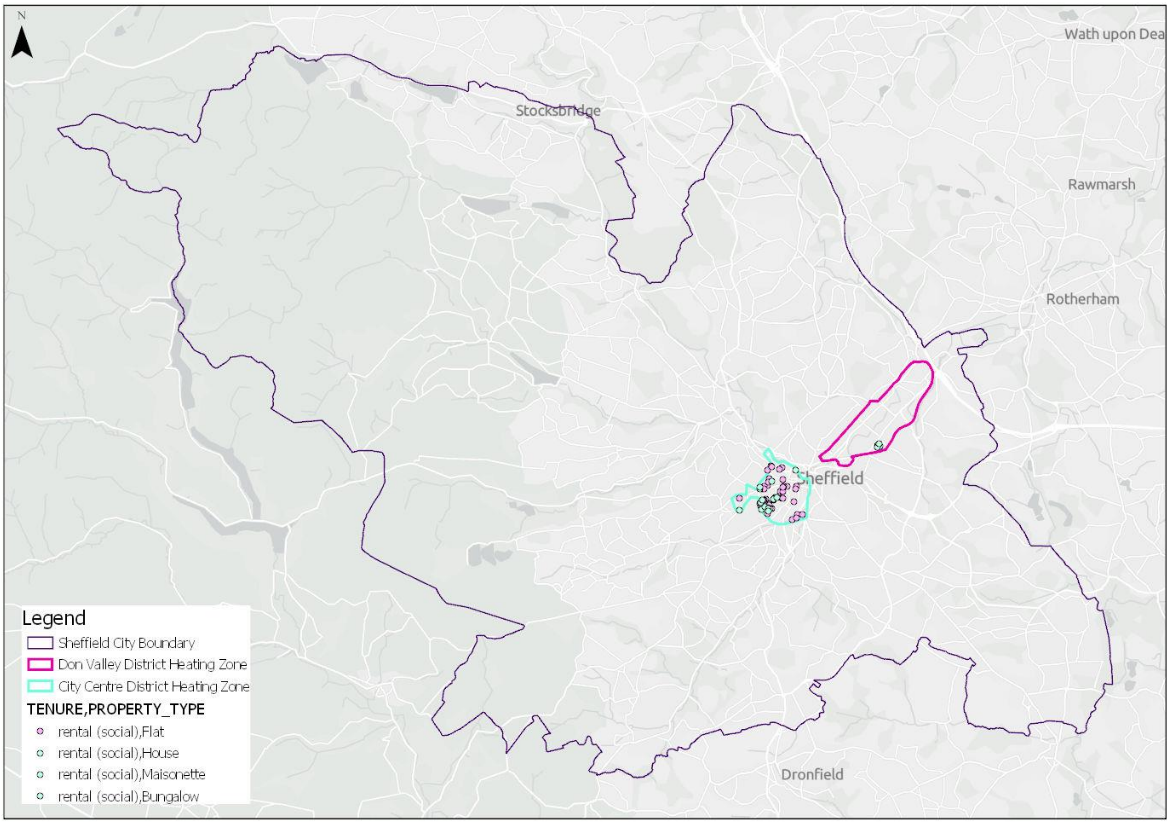
4.6.2 District heating

Currently, there are two main district heating networks in Sheffield; the City Centre Zone supplied by the energy from waste heat network and the Don Valley Zone supplied by biomass combined heat and power (CHP) heat network. The district heating networks could be expanded to connect to

[39] DECC Statistics. Estimates of heat use in the United Kingdom in 2013. 2014.
[40] Ministry of Housing, Communities & Local Government. Energy Performance of Buildings Data: England and Wales. [Online] 2020. https://epc.opendatacommunities.org/.
[41] https://ao.com/

additional homes to replace existing gas boilers. The estimated areas of expansion for the heat networks have been based on areas that have high heat demands.

Expanding the district heating networks would mean that 910 council flats and 156 council homes would then fall within the City Centre Zone heat network catchment area and 8 council homes would then fall within the Don Valley Zone heat network catchment area. It is assumed that all these properties within the catchment area would be connected. There may be opportunities to expand the district heating networks further but any changes to the district heating networks would require a detailed analysis.



Locations of council homes in expanded district heating zones
Based on EPC data

The cost of expanding the district heating network and connecting these additional properties is estimated to be £1,500/dwelling for the hydraulic interface units and heat meters with an additional £200/MWh for the heat network[42]. Therefore, the cost of expanding the district heating network and connecting these additional council homes in Sheffield is expected to cost in the region of £3m. These costs do not include additional heat generation plant which would be required for an expansion of this scale. There may also be additional costs associated with upgrading systems within buildings. The total costs for expanding the district heating network would need to be estimated as part of a detailed study.

It is anticipated that it will start to be implemented from 2025 and will be delivered by 2030. This would mean that around 200 properties per year between 2025 and 2030 would need to connect into the district heating network.

In addition to the main district heating networks, there are approximately 6,000 council homes connected to 148 local heat networks. Over 85% of these local heat networks are supplied from a

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[42] DECC, Assessment of the cost, performance and characteristics of UK heat networks. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/424254/heat_networks.pdf

centralised gas plantroom and these properties have been considered in the next section on heat pumps.

4.6.3 Heat pumps

In areas that are not served by the two main heat networks, the existing gas-based systems should be replaced electric infrastructure. This will mean that fossil fuel-based heating systems are removed from all remaining council homes.

There are two main methods to transfer heat to electric infrastructure; through electric resistance heaters and elements or using heat pump technologies such as air source heat pumps (ASHP) or ground source heat pumps (GSHP). Heat pumps technologies are preferred as they have much higher efficiencies than both gas-fired boilers and electric resistive heaters. It is assumed that domestic heat pumps will have a coefficient of performance of around 3.3 compared with a typical gas-boiler that has an efficiency of around 85%, depending on the age, or near 100% for electric resistive heaters.

There is estimated to be in the region of 35,000 council homes with gas heating[43]. This figure includes the council homes that are connected to the local heat networks are fed from a centralised gas plantroom.

The gas boilers that are in individual homes could be replaced with air source heat pumps. Whereas, centralised air or ground source heat pumps might be better suited to the homes that are currently connected to gas-based local heat networks.

For heat pumps to work efficiently, homes will need to be well insulated and draught-proofed to minimised heat losses. Heat pumps produce heat at lower temperatures than traditional boilers and so emitters may need to be replaced to those better suited to operate at lower temperatures, such as underfloor heating or larger radiators.

Heat pumps are normally sized to suite the temperature required for both space heating and hot water, however, dedicated heat pumps for hot water are sometimes used.

The installation of heat pumps can also help to reduce local air pollution caused by other heating systems as heat pumps do not emit any NO_x, SO_x or particulate matter (PM) locally, all of which are key contributors to air pollution[44].

As with many of the proposed measures, case studies for adoption are often limited to pilot schemes or low volume trials with early adopters, such as the Freedom hybrid heat pump project in Bridgend[45]. Leeds City Council are developing six new district heating clusters to provide low-carbon heat for 26 council apartment blocks. The low-carbon heat options considered include the use of central air source heat pumps, central ground source heat pumps, and boreholes/ambient loops with individual heat pumps at each home. Acis Group are also currently looking into using heat pumps rather than gas in properties.

The cost of installing domestic heat pumps is expected to range between £5000 to £7000 per property, with an additional cost of approximately £2000 to replace heat emitters[46]. Therefore, cost of installing heat pumps across the council homes in Sheffield is expected to cost in the region of £280m.

The unit cost of electricity is higher than that of gas so despite the energy savings, the annual operation cost of heat pumps is expected to be similar or slightly higher to that of gas boilers[47]. The Council should lobby for the use of subsidies and grants to help address the operational cost difference between gas-boilers and heat pumps, especially for households where fuel poverty could be an issue.

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[43] Ministry of Housing, Communities & Local Government. Energy Performance of Buildings Data: England and Wales. [Online] 2020. https://epc.opendatacommunities.org/.

[44] Delivering net zero: a roadmap for the role of heat pumps, Heat Pump Association, 2019

[45] https://www.westernpower.co.uk/projects/freedom

[46] Element Energy for Department for Business, Energy and Industrial Strategy, Hybrid heat pumps.

[47] https://energysavingtrust.org.uk/renewable-energy/heat/air-source-heat-pumps

The Renewable Heat Incentive (RHI) is a government financing scheme to support renewable heating systems like heat pumps. Payments are provided based on the renewable proportion of the heat demand and the current domestic RHI tariff for air source heat pumps is 10.85p/kWh[48]. Other social housing landlords, such as Coastline Housing Ltd in Cornwall and Wrexham County Borough have installed heat pumps on properties are benefiting from the scheme[49].

It is anticipated this measure will start to be implemented from 2025 and will be delivered by 2030. This would mean that around 7,000 properties per year, with capital costs of around £50m, between 2025 and 2030 would need to have heat pumps installed. This equated to over 130 properties a week. The scale of this challenge will need action across all element of the supply chain, from system availability, installation and ongoing maintained.

As with switching to electric cooking, it is recommended that gas boilers are phased out when they reach their normal replacement cycle, which is typically 10-15 year. However, there is likely to a significant number of boilers that are still fully functioning that would need to be replaced ahead to meet the net zero carbon target.

It is also worth highlighting that new energy efficient gas central heating is planned for 12,000 homes as part of the Sheffield housing improvement project. To avoid the need to replace these new gas boilers in the near future a direct switch to heat pumps should be considered now. Installing heat pumps rather than the new gas boilers would avoid unnecessary costs associated with replacing the boilers with heat pumps before they become obsolete and it would also minimise disruption to tenants.

With regular scheduled maintenance, air source heat pumps are expected to operate for 20 years or more[50]. It is recommended that the council's in-house are trained appropriately heat pump systems so they can carry out inspections to ensure the heat pumps continue working efficiently. Maintenance costs are expected to decrease as the number of installations increase.

It is not a given that the current electrical infrastructure will be able to cope with the increase in demand cause by switching to heat pumps. The Council should hold discussions with local electricity infrastructure providers to understand the current and future plans for changes in capacity.

The tenants will also need support and education around the differences between the way systems deliver heat. The costs associated with tenant engagement will vary depending on the approach taken.

4.7 Generate renewable electricity

Energy efficiency measures are expected to help reduce the electricity demand through the mass roll out of LED lighting and the continued improvement in appliance efficiency. However, electrification of heating is required to reach the zero -carbon target, and this will increase the electricity demand.

The zero carbon by 2030 target can only be met if the grid is also decarbonised by 2030. The Council will be expected to support the decarbonisation of the grid by generating renewable electricity within the city.

4.7.1 Solar photovoltaics (PV)

PV panels convert sunlight directly into electricity. They are typically mounted on a roof and have higher efficiencies when oriented south.

Currently there are only a very small number of council home that have solar PV installed. However, there is the potential to generate up to 11 GWh of solar energy by installing solar PV on council homes within Sheffield. These building mounted PVs are estimated to reduce emissions by 1.3 $ktCO_2$.

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48 https://www.ofgem.gov.uk/publications-and-updates/domestic-rhi-tariff-table
49 https://www.ofgem.gov.uk/sites/default/files/docs/2015/03/drhi_case_studies_final_web.pdf
50 https://energysavingtrust.org.uk/advice/air-source-heat-pumps/

It was beyond the times and resources available for this study to carry out a full citywide solar analysis for the potential generation from PVs. As such, the assumptions are based on 20% (~4,000) of council houses being suitable to install a PV array, where a 3kWp PV array is expected to generate 2.7MWh/house/year[51].

This a modest estimate and could be increased to a higher proportion of properties but would require a more detailed analysis. Increasing the number of PV installations would likely mean accepting a slight reduced in the projected energy output per panel as the arrays would be installed on roofs that vary from the 'optimal' conditions (such as orientation, tilt, shading etc.).

The cost of installing photovoltaics is expected to range between £4,000 to £6,000 per 3kW array[52][53]. Therefore, cost of installing photovoltaics across 4,000000 council homes in Sheffield is expected to cost in the region of £20m.

Tenants could see a significant reduction in their electricity bills when the energy generated by PVs is used to supplement the household energy demand, helping to assist in tackling fuel poverty. If the PVs are generating excess electricity surplus to demand, it might also be worth investigating export payments from Smart Export Guarantee or diverting any surplus electricity to power the immersion heater in properties with hot water tanks.

It is anticipated that PV installation will start to be implemented from 2020 and will be delivered by 2030. This would require almost 400 installations per year at an annual cost of around £2m. There is an opportunity to install PVs as part of the planned roof renewal/roofline and roof repair work.

4.8 Directly deliver zero carbon new build homes

The Sheffield City Council New Homes Delivery Plan, published in 2018, sets out a plan to support the building of over 2,000 new homes a year over the next 5 years. As part of this plan, it is estimated that around new 1,500 council homes will be built by 2029.

In order to meet the zero -carbon goal, all new homes will need to be zero carbon and it is understood that Sheffield City Council are working towards this for the new homes that they are delivering. Sheffield City Council are also working with Active Building Center to look at achieving zero carbon for these new homes. 69 of these new council homes are complete and a further 241 are already onsite and have been designed using a fabric first approach and are achieving above Building Regulations standards. The fabric first approach has also been combined in some of the homes with the installation of MVHR systems and photovoltaic panel installations or designed with the correct roof orientation to accept a photovoltaic panel installation in the future.

However, it should be acknowledged that the new homes make up a small proportion compared to the number of existing homes and the impact of making these homes zero carbon will be minimal if efforts are not also made to reduce emissions from existing housing stock.

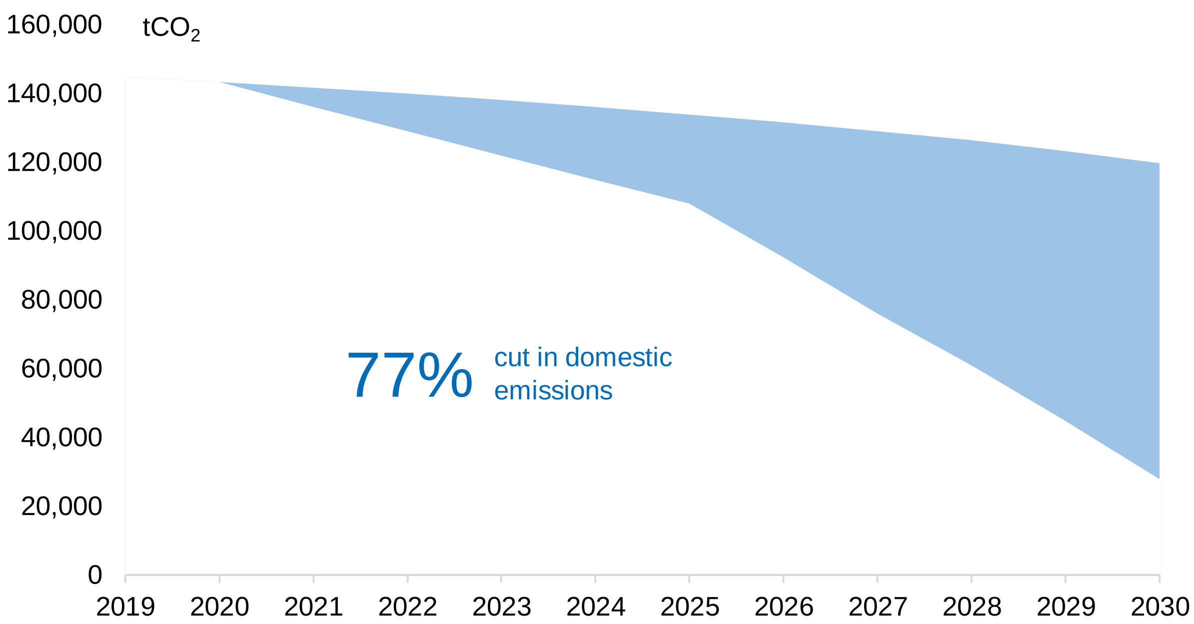
It is worth noting that all acquisitions will also need to be brought up to zero carbon standards by 2030, whether this be prior to the acquisition or remediation action after.

[51] https://globalsolaratlas.info/map.
[52] https://www.renewableenergyhub.co.uk/main/solar-panels/
[53] https://www.gov.uk/government/statistics/solar-pv-cost-data

4.9 Emissions impact

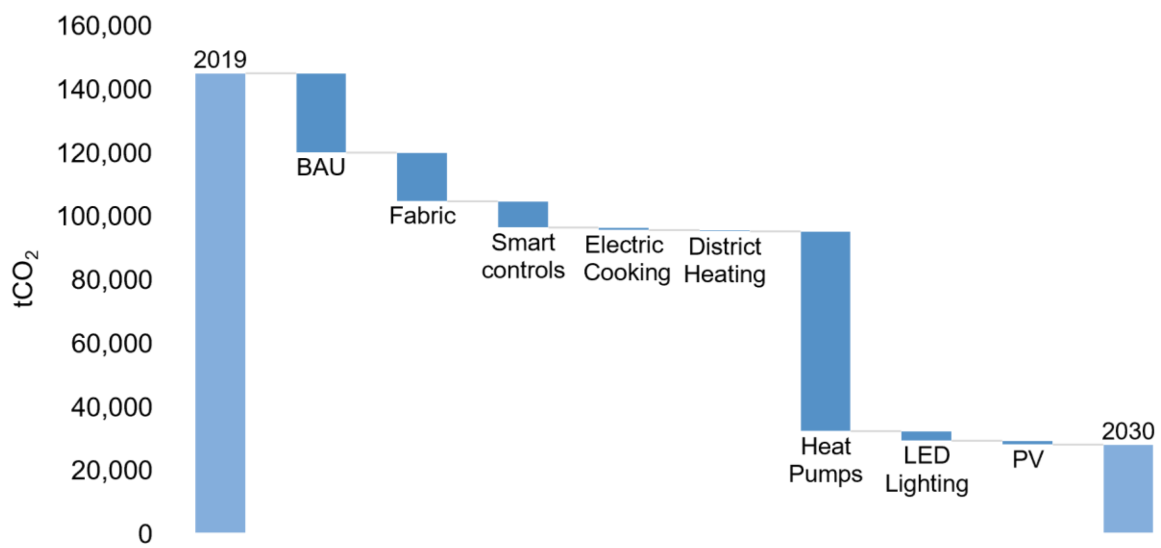
The measure proposed as part of the net zero strategy reduce emissions by 77% below the baseline in 2030, an 81% overall cut from 2019.

Domestic measures emissions pathway



The waterfall chart below shows the contribution of each measure category to the domestic emissions reduction. Heat pumps are the dominant measure, accounting for 68% of emissions reduction beyond the BAU baseline in the net zero pathway. The efficiency measures account for 17% with smart controls delivering an extra 9%. Roof top solar provides limited emissions savings of 1.4% in 2030 because the wider grid is also largely decarbonised at that point. Residual emissions in 2030 are 27,766 tCO_2.

Domestic emissions reduction by measure

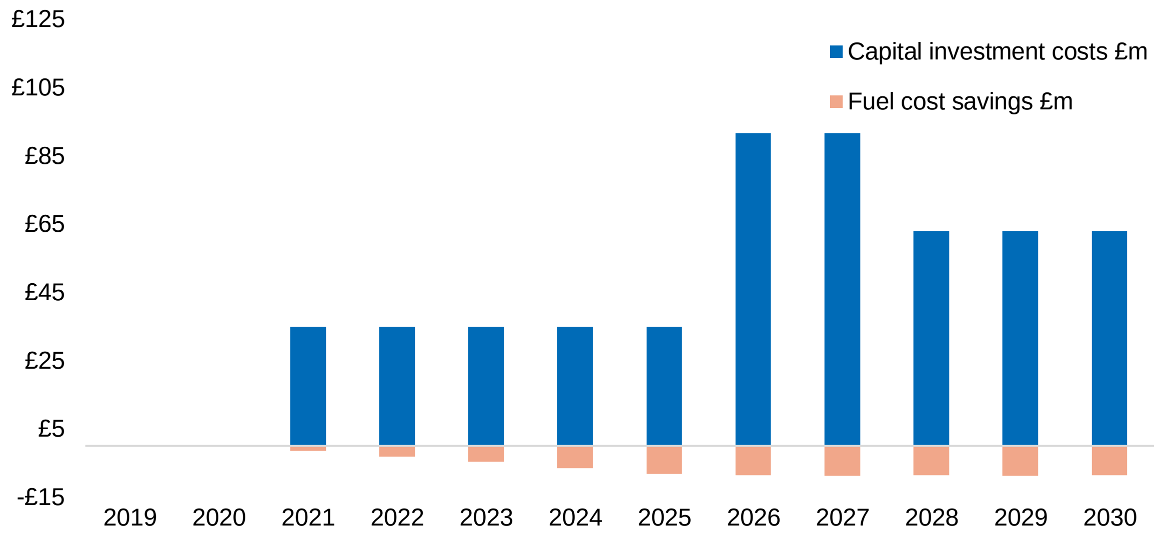


4.10 Cost assessment

We have undertaken a high-level cost assessment to give an indication of both the total capital investment required to deliver the domestic measures and the fuel costs relative to the business as usual baseline to 2030. More information and key cost assessment assumptions are provided in Section 9.

The in-year figures for capital investment costs and fuel costs are presented below. The total domestic capital investment costs to 2030 are estimated to be £547m. Fuel cost are predicted to fall by £67m, or about 13.9%, relative to the business as usual projection.

Estimated annual capital investment costs and fuel cost savings for the domestic sector 2019-2030



Heat switching measures begins in 2026 and accounts for the large increase in capital investment costs from then onwards. Prior to that the efficiency measures, such as fabric improvements and smart heating controls, for both houses and flats make up the bulk of capital investment costs.

4.11 Actions summary

The key measures that the council should take to decarbonise social housing fall into the following categories:

- Improve the fabric of homes
- Reduce energy consumption in homes
- Remove fossil fuels
- Generate renewable electricity
- Directly deliver zero carbon new builds

Below are priority actions that the council can take to achieve this. Work on these should begin without delay. The proposed actions are described in more detail in Section 10, along with actions which apply across sectors.

Domestic priority actions	**Short** Up to 2022	**Medium** 2023-2026	**Long** 2027-2030
Launch a programme of detailed energy surveys and technical studies to underpin the zero carbon retrofit measures.	●	●	
Develop an intensive programme of works on Council-owned domestic properties to kick-start an increased local delivery pipeline.	●	●	
Require that all new social homes are zero carbon	●	●	
All Council acquisitions to be brought up to zero carbon standards		●	●
Secure funding from BEIS via innovation and/or energy programmes, such as the Social Housing Fund, Whole House Retrofit Programme, and the forthcoming and Net Zero Innovation Programme.	●		
Scale-up a whole house approach to net zero retrofits, delivering a comprehensive package of measures together.		●	
Initiate discussion with local electrical infrastructure providers to understand how capacity impacts on meeting zero carbon target (such as electrified heating) and develop a programme of strengthening works.	●	●	
Work with commercial partners in district heating sector to develop a detailed heat study for expanding heat networks	●	●	

5 Non-domestic

This section presents the results of energy & emissions modelling for non-domestic properties owned by the council. It includes an analysis of emissions projections, identification of net zero mitigation measures and an assessment of the impact on emissions.

5.1 Introduction

Sheffield City Council have a buildings estate which includes the expected mix of civic buildings including schools & libraries as well as operational buildings like offices and workshops.

The council's Transport and Facilities Management team have provided building asset management information along with energy consumption records for 2017-2019. Publicly available Display Energy Certificates (DEC) have been sourced to provide information on heating system and fabric energy efficiency. Together, they provide a high level understanding of the building's energy performance in the 2019 base year, covering the following attributes:

- Building category
- Heat and power demand
- Fabric energy efficiency
- Existing heating system
- Heat & DHW demand category
- Listings
- Existing PV
- Solar potential
- Access to gas grid
- District heating potential

5.2 Boundary and scope

The non-domestic analysis incorporates buildings that are owned and managed by the council. This is where the council has responsibility building services and therefore has the ability to directly address emissions. A substantial subset of buildings owned by the council are operated and managed by the lessee, tenant or other party. In these cases, as with Academy Schools and PFI arrangements for example, the council's ability to influence energy use is limited. Contractor owned buildings are not included within the boundary.

Scope 1 and 2 emissions associated with the operational use of buildings are included. Scope 3, embedded construction and operational emissions are excluded.

Some buildings within the council's control have also been excluded. This includes vacant buildings, small sites like cabins and pavilions as well as sites with no recorded energy data.

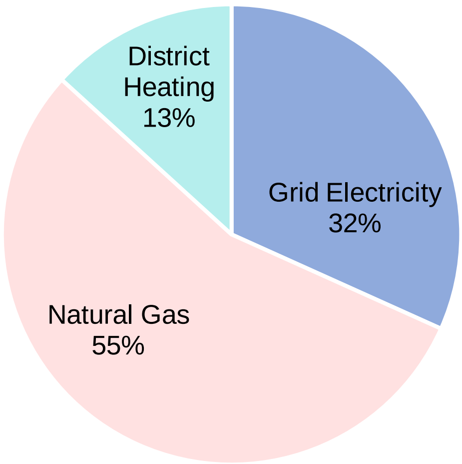
5.3 Energy use analysis

122 establishments comprising one or more buildings fall into the scope of the non-domestic assessment, 19 of which are listed buildings. These represent a wide range of building constructions, sizes and uses. They have been categorised into groups for analysis:

	Count
Schools	52
Community use	34
Office	17
General Industrial	5
Cultural	14

The total energy consumption for the 43,716 MWh, of which approximately 2/3 is for heating and 1/3 for power as shown below. The buildings supplied by district heating are located in the city centre and are connected to the energy from waste facility.

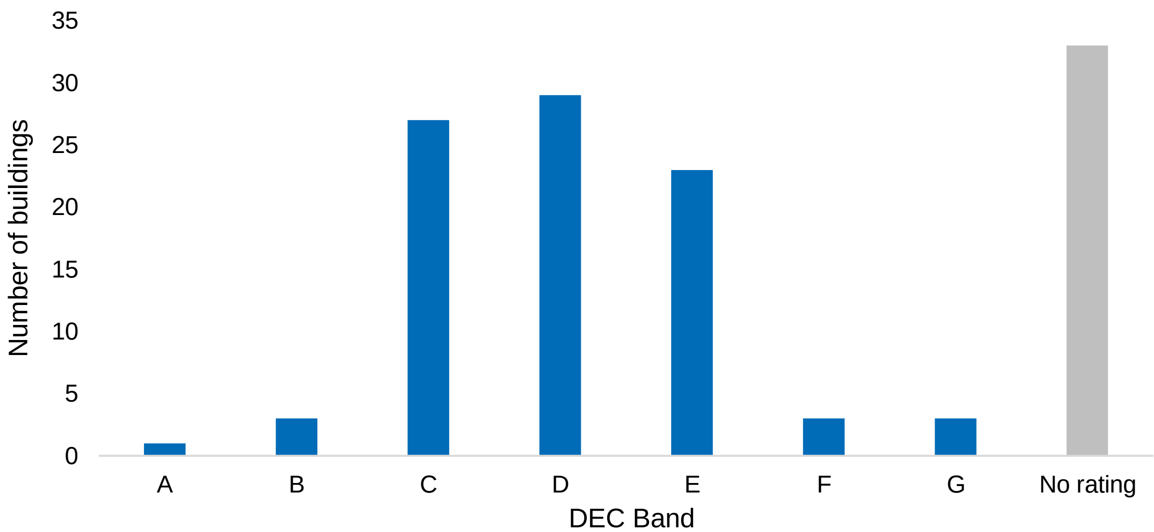
Non-domestic energy use by fuel



There are currently only two small rooftop installations, at Jordanthorpe and Moonshine Lane Housing Offices, generating 4,700kWh per year, meeting 0.034% of electricity demand in the non-domestic estate.

DEC operational rating bands were used to determine which buildings are suited to each efficiency and fabric package. The figure below shows the distribution of DEC bands across the stock, with the majority between C and E. Note that the 33, typically smaller buildings, without DECs were assumed to be D rated in the modelling.

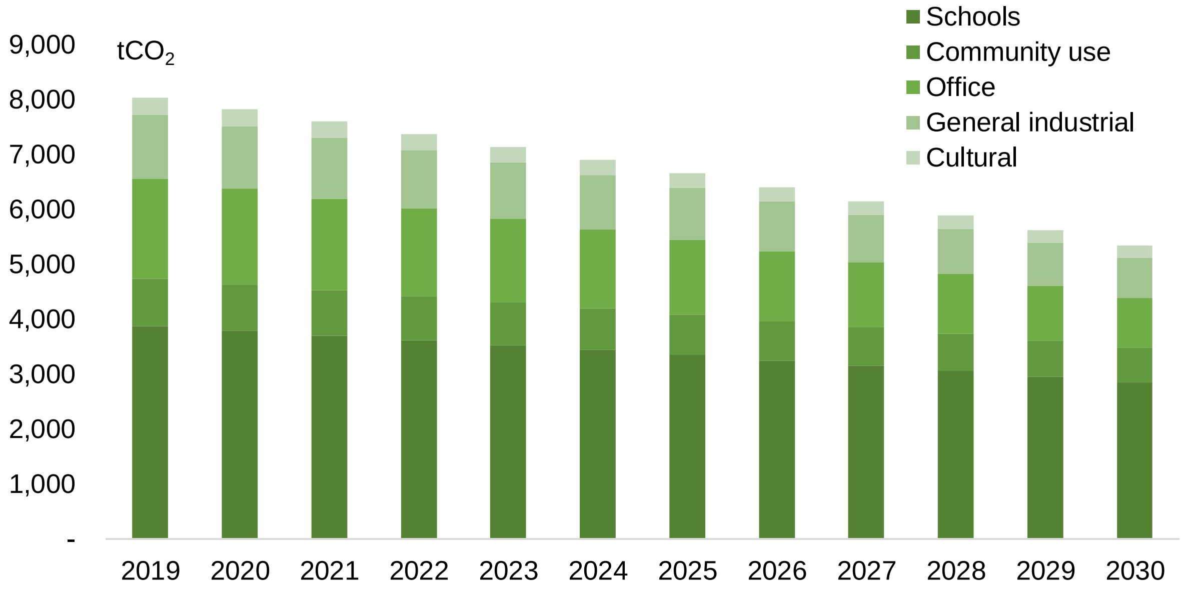
Number of buildings by DEC operational rating band



5.4 Baseline projection

Carbon emissions in 2019 are estimated to be 8,040 tCO_2. The baseline projection reflects wider trends in energy system decarbonisation. A nominal underlying improvement in energy use has also been assumed, reflecting wider economic trends. We have assumed that the stock and present uses of buildings remains unchanged. Together, these means total emissions are expected to fall to 5,346 tCO_2 by 2030, a reduction of 34%.

Non-domestic emissions baseline, by building type



5.5 Options identification

There are a range of emission reduction measures that can be implemented in buildings which utilise mature, well understood and often relatively readily implementable technologies. These are listed below and have been grouped into the following measures packages:

1. Energy management: Measures that reduce unnecessary energy use.
2. Lighting and controls: Low energy lighting and improved heating and electrical controls.
3. Fabric lite: Lower cost and less intrusive measures to improve the building fabric.
4. Fabric deep: A comprehensive package of fabric measures which can transform the energy performance of a building when deployed together.
5. Heating replacement: Switching the existing fossil fuel heating system for a low or zero carbon alternative.

This should not be taken as an exhaustive list as there may be building specific measures that can and should be implemented, which can be identified by site staff or an energy audit. Key modelling assumptions are included at the measures package level below.

5.5.1 Energy management

These are measures that reduce unnecessary energy use. This package of measures is assumed to reduce building heat and power demand by 7.5% on average (5-10% range). The cost per building is £2,000, assuming the measures are deployed at scale. This includes behaviour change programmes and submeters at £500 each with engineer’s time (@£500 per day) to install and optimise systems.

5.5.1.1 Staff education

This is measure would educate staff in how to save energy including posters, guidance documents, training such as webinars and targeted training for individuals with greater control over energy consumption.

5.5.1.2 IT Policy

An IT policy can assist in saving energy by outlining best practice for energy saving measures such as utilising hibernation mode and automatic shutdown after a period of inactivity on devices. It can also include energy efficiency requirements for the purchasing of new equipment.

5.5.1.3 Energy efficiency equipment

The considerations of energy efficiency when purchasing new equipment can assist in decreasing a buildings energy consumption. It is recommendable to include energy efficiency requirements in any procurement policies.

5.5.1.4 Monitoring

This is the proactive review of the buildings energy data to identify areas of wastage, such as out of opening hours energy use, and increasing consumption trends. This is assisted by there being individuals who are accountable for the building's energy consumption, either at site or in a central role.

This could be used to inform the site of their energy consumption to enable them to investigate and act upon changes in consumption or to produce league tables of energy consumption by building category in order to encourage reductions.

There are many suppliers that offer online energy platforms with remote logins and varying levels of access which would facilitate this.

5.5.1.5 Submetering

Submetering on key energy using areas of equipment (such as ventilation and cooling systems) can assist in identifying unnecessary consumption by providing better granularity of data and so better visibility of consumption trends.

5.5.1.6 BEMS (building energy management system)

Modern BEMS / Energy Management software packages are effective tools to both reduce energy consumption and sustain savings made. It is commonplace for energy management teams to rely heavily on these tools to track energy consumption, analyse performance, set targets and trigger alarms when deviations occur to facilitate interventions.

5.5.2 Lighting and controls

Low energy lighting and improved heating and electrical controls, along and minor building energy upgrades. This package of measures is assumed to reduce building heat and power demand by 12.5% on average (10-15% range). The capital investment cost is assumed to be £1.5/m^2 plus £1,500 per building. This includes 1 light fitting per 5m^2 with 50% requiring conversion to LED, and plant room insulation or equipment improvements.

5.5.2.1 LED lighting and motion / daylight controls

The installation of LED lighting with appropriate controls can realise significant energy savings in comparison to other lighting technologies. LED lighting comes with the dual benefit of reduced energy consumption (up to 75%) and longer lamp lifetime (often with extended warranties). Incorporating motion and / or daylight sensors as part of the lighting controls will assist in ensuring lighting is only on when needed.

5.5.2.2 Heating / cooling policy and controls

Having a heating / cooling policy clearly sets out best practice and helps to reduce wastage. This can be recommended temperature setpoints by building activity level (available from sources such as CIBSE and the carbon trust), correct siting of temperature setpoints, avoiding simultaneous heating and cooling by the incorporation of a 4 degree dead band, holiday shut-downs and expected operational times.

Heating / cooling control systems can also be improved by ensuring heating / cooling is zoned by activity level and / or by areas with greater and less solar gains to ensure each area gets the correct level of heating / cooling. Weather compensation could also be incorporated into the system.

5.5.2.3 Plant room and pipe insulation

In order to ensure heat is not dissipated from a heating system in any unheated areas (such as plantrooms) pipework should be properly insulated. Removable insulating covers are also available for valves and flanges.

5.5.2.4 Heating, ventilation and cooling system improvements

There are multiple ways to improve heating, cooling and ventilation systems to ensure they operate more efficiently including pump replacement, proactive maintenance and replacing aging equipment. In some instances where the hot water is provided by the main heating system in may be more efficient to move to instantaneous point of use hot water heaters, for example where there are long pipe runs or the boiler is running at a less efficient lower capacity when just providing hot water.

5.5.3 Fabric lite

This covers lower cost and less intrusive measures to improve the building fabric. These targeted measures would be established on a site-by-site basis through energy audit's using a thermal camera. It is likely to include loft and/or cavity insulation and draught proofing with ad hoc replacement of doors and windows. This package of measures is assumed to reduce building heat demand by 7.5% within a 5-10% range. The cost is assumed to be £17.5/m^2 of floor area, within a range of £15-20/m^2.

5.5.3.1 Thermal survey

Thermal imaging cameras can be used to identify areas of heat loss from a building. These are available for purchase or hire with costs depending on their level of functionality. Accessories to utilise phones as thermal imaging cameras are also available.

5.5.3.2 Loft and cavity wall insulation

Loft insulation and cavity wall insulation reduce heat losses from a building. Retrofits can be undertaken at relatively low cost without significant disruption to the site,

5.5.3.3 Replacement doors and windows

Damaged, aging and ill-fitting windows and doors can be a significant source of air infiltration. These can be easily identified in a thermal survey. Repair or replacement with a modern equivalent as needed can deliver substantial savings alongside other benefits.

5.5.3.4 Draft blockers and seal

Draft blockers and seals on doors, windows or other areas can reduce heat loss from the building and so energy consumption. These could be identified using the thermal survey s

5.5.4 Fabric deep

A whole building package of fabric measures which can transform the energy performance of a building when deployed together. This package of measures is assumed to reduce building heat demand by 20%, within a 10-30% range. The cost is assumed at £50/m^2 floor area (£40-60/m^2 range. While all costs can vary considerably, the cost of these fabric measures are particularly site by site dependent and are indicative only.

5.5.4.1 Fabric insulation

Internal or external wall insulation is applied to the building, decreasing heating energy consumption in conjunction with loft or roof insulation. Thermal bridging and air tightness and strictly managed through the retrofit process.

5.5.4.2 Door replacement and secondary doors

The replacement of doors with those which lose less heat through them can reduce heat losses from a building. The inclusion of a second set of doors to create an unheated lobby can also reduce heat losses from a building, especially where the doors are frequently used.

5.5.4.3 Window replacement

Systematic replacement of windows to efficient double glazed units (metal or uPVC frame) can reduce heat losses from a building, as well as air infiltration.

5.5.4.4 Solar film and solar shades

For buildings where large solar gains increase the use of air conditioning, then solar shades or solar film to the building windows can help decrease energy consumption.

5.5.5 Heating replacement

Switching the existing fossil fuel heating system for a low or zero carbon alternative. District heating and heat pumps have been described above in Section 4.6.

In addition direct electric heating is also considered for smaller, low use buildings where the cost and disruption of changing the internal distribution system and emitters make heat pumps less viable.

5.5.6 Heating technologies not taken forward

A number of potential heating technologies have not been included in our analysis.

5.5.6.1 Solar hot water

Solar hot water is typically a supplementary source of heating rather than a primary replacement for a fossil fuel system. A heat pump or other low carbon source would still be required.

5.5.6.2 gas CHP

No new build gas CHP is included. In the context of net zero it should be considered a high carbon supply. It is assumed that gas boilers would be used temporarily while awaiting future connection to a low carbon district heating network. Heat networks should be moving rapidly towards zero carbon fuels and new gas CHP is not consistent with that.

5.5.6.3 Individual biomass boilers

Individual biomass boilers are not included on both air quality grounds and with regard to the availability of sustainable fuel supply.

In addition to local air quality concerns, sustainable low-carbon biomass is a flexible and finite resource. The wide range of possible uses of biomass in energy generation means that demand is likely to exceed sustainable supply on a UK and a global level. This means decisions will need to be made as to where this finite biomass resource is best used across the economy, with priority given to uses that give the greatest overall levels of emissions abatement. The Committee on Climate Change's *Biomass in a Low-Carbon Economy*[54] sees only limited use of biomass to heat buildings with use in timber for construction and biomass energy with carbon capture and storage

5.5.6.4 Hydrogen

It is assumed that any widespread uptake of hydrogen as a heating fuel in buildings comes later - mid 2030s onwards. It does not feature in our analysis as a result. However, where it is possible that properties could still be connected to the gas network in 2030 then the installation of hydrogen ready boilers when available in 2020s would represent a low-regret way to future proof gas heating.

[54] CCC, Biomass in a low-carbon economy 2019

5.6 Approach to net zero approach

5.6.1 Heat supply

To reach net zero, all sources of emissions need to be tackled. However, in buildings the principal challenge is to end the use of fossil fuels for space heating and hot water. A heat-led approach to non-domestic buildings has been taken, which identifies what is likely to be the most cost effective and least disruptive low carbon heating source as a starting point. The options considered are:

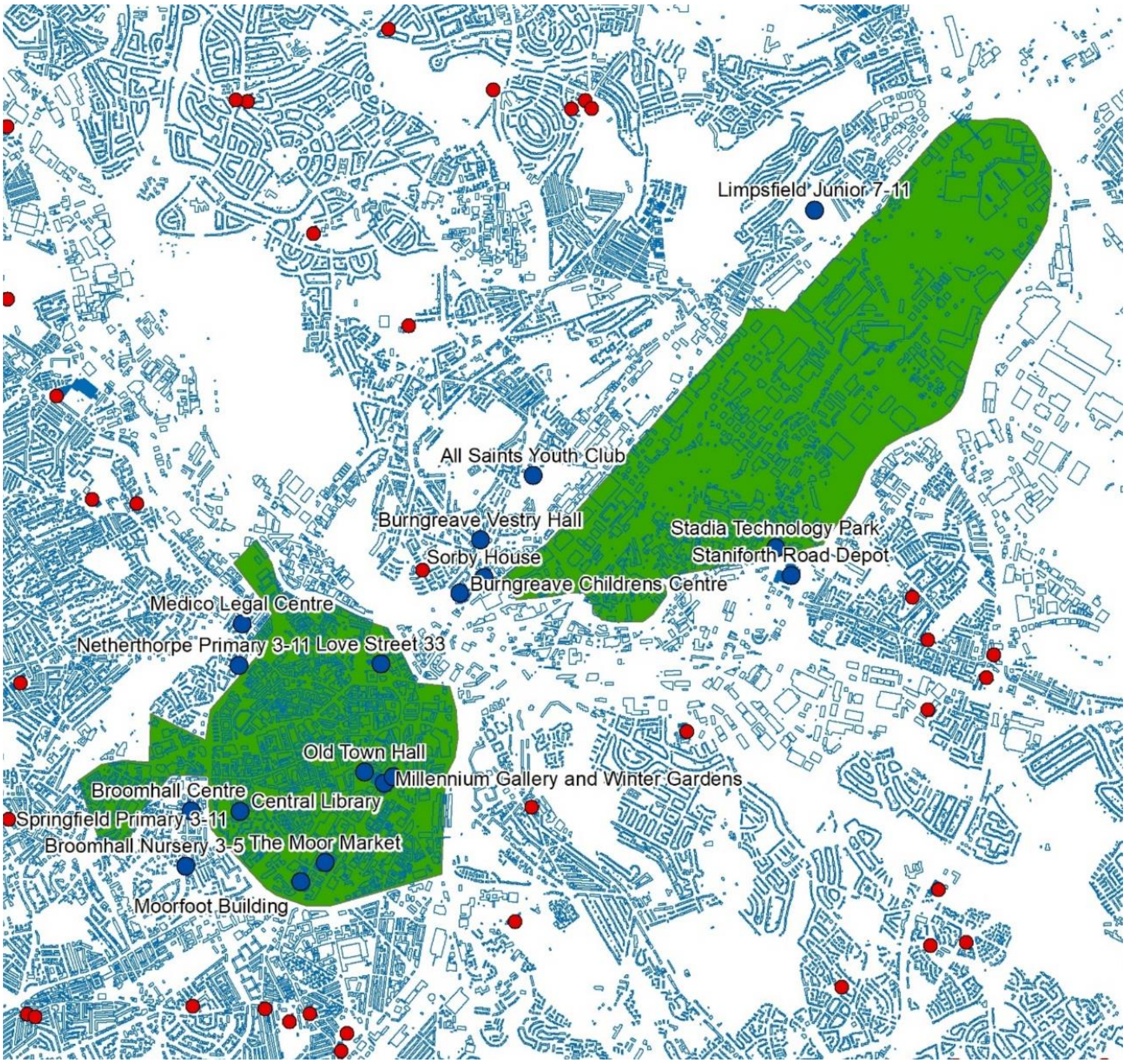
1. District heating: Connection to a low carbon district heating network is the preferred option where a connection is available. It is often less costly to connect and is less disruptive, with no change to the internal plumbing and emitters required.
2. Individual heat pumps: The preferred option where district heating is not available. Retrofit heat pumps can be disruptive and expensive to fit. They are only effective in buildings that are relatively efficiency and airtight. The low temperature heat generated mean new emitters are often required.
3. Direct electric heating: The lowest capital cost option, suited to buildings with low heat demand or where heat use is infrequent.

Heating system modelling assumptions by availability of a district heating connection and heat demand

District heating	Heat and DHW demand	Heating system
Connection available		District heating
No connection	High	Heat pump
	Med	Heat pump
	Low	Direct electric

Spatial analysis has been used to identify the buildings that are located in the two main district heating networks in Sheffield; the City Centre Zone supplied by the energy from waste heat network and the Don Valley Zone supplied by biomass combined heat and power (CHP) heat network. It assumed that council buildings within 400m of the zones could connect, potentially acting as a catalyst to extend the infrastructure to more areas of the city.

Spatial analysis showing non-domestic buildings in relation to district heating zones. Blue points are connected to the network by 2030, if not already.



This spatial analysis indicates that an additional 14 buildings would connect to the networks (seven in the city centre and seven in Don Valley), amounting to 4,059 MWh per year of heat demand. The capital investment cost for the within building heat exchange manifold & metering is £208,000. This does not include the cost of connection the distribution network, which is likely to be the more significant cost element but is location dependent.

Direct electric is potentially suited to 17 buildings in the dataset, which are the smallest community use buildings and school buildings like nurseries. The capital investment cost for the heating units is £84,000.

The remaining 83 buildings in the dataset are assumed to require individual heat pumps, replacing natural gas demand of 17,678 MWh. The costs of the heat pump units are estimated at around £4.6 million, based on £950/kW system costs.

In many cases, the heat emitters and internal distribution pipework or ducting will also need to be upgraded so that heat pumps can provide thermal comfort and operate efficiently. The approach will vary significantly between buildings as existing emitters, distribution and space available will all need to be taken into account. For example:

- Existing radiators can be replaced with oversized radiators, or fan assisted radiators where fabric efficiency is low.
- Existing centralised systems with air handling units may need to be replumbed or alternatively an additional a refrigerant circuit can be added. New emitters, either wall units or ceiling

cassettes would be required. This approach can allow for heat recovery between rooms and can offer cooling.

- Existing underfloor systems, as in many modern post-2000 schools, can be adopted. Retrofit underfloor heating can be an effective option in historic and solid wall buildings where high outputs at low temperatures are required.

Limited good quality emitter and distribution cost data is available. We have drawn from the recent report, Heat Pump Retrofit in London[55], which has analysed the costs and performance of retrofits in 15 real buildings, which includes offices and a library. Costs vary between £13.79/m^2 (2,413m^2 office) and £88.16/m^2 (500m^2 library). We have used the value for a small office(~800m^2) for the cost assessment, £26.50 per m^2 because it is considered most representative of the council's building stock.

Estimated non-domestic emitter and distribution costs are £3 million, in addition to the £4.6 million, for the heat pump units themselves. The cost of upgrading building fabric to a suitable performance standard is discussed and accounted for below.

5.6.2 Building fabric

This then helps to prioritise the level of energy efficiency investment. Improving the fabric energy efficiency of buildings reduces their heat demand and makes them more comfortable. In general, fabric improvements are targeted at the buildings which are least energy efficient. However, deep retrofits can be disruptive & expensive, with high abatement costs. As a result, they are most important in inefficient buildings that will be switched to heat pumps. In order for heat pumps to work effectively, they need to be deployed in well insulated and airtight buildings with emitters designed for a low temperature heat supply.

Where buildings are already relatively efficient, the fabric lite package is considered sufficient. Fabric lite is also assumed to be appropriate for listed buildings. Further improvements may still be worthwhile with heat pumps. This will deliver the greatest benefit, with improved heat pump operation and comfort. Replacing the internal emitters and heat distribution system may be required and creates an opportunity for these measures to be undertaken.

Fabric packages modelling assumptions by existing building fabric efficiency

DEC rating	Fabric Lite	Fabric deep
Not efficient (D-G)		✓
Efficient (A-C)	✓	

5.6.3 Energy management & building services

It is assumed that best practice energy management measures are rolled out across all buildings. Buildings services measures are rolled out to all D-G rated buildings. These measures, like LED lighting and efficient HVAC, are assumed to be in place in the most efficient buildings already.

Energy management & building services modelling assumptions by existing building fabric efficiency

DEC rating	Energy management	Buildings services
Not efficient (D-G)	✓	✓
Efficient (A-C)	✓	

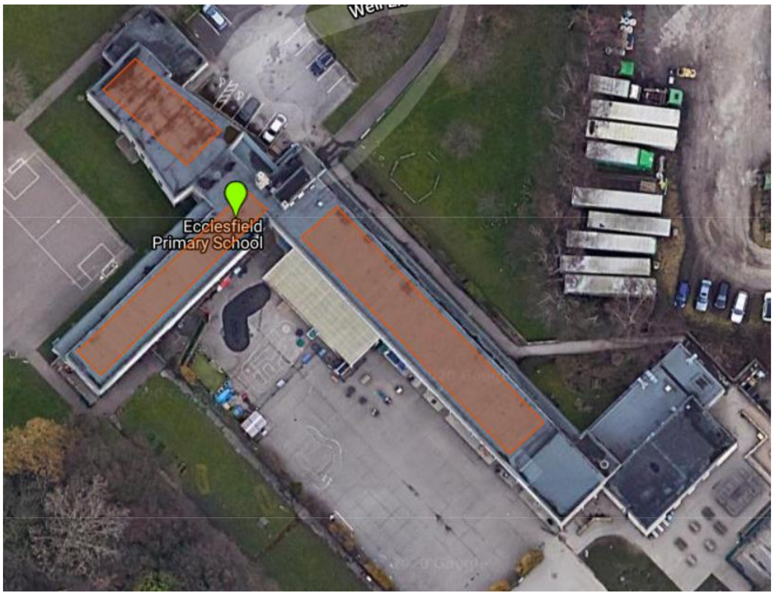
The packages of energy efficiency measures proposed reduce electricity demand by 18-24% and heat demand for heating by 22-34% at a cost of around £3 million.

[55] https://www.london.gov.uk/sites/default/files/heat-pump-retrofit-in-london-v2.pdf

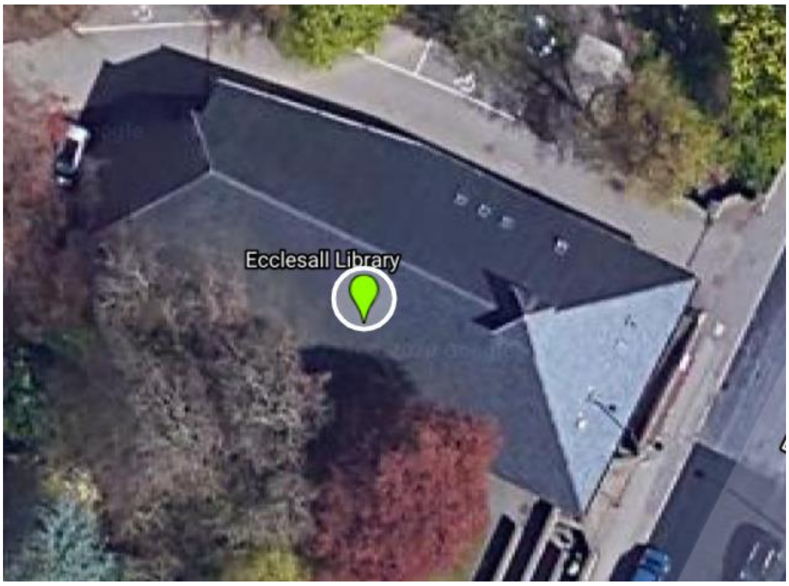
1.1.1 Roof top solar

Opportunities for roof top solar should be maximised across the entire non-domestic building estate. Solar PV is a widely used and mature technology that can be incorporated into many types of building. Larger buildings with unobstructed flat or pitched roofs are the most promising. Some building types have building plant at roof level which limits any potential.

We have assumed that 10% of non-domestic roof space will be suited to solar PV based on a visual analysis of roof space at 20 representative council buildings (examples below). This takes account of factors like orientation, obstructions and overshading as well as buildings that will be entirely unsuited because of their age or historic status.



Ecclesfield Primary: 33% - 1890m^2 total roof space, 620m^2 estimated usable, Google Earth



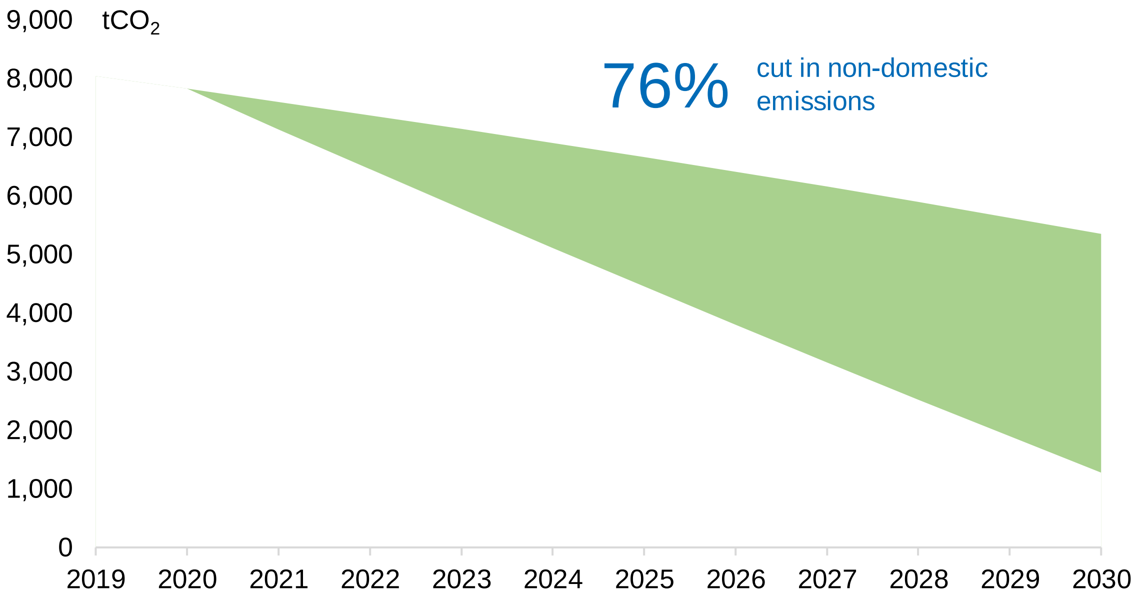
Ecclesall Library: 0% - 530m^2 total roof space, 0m^2 estimated usable, Google Earth

In Sheffield 856kWh/kWp can be generated, reflecting irradiation levels and a range of installations at 30 deg from SE to SW facing. It is estimated 21,700m^2 of panels could be installed on council buildings, which would generate 3,145MWh per year. The capital investment cost for 3.6MW of large rooftop solar is estimated to be £3.25million.

5.7 Emissions impact

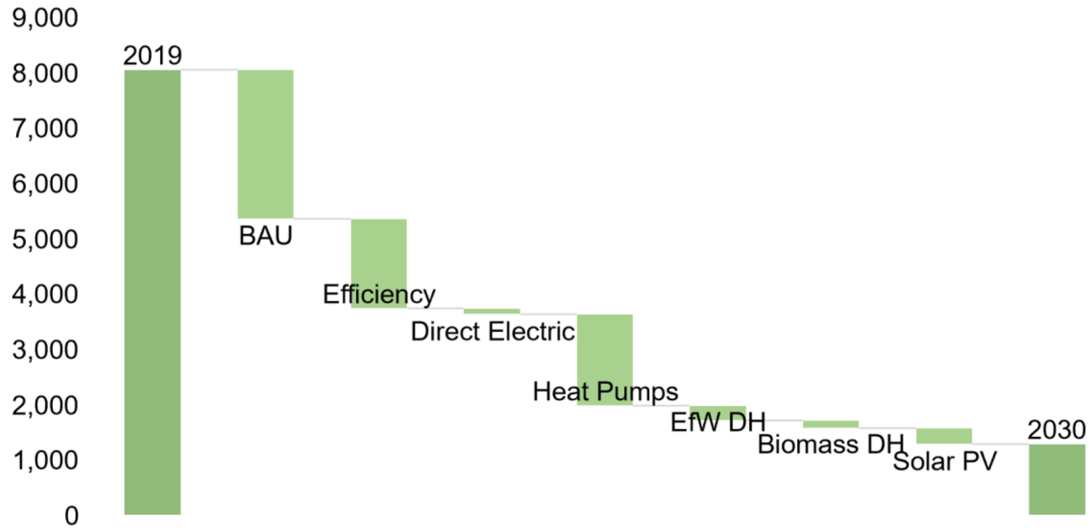
The measures proposed as part of the net zero strategy reduce emissions by 76% below the baseline in 2030, an 84% overall cut from 2019.

Non-domestic measures emissions pathway



The waterfall chart below shows the contribution of each measure category to emissions reductions. The efficiency measures account for 40% of savings over the BAU baseline but also play a key enabling role in the adoption of heat pumps (41%), which are only effective in relatively efficiency and airtight buildings. The overall contribution of reductions from other heating sources is smaller at 12%. However, these are lower cost and less disruptive measures and should be taken up as far as possible. Roof top solar can reduce non-domestic emissions by a further 7.3% in 2030. Residual emissions in 2030 are 1,274 tCO_2.

Non-domestic emissions reduction by measure

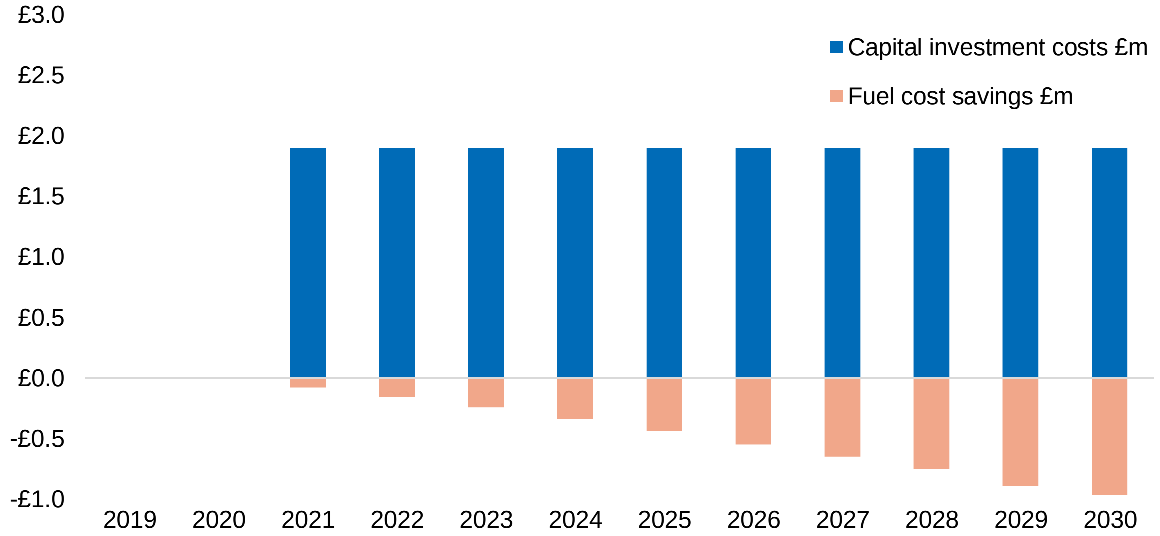


5.8 Cost assessment

We have undertaken a high-level cost assessment to give an indication of both the total capital investment required to deliver the non-domestic measures and the fuel costs relative to the business as usual baseline to 2030. More information and key cost assessment assumptions are provided in Section 9.

The in-year figures for capital investment costs and fuel costs are presented below. The total domestic capital investment costs to 2030 are estimated to be £19m. Fuel cost are predicted to fall by £5.1m, a 17% reduction relative to the business as usual projection.

Estimated annual capital investment costs and fuel cost savings for the non-domestic sector 2019-2030



The measures applied to schools make up the majority of the total capital investment costs, amounting to £9.6m in total across the 10 years.

5.8.1 On-going costs

The cost assessment indicates a fuel cost saving from both reduced energy demand and the increased efficiency of heat pumps, overcoming the higher cost of electricity relative to natural gas.

In addition, the on-going maintenance costs air source heat pumps (likely to be the most common) should be lower than for existing gas boilers over their lifetime. Pumps and filters will need to be checked and periodic F-gas checks will be required, depending on the refrigerant. However, higher costs should be expected in first two years for extended commissioning and optimisation. Good monitoring and data collection are essential to resolving common commissioning issues and a Metering and Monitoring Service Package (MMSP) should be a pre-requisite for all installations. Ground source heat pumps also have low on-going costs, but where there is an issue, it can be more expensive to resolve, particularly with open loop systems.

While specialist maintenance contractors will likely be required in some roles or for bespoke systems, existing maintenance teams can be trained to take on a growing set of responsibilities, particularly where standardised or packaged heat pump solutions are deployed. Operational monitoring roles can also be taken on. Adopting a consistent metering and monitoring package across the portfolio will allow effective oversight and feed into on-going optimisation and review process.

5.9 Actions summary

The key measures that the council should take to decarbonise its non-domestic building stock fall into the following categories:

- Reduce energy consumption through energy management, low energy lighting & controls.
- Adopt a heat-led approach by identifying the most cost effective and least disruptive low carbon heating source available. This means connecting to an existing district heating network where available. The primary alternative is an individual heat pump.
- Improve building fabric and air tightness. Fabric measures which are likely to be cost effective should be undertaken across the stock.
- A whole building fabric approach should be considered for the least efficient buildings. Addressing heat loss and air tightness are essential for the effective operation of heat pumps. These should be installed as part of a wider refurbishment as changes to internal pipework and emitters is likely.
- Generate renewable electricity from roof top solar arrays

Below are priority actions that the council can take to achieve this. Work on these should begin without delay. The proposed actions are described in more detail in Section 10, along with actions which apply across sectors.

Non-domestic priority actions	**Short** Up to 2022	**Medium** 2023-2026	**Long** 2027-2030
Deploy BEMS, AMR, permanent submetering and temporary energy loggers on all buildings. Use data analysis to target energy management and low-cost building energy measures.	●		
Develop an intensive programme of works on Council-managed non-domestic properties to kick-start an increased local delivery pipeline.	●	●	
Pilot whole building net zero retrofits, delivering a comprehensive package of measures together.		●	
Develop a long-term energy masterplan that integrates heat, power and transport energy vectors for a building or cluster of buildings with large or complex energy needs.	●	●	
Scale-up the existing revolving energy efficiency fund and align it with the approach to net zero buildings. This could include grant funding from Public Sector Decarbonisation Scheme and the city's investment budget.	●	●	

6 Fleet vehicles

This section presents the results of energy & emissions modelling for fleet vehicles owned by the council and operated on its behalf by key contractors. It includes an analysis of emissions projections, identification of net zero mitigation measures and an assessment of the impact on emissions.

A diverse fleet of 1,145 vehicles is operated by Sheffield City Council and its two principal contractors; Amey and Veolia.

The Sheffield City Council fleet is made up of around 900-950 road vehicles. The largest segment is vans followed by cars and buses (including minibuses used for school transport), while the smallest segment is trucks. The vast majority of the fleet is diesel, although the car segment has some electric and hydrogen vehicles, including several electric vans. Around 10% of the bus and minibus fleet are leased, while all other vehicles are owned. The fleet carries out a range of services including city wide emergency care alarm services, parks, housing and parking.

Amey operates the Streets Ahead Highways Maintenance and Management service across Sheffield. This is a 25-year programme (2012-2037) that covers both highway maintenance and a street cleaning service. The 170-vehicle strong Amey fleet is mainly comprised of vans and trucks, although there are also a significant number of large specialist vehicles such as gritters and sweepers. There are only 5 cars in the fleet.

Veolia provide waste disposal services across Sheffield that include household waste collection and operating recycling sites. Veolia operate the smallest of the three fleets with 60 vehicles. As expected, the majority are refuse trucks (large specialist).

6.1 Boundary and scope

The scope of this fleet analysis is limited to the vehicles that are operated by SCC, Amey and Veolia. Grey fleet is not included. Annual emissions from these vehicles are calculated from data on the annual fuel consumed and emission factors for each vehicle and fuel type. The vehicles span a wide range of segments, makes and models, and so they have been placed into five vehicle type categories. Aside from the electric and hydrogen vehicles, over 90% of the vehicles in the fleet are diesel.

Fleet analysis scope

Fleets	Vehicle segments	Fuel types	Impact categories
Sheffield City Council	Car	Diesel/petrol	Annual CO_2 emissions
Amey	Van	Electric	
Veolia	Trucks	Hydrogen	
	Buses		
	Large Specialist		

6.2 Energy use analysis

The first step to estimate the energy usage of the existing fleet was to analyse the various datasets provided by the three fleet operators and generate counts of vehicles by segment and fuel. The table below provides a breakdown of the total fleet. The van segment is by far the largest segment, followed by cars, buses and trucks. Large specialist vehicles form over 80% of the Veolia fleet, but it is the smallest overall segment. SCC operates 18 electric cars while Amey has a similar number of electric vans. In total, the number of electric and hydrogen vehicles makes up less than 4% of the total fleet.

Fleet base year size analysis

Segment	Fuel Type	Number of vehicles in SCC fleet	Number of vehicles in Amey fleet	Number of vehicles in Veolia fleet	Total vehicles
Cars	Diesel/petrol	202	5		**207**
	Electric	18			**18**
	Hydrogen	5			**5**
Vans (<3500kg)	Diesel/petrol	375	29	6	**410**
	Electric	5	22	2	**29**
Trucks	Diesel/petrol	101	79		**180**
	Electric	0			**0**
Bus/minibus	Diesel/petrol	209			**209**
	Electric	0			**0**
Large specialist	Diesel/petrol	0	35	50	**85**
	Electric	0		2	**2**
All	**All**	**915**	**170**	**60**	**1,145**

The next step requires the calculation of annual fuel consumption for each vehicle segment. Fuel consumed is the primary unit that has been used to describe the energy use of the diesel and petrol vehicles. In the model, this is converted into a kWh value to calculate the emissions. For electric and hydrogen vehicles, a kWh value has been calculated from the annual mileage using an average efficiency conversion factor. The table below shows that despite having the smallest segment size, the large specialist vehicle segment has the largest annual fuel consumption, primarily as a result of low efficiency associated with the type of operations the vehicles are used for (typically refuse collection). Due to their higher efficiency, the total annual fuel consumption of the car fleet is the lowest of any segment.

Fleet base year activity and energy use analysis

Segment	Fuel Type	Total vehicles	Avg mileage /vehicle	Total annual mileage	Avg fuel consumed /vehicle	Total fuel consumed
Cars	Diesel/petrol	207	6,380	1,320,707	733	151,794
	Electric	18	6,802	122,432	-	-
	Hydrogen	5	7,327	36,635	-	-
Vans	Diesel/petrol	410	6,678	2,738,176	1,162	476,621
	Electric	29	5,508	159,736	-	-
Trucks	Diesel/petrol	180	7,539	1,357,058	2,243	403,814
	Electric	0		-		-
Bus/minibus	Diesel/petrol	209	8,081	1,688,973	1,740	363,746
	Electric	0		-		-
Large specialist	Diesel/petrol	85	6,440	547,437	5,555	472,194
	Electric	2	6,582	13,163 -		-
All	All	1,145	6,973	7,984,317	1,632	1,868,169

6.3 Fleet baseline projection

In order to develop a baseline projection of carbon emissions for the three fleets, a set of assumptions were developed that are applied to the combined fleet. The assumptions are focused on annual fuel consumed and consider reductions resulting from both a switch from diesel /petrol to electric and efficiency improvements. These have been derived from insight into the plans and views of the fleet managers, and an understanding of the current market and regulatory landscape. The plans and view of each fleet were captured during a workshop and are summarised in the table below.

Plans and views of fleet managers

SCC	There is currently a 6-year replacement programme ongoing that includes around 900 vehicles. The aim is to ensure all vehicles are Euro 6/VI compliant, while SCC will also be looking at EVs where it is most appropriate. This will most likely be in the car and van segment, although no electrification targets have been set. There are five hydrogen cell cars in the fleet, although the council has experienced a number of issues with them, such as the fuelling station being out of use. While telematics systems are being used, these are mainly from a safety perspective and while the council will likely review eco-driving measures in the near future, they are not currently considered very effective.
Amey	Amey operates the majority of the fleet under a long-term private finance initiative (PFI) with around 10 short term hire vehicles. Amey's contract with SCC is carbon benchmarked, which can result in penalties if targets are exceeded. They currently have around 40 vehicles older than Euro 6/VI that they are in discussion with the Council over replacing. Amey does see potential for electrifying its car and van segments but they are aware that electrifying larger vehicles is currently very difficult. The hilly terrain of Sheffield also must be taken into account. Hydrogen is not currently seen as an option, although Amey is doing some work with biofuels. They expect to lose around 5 vehicles through efficiency improvements over the next few years, however, the future fleet size is dependent on the Government's waste strategy. For example, a requirement to increase frequency of waste collections (to weekly) could increase activities and require additional vehicles.
Veolia	The Veolia contract with Sheffield ends in 2038. During a replacement of the recycling fleet in 2019, they selected Euro 6/VI models with an electric-powered lift (more fuel efficient) as it was deemed unviable to go with CNG and EV models at the time. As a result, the majority of the fleet are now Euro 6/VI with some Euro 4/IV & 5/V. In general, Veolia are having conversations about electrification at a companywide level and there are plans to expand the number of EVs, although they are also waiting for vehicle manufacturers to bring forward suitable models. Dennis has an electric model coming out, but there is likely to be a CAPEX premium of £200-250k relative to diesel equivalents.

Based on current market availability and technology and price trends, it is expected that a switch to full electric vehicles will be most achievable in the passenger car and light van vehicles segments. In both these segments, a range of models are already available for purchase and lease with whole life costs (WLC) that are equal to or lower compared to equivalent petrol and diesel models. Premiums may still exist in some cases over the next few years.

For large vans and heavy duty vehicles (including trucks, buses, plant and other specialist vehicles), there is currently less commercial availability of electric models and the performance and cost of these are still some way off parity with conventional diesels models.

Over the next 10 years, it is assumed that the overall fleet size will remain the same in the baseline. Only Amey gave an indication that fleet size may change but this is uncertain and would be very small in magnitude. The biggest change is predicted across the car and van fleets where around half of the vehicles are expected to switch to electric by 2030. Most of the cars and vans are operated by SCC, who are already operating over 20 electric vehicles and have indicated that they will be considering electric in their replacement programme. Despite limited model availability and higher prices for electric buses/minibuses, a limited number of these vehicles are predicted to switch to electric. These vehicles have predictable routes meaning appropriate charging solutions can be planned. Furthermore, the range of electric models is expanding and there are examples of local authorities across the UK who have made the switch with some of their fleet.

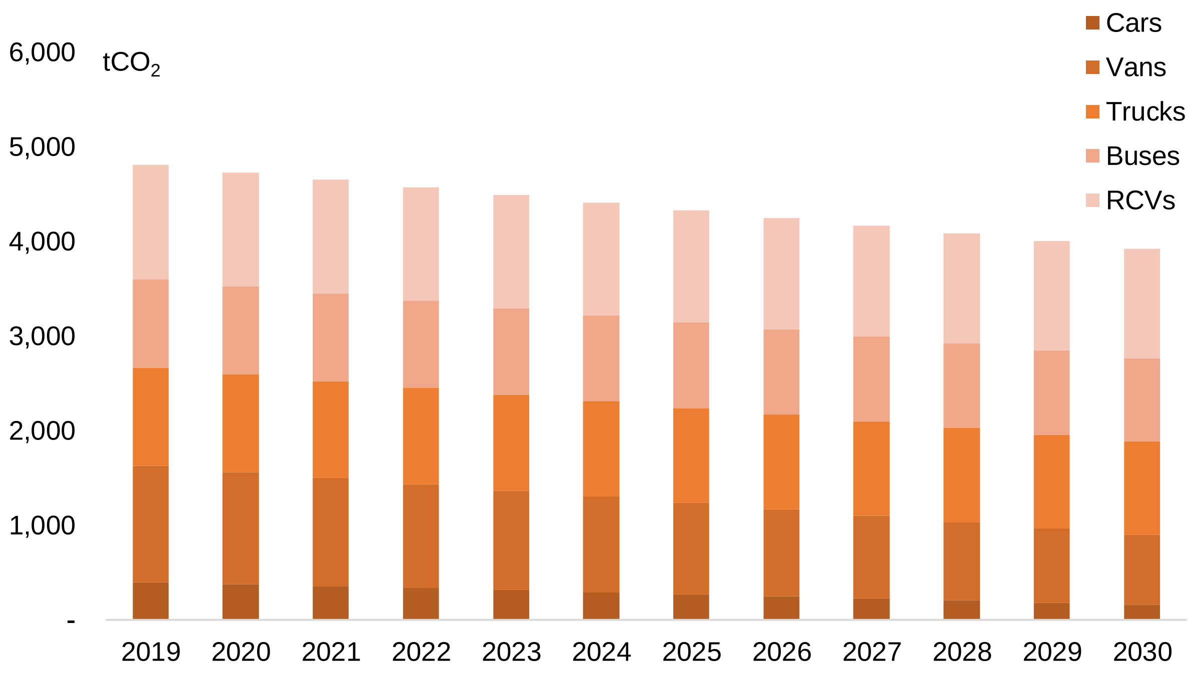
For trucks and large specialist vehicles, it is expected that the main change will be a consolidation of the fleet to Euro VI compliance. While some zero emission models are appearing on the market, for these larger vehicles the performance and price is still quite far off parity with diesel equivalents and neither Amey nor Veolia have expressed an intention to switch their larger vehicles to electric in the near term.

Summary of fleet baseline assumptions

Vehicle segment	Projection assumption
Cars	60% switch to electric between 2020-2030
Vans	40% switch from to electric between 2020-2030
Trucks	5% efficiency improvements seen in non-Euro VI vehicles (50% trucks) between 2020-2030
Buses	5% switch to electric between 2020-2030
Large specialist	5% efficiency improvements seen in non-Euro VI vehicles (30% specialist) between 2020-2030

Carbon emissions in 2019 are estimated to be 4,810 tCO_2. Annual emissions fall by 19% to 3,920 tCO_2 between 2019 and 2030, resulting primarily from the take up of electric vehicles in car and van segments. The emissions from other vehicle segments stay roughly the same.

Fleet baseline emissions baseline, by vehicle type



6.4 Options identification

In the baseline and scenario, projections have been developed from assumptions that are based on two high level measures – alternative technology and efficiency improvements.

6.4.1 Measures included in the model

Transport decarbonisation measures can be categorised within the Avoid-Shift-Improve framework. This approach was initially developed in the early 1990s in Germany as a way to structure policy measures to reduce the environmental impact of transport, however it can also be a useful reference to structure action for reducing the environmental impact of fleets. The priority should be to try and avoid emissions (i.e. reduced travel), followed by a shift to more efficient vehicles (i.e. public transport/cycling) and finally to improve by using more energy efficient vehicles (i.e. EVs). In this report, two measures are considered - efficiency and alternative technology – where efficiency measures relate to 'avoid', and alternative technology reflects 'improve'. It is assumed that the activities of the fleet cannot be shifted to more alternate modes of transport.

6.4.1.1 Efficiency

The measure includes interventions that target improvements in the efficiency of journeys that would result in reduced fuel consumed and lower CO_2 emissions. This measure may also result in a smaller fleet if reduced mileage can be converted into a fewer vehicle. Many of the specific interventions under this measure relate to company policy, driver behaviour and existing, mature technologies such as telematics systems.

6.4.1.2 Vehicle electrification

This measure consists of the interventions required to replace the existing vehicle fleet with ultra-low or zero emission vehicles. This targets the direct reduction of transport emissions using alternative technologies (i.e. vehicle powertrains and fuels). While full electric vehicles are the main focus of the modelled net zero measures, the lowest emission plug-in hybrids are also within scope. Hybrid electrics are seen by some as an important 'stepping stone' to fully electric vehicles, but the environmental performance of hybrid electric vehicles has been under increased scrutiny and criticism in recent years. Research suggests that their real world emissions are far higher than the official test values suggest[56].

6.4.2 Interventions

Underpinning the two measures discussed above are a number of interventions. These specific activities have not been modelled directly as their specific take up and impact are difficult to quantify and are outside the scope of this report. However, it is important to recognise the drivers and challenges for each measure.

6.4.2.1 Efficiency

Fleet operators already can target improved journey efficiency through driver training, and vehicle maintenance policy that ensures vehicles are operating in an optimal condition. Telematics systems can also be effective in influencing better driver behaviour and facilitate evaluation of usage patterns that can inform improved journey planning and vehicle type selection. Fleet operators can also look to improve the efficiency of the overall fleet operation by implementing remote monitoring systems that result in fewer call outs, encouraging less business travel, consolidating trips, and optimising route planning. The consolidation of journeys, resulting from multi-purpose vehicles and effective fleet planning can be a very effective way to reduce overall mileage and fleet size. Average annual mileage per vehicle is relatively low and so there may be scope for journey consolidation. Reducing the size of the fleet also reduces the burden on switching vehicles to electric, keeping costs down.

The council and its strategic partners have already made use of fleet efficiency technology and have deployed behaviour change programmes. However there is scope for these efforts to be intensified.

[56] https://www.transportenvironment.org/sites/te/files/publications/2020_09_New_evidence_PHEV_emissions.pdf

6.4.2.2 Vehicle electrification

Switching the fleet to electric will require an effective strategy for replacement of the fleet over time, which should consider investment in both the vehicles and supporting charging infrastructure. It should also account for market developments and the evolving policy landscape. For example, it would make sense to replace cars and vans first, followed by larger vehicles when the regulatory and market conditions are more supportive. Over the last few years, the electric car market has improved considerably in terms of cost and performance[57]. While premiums still exist on purchase and lease prices of EVs, the savings in running costs can make EVs cheaper than petrol and diesel equivalents over their lifetime[58]. Improvements in battery performance and charging speeds also mean that the performance of electric cars are rapidly approaching parity with petrol and diesel cars. However, shorter driving ranges and charge points availability continue to be a barrier to uptake in the short term. The electric van market is slightly behind cars, although the higher typical annual mileage means that whole life savings can be greater.

In terms of availability, there are more than 100 fully- or part-electric cars available to buy or lease in the UK[59] and while the choice of electric vans is more limited, their numbers are set to increase. The overall momentum in the market is demonstrated by the EV100 initiative, where over 80 business (majority UK based) have pledged to electrify their fleets by 2030. A selection of fleet electrification activities by UK councils are presented below:

- **Barking and Dagenham** c**ouncil** purchased three all-electric Renault Kango Crew vans for parking enforcement and will save an estimated £11,000 a year in maintenance and fuel costs[60].
- **Oxford City Council** has ordered 33 EVs, which are a mix of cars, vans, a street sweeper and an excavator. They are also trialling a new electric refuse truck, provided by Dennis Eagle[61].
- **Leeds City Council** have purchased 122 electric vans. Twenty vans will be used in a new EV Trials Scheme, while the majority will be used directly by the council to carry out a range of services across the city, including property maintenance and civil enforcement[62].

Switching larger vehicles (i.e. large vans, trucks, buses and specialist heavy duty vehicles) to electric is a challenge for fleet operators, and indeed for the transport sector as a whole. The technology readiness for electric trucks is much lower compared to cars and vans, reflected by the small number of these vehicles in operation. Analysis by the IEA[63] shows that most electric heavy duty trucks are in prototype and customer trial stages, while only a handful are in production. Both Volvo and Renault Trucks started producing electric trucks in 2019, and Scania deployed two battery electric city distribution trucks of 27‑tonne GVW in early 2020. Meanwhile, the electric truck manufacturer Nikola recently announced a US deal for a minimum of 2,500 electric refuse trucks, with full production deliveries expected in 2023. Urban electric buses have been a success story, with many EV bus procurement activities around the world. This has been driven by the ambition of local authorities to improve local air quality, longer terms investment portfolios and predictable fleet operation allowing effective EV charging planning. In Europe, the number of electric trucks registered more than doubled from 2018 to 2019.

Suitable charging infrastructure must be available to support the diverse requirements of the whole fleet. Cars and vans are likely to be taken home to the domestic premises of drivers and private charge points can be installed where access to off-street parking is available. The fleet operator would be expected to pay for these, and government subsidies may be available. Public charge points may also be required for drivers that rely on on-street public chargers. While the overall deployment of public

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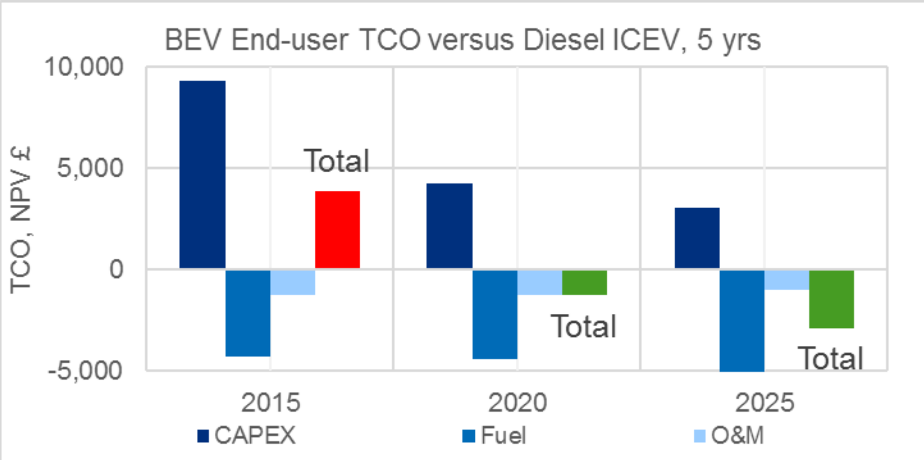
[57] https://www.theccc.org.uk/publication/plugging-gap-assessment-future-demand-britains-electric-vehicle-public-charging-network.
[58] https://www.leaseplan.com/-/media/leaseplan-digital/ix/documents/leaseplan-white-paper_tco-of-evs.pdf?la=en
[59] https://www.zap-map.com/electric-vehicles/electric-models/
[60] https://www.barkinganddagenhampost.co.uk/news/environment/electric-vans-for-council-officers-1-6520687
[61] https://www.commercialfleet.org/news/truck-news/2020/07/20/electric-bin-lorry-to-be-trialled-in-oxford
[62] https://greenfleet.net/news/18062020/leeds-city-council-takes-120-electric-renault-kangoo-vans
[63] https://www.iea.org/reports/trucks-and-buses

charges is rapidly expanding, further planning consideration should be given to public charge point installation in Sheffield. For larger vehicles that are usually return to base, fleet operators would need to invest in charging stations at the depots. These are likely to be faster and more expensive chargers given the size of the batteries required in these vehicles, although charge points could be shared between multiple vehicles.

Recent analysis by the RAC Foundation concludes that 50% of vans in the UK are suitable candidates for electrification because they only venture 15 miles from base, meaning drivers and fleet operators can use local knowledge to decide where and when they can best be recharged[64]. This value will be closer to 100% for the vans operated by and on behalf of the council, which are likely to all be operating within Sheffield.

Average van end user total cost of ownership, 5 yrs. Source: Ricardo analysis



Summary of interventions

	Efficiency	Vehicle electrification
Fleet operator	• Carsharing for business travel and commuting • Telephone/web-based conferencing • Work from home • Optimised route planning • Telematics • Eco-driver training • Fleet consolidation – multipurpose vehicles and trip • Vehicle maintenance	• Fleet electrification strategy • Provision of suitable EV charge points at key locations
External factors	• No interventions identified	• National and local government policy and financial support for EVs and charging infrastructure • Implementation of low emission zone • Installation of public charge points

[64] https://insideevs.com/news/443891/uk-van-electric/?utm_source=RSS&utm_medium=referral&utm_campaign=RSS-all-articles

6.5 Fleet net zero strategy

In order to demonstrate the level of ambition and magnitude of change required to meet net zero targets by 2030, an ‘electrification’ scenario has been defined that assumes a complete switch to electric vehicles across the whole fleet. A small reduction in the annual mileage and fuel consumption of the fleet is also assumed to take place, resulting from measures that target efficiency improvements.

Summary of fleet scenario assumptions

<table>
<tr><th>Vehicle segment</th><th>Efficiency improvement assumption</th><th>Fuel switching assumption</th></tr>
<tr><td>Cars</td><td rowspan="2">10% efficiency improvements</td><td rowspan="2">100% switch from diesel to electric between 2020-2030</td></tr>
<tr><td>Vans</td></tr>
<tr><td>Trucks</td><td rowspan="3">5% efficiency improvements</td><td rowspan="3">100% switch from diesel to electric between 2025-2030</td></tr>
<tr><td>Buses</td></tr>
<tr><td>Large specialist</td></tr>
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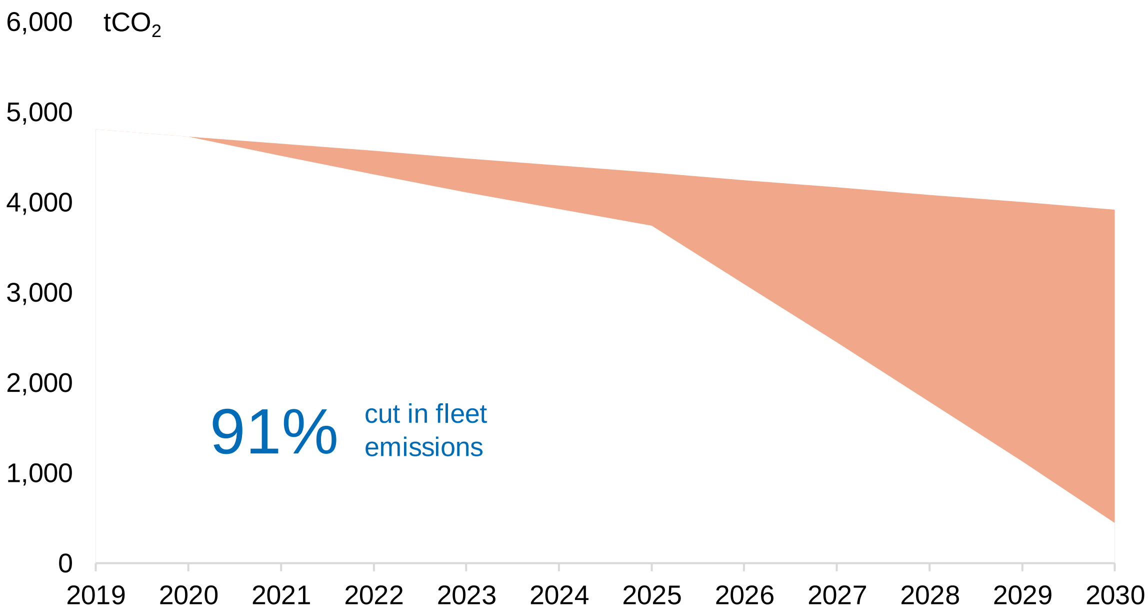
6.6 Emissions impact

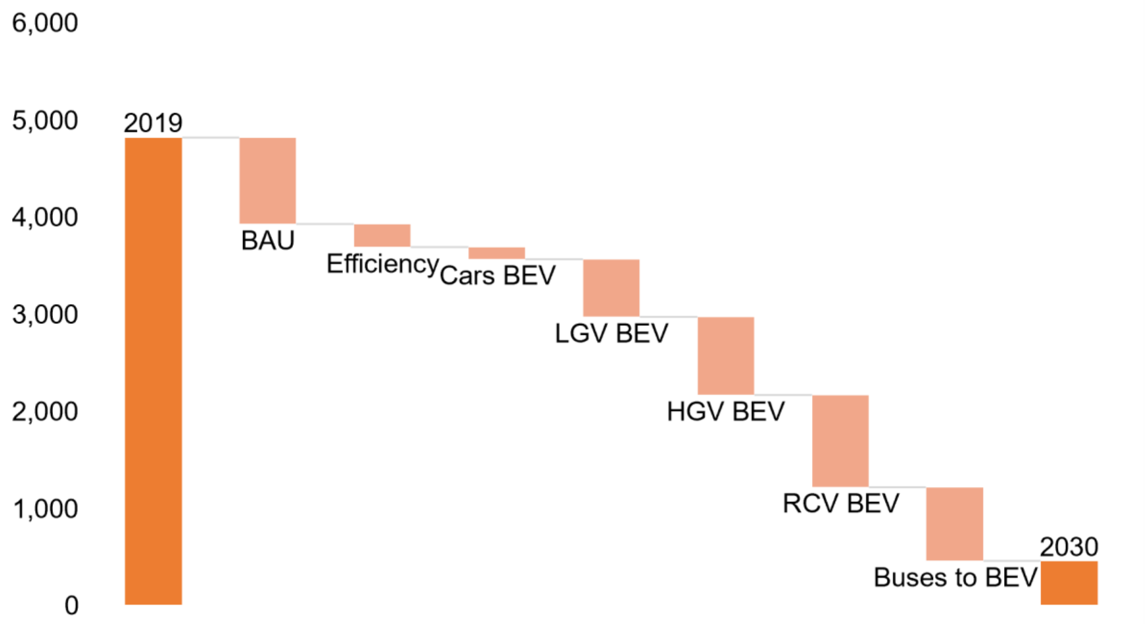
The measures proposed as part of the net zero strategy reduce emissions by 89% below the baseline in 2030 with a 91% overall cut from 2019.

Fleet vehicle measures emissions pathway



The waterfall chart below shows the contribution of each measure category to emissions reductions. The majority of emissions savings from fleet efficiency measures and uptake of passenger and van EVs are accounted for within the BAU baseline projections. The most significant additional reductions beyond BAU are associated with the electrification of heavier vehicles, including HGVs (23%), refuse collection (27%) and buses (22%). Residual emissions in 2030 are 450 tCO_2 with all emissions associated with the supply of electricity. As the grid continues to decarbonise beyond 2030 these emissions will continue to decline.

Fleet vehicles emissions reductions by measure

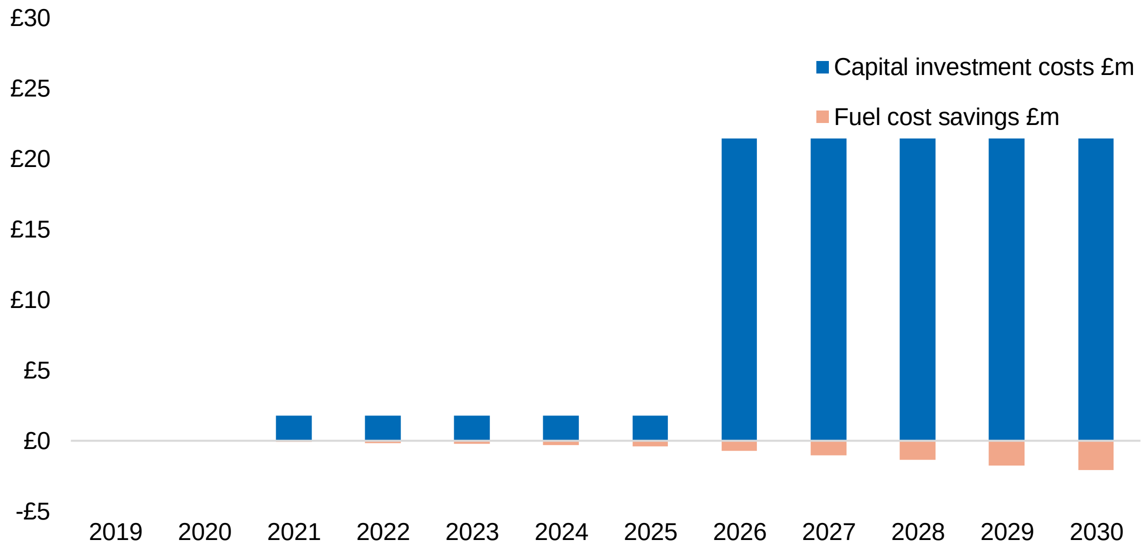


6.7 Cost assessment

We have undertaken a high-level cost assessment to give an indication of both the total capital investment required to deliver the fleet measures and the fuel costs relative to the business as usual baseline to 2030. More information and key cost assessment assumptions are provided in Section 9.

The in-year figures for capital investment costs and fuel costs are presented below. The total fleet capital investment costs to 2030 are estimated to be £116m. Fuel cost are predicted to fall by £8.1m, a 28% reduction relative to the business as usual projection.

Estimated capital investment costs and fuel cost savings for the fleet vehicles sector 2019-2030



The switching of trucks, specialist vehicles and buses to BEV is modelled to begin around 2026 which makes up the majority of the additional capital investment costs for the fleet vehicles sector (£98m in total). Note that it is assumed that the majority of capital investment in car and van electrification happens under business as usual and is therefore not included here.

6.7.1 On-going costs

It is the cheaper ongoing and maintenance costs for EVs that can often offset the higher purchase premiums and make them cheaper alternatives to conventional petrol and diesel equivalents. Fuel costs can be three to four times cheaper and maintenance and repair costs also tend to be lower due to fewer moving parts[65]. Of course, EVs will still incur maintenance costs common to all vehicles, such as tyres and brakes, windscreens, wiper blades and washer fluid, and general wear and tear. Compared to conventional combustion engine vehicles, electric car parts include the electric motor, electronic power control, inverter and charger[66]. While repair and maintenance of the battery can be a concern, real world data shows that the rate of battery decay is less than feared[67], while manufacturers often offer good warranties of around 8 years or an equivalent mileage. A broader concern around EV repair and maintenance is the availability of skilled EV technicians, although there are good support measures in place, aimed at upskilling and accrediting EV retailers and the EV aftermarket[65].

A more significant cost consideration related to EVs is for the operation and maintenance of any supporting charging infrastructure that the local authority or other fleet operator may choose to strategically and proactively invest in. After procurement, the local authority would typically pay a monthly fee to a supplier for operation and maintenance. The advantages and disadvantages of the 'Own & Operate' model from the perspective of local authorities is presented in an EST report in 2019[68], and is adapted from a presentation given by Go Ultra Low Nottingham.

6.8 Alternative net zero pathways

The net zero strategy modelled focuses on a switch to electric vehicles across all vehicle segments. This is our central expectation. However, more so than for other sectors, there is uncertainty about the optimum technology route to net zero in 2030. Other zero- and low-emission vehicles technologies could potentially form part of a credible alternative route to net zero.

Considering the current market landscape for cars and light vans, it is likely that all scenarios should focus on a switch to pure electric for these vehicle segments. However, the picture is less clear for larger vehicle types. Across Europe, the number of natural gas vehicles rose by 70% in 2019, but emission reductions are limited by emission leakages and poor engine performance. The biggest recent trend in fuel switching of trucks recognises the potential of hydrogen and biofuels for the larger vehicle types.

6.8.1 Hydrogen

The most viable alternative to electric is hydrogen, although similar to electric, the technology readiness for hydrogen trucks is currently low. Analysis by the IEA[69] shows that hydrogen and fuel cell heavy duty trucks are currently in the prototype stage and T&E estimates hydrogen electric trucks for regional delivery will reach cost parity with diesel by early 2040s[70]. A report by the Committee on Climate Change (CCC), flags the role that hydrogen can play but highlights that early Government commitment is key[71]. Furthermore, the European Commission's new hydrogen strategy includes ambitious targets for green hydrogen produced from 100% renewable electricity and supports the International Road Transport Union (IRU)'s vision that green hydrogen is the most promising alternative fuel for commercial road transport, especially for longer distances and heavier loads[72].

In commercial road transport, especially for longer distances and heavier loads, green hydrogen is the most promising alternative fuel. A hydrogen refuelling station has been implemented in Rotherham,

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[65] https://www.bvrla.co.uk/resource/bvrla-road-to-zero-report-card.html
[66] https://www.theaa.com/driving-advice/electric-vehicles/electric-car-maintenance
[67] https://pod-point.com/guides/driver/ev-maintenance-costs
[68] https://energysavingtrust.org.uk/sites/default/files/Local%20Authority%20Guidance%20-%20Procuring%20electric%20vehicle%20charging%20infrastructure.pdf
[69] https://www.iea.org/reports/trucks-and-buses
[70] Transport & Environment, Comparison of hydrogen and battery electric trucks, June 2020 available here
[71] https://www.theccc.org.uk/publication/hydrogen-in-a-low-carbon-economy/#key-findings-and-recommendations
[72] https://www.iru.org/resources/newsroom/eu-steps-gas-towards-hydrogen

South Yorkshire[73], but the development of suitable supporting refuelling infrastructure is still expected to be a key barrier to wider scale adoption of hydrogen HGVs. Hydrogen dual fuel vehicles could also be a solution to the short term need to decarbonise the large and heavy-duty vehicle fleet, while hydrogen fuel cell technology develops further. Yorkshire Water, in cooperation with ULEMco, have converted a 7.5 tonne water tanker to use a hydrogen dual fuel powertrain that reduces carbon emissions by a third[74].

6.8.2 Biofuels

While the focus is on electric and hydrogen powertrains for decarbonising the heavy duty vehicle sector, low-carbon combustion fuels, such as biofuels, can also play a role. The benefit of biofuels is that they can reduce the transport emissions of existing vehicles, while the cost-effectiveness of electric and hydrogen improves. For example, Waitrose has 76 Bio-CNG HGVs, which reportedly can cut vehicle greenhouse gas emissions by up to 85% compared to diesel.

6.8.3 Beyond 2030

The most significant developments beyond 2030 are likely to be in the alternative vehicle market and the deployment of supporting charging and re-fuelling infrastructure[75]. The continued decarbonisation of the electricity supply is also an important factor to consider, and while grid carbon emissions are expected to reduce over the next decade, we may not reach zero emission grid electricity until after 2030.

It is expected that travel reduction and efficiency actions can be optimised in the next 5 years with the technology and policies that are widely implemented today. However, in the latter half of the next decade and beyond 2030, connected and autonomous driving features will lead to even greater journey efficiency and emission reductions although the impact of efficiency improvements on CO_2 emission reduction will diminish as the vehicle fleet transitions to ultra-low or zero emission vehicles. Therefore, autonomous vehicle features are more likely to bring further cost savings and safety benefits.

[73] https://www.itm-power.com/h2-stations/rotherham-wind-hydrogen-station
[74] https://ulemco.com/?p=2912
[75] Morganti, E. and Browne, M., 2018. Technical and operational obstacles to the adoption of electric vans in France and the UK: An operator perspective. Transport Policy, 63, pp.90-97.

6.9 Actions summary

The key measures that the council should take to decarbonise its vehicle fleet and those of its key strategic contractors fall into the following categories:

- Reduced mileage through driver behaviour, optimising route planning, journey consolidation and telematics. Together these can increase efficiency while reducing fuel costs. Shrinking the size of the fleet can also reduce the capital cost of vehicle replacement.
- Switching cars and vans to electric through fleet replacement programmes, investing in both the vehicles and supporting charging infrastructure
- Switching larger vehicles (i.e. large vans, trucks, buses and specialist heavy duty vehicles) to electric is a longer-term challenge but an increasing number of models are expected to become available before 2030.

Below are priority actions that the council can take to achieve this. Work on these should begin without delay. The proposed actions are described in more detail in Section 10: Recommendations, along with actions which apply across sectors.

Fleet priority actions	**Short** Up to 2022	**Medium** 2023-2026	**Long** 2027-2030
Build the evidence base for action - Undertake a fleet consolidation and electrification feasibility assessment	●		
Roll out behaviour change programmes	●		
Begin to accelerate the electrification of all cars and vans	●		
Work with key contractors to align their vehicle policy with the council's zero carbon targets		●	
Commit to trialling low carbon large and specialist vehicles as they become available, in preparation for a complete switch away from diesel.		●	

7 Street lighting

This section presents the results of energy & emissions modelling for the street lighting in Sheffield. It includes an analysis of emissions projections, identification of net zero mitigation measures and an assessment of the impact on emissions.

Street lighting in Sheffield is managed by Amey through the Streets Ahead programme. It has invested in upgraded street lighting, with all sodium lights now converted to LED, improved light quality and a centrally controlled monitoring system.

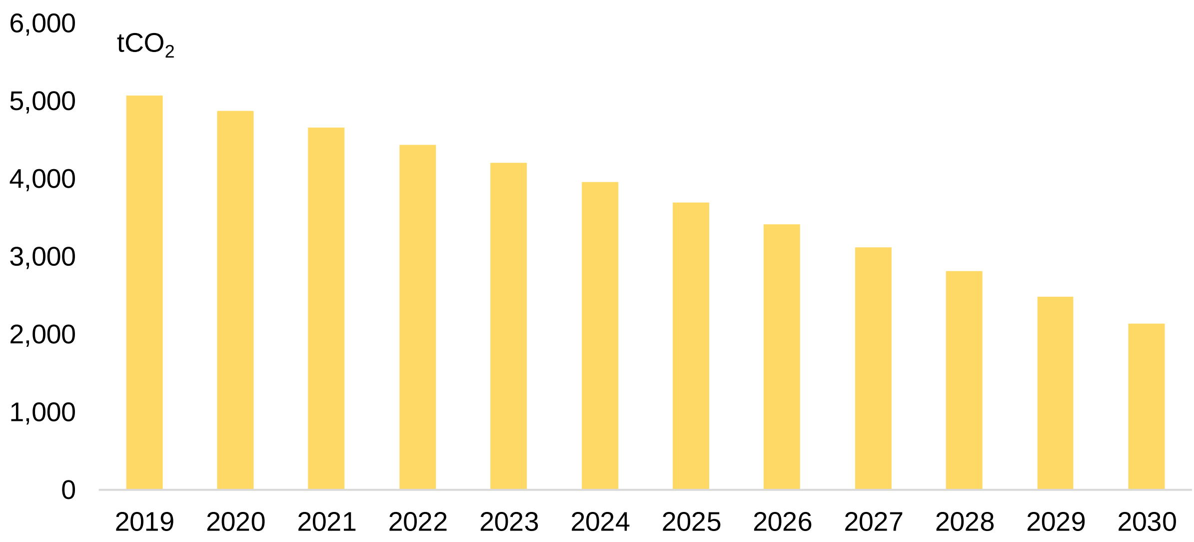
7.1 Energy use analysis

In 2013/14, the cost of electricity for street lighting was £3.1million, calculated to result in 17,168 tCO_2. emissions. The conversion to LEDs was completed in 2017/18 and was estimated to have resulted in a 40% reduction in energy use, decreasing from around 32,500MWh to 20,000MWh per year[76].

7.2 Baseline projection

Carbon emissions in 2019 are estimated to be 5,072 tCO_2\. The projected fall in carbon emissions associated with grid electricity means that this is expected to fall over the next 10 years, without any further improvement in efficiency. The baseline projection estimates emissions from street lighting of 2,137 tCO_2 in 2030, a reduction of 58%.

Street lighting emissions before measures



7.3 Options identification

The council has been exploring opportunities for further energy savings from street lighting. The lighting control system allows lighting levels to be dimmed at certain times and lighting schedules to be trimmed to more closely fit need. Currently the streetlights operate at 84% of capacity to deliver the required light output with dimming on traffic routes to 54% from 8pm and on residential streets from midnight.

Pilot projects in three areas of the city have trialled an additional 4-14% dimming from adjustments to the timing and intensity of lighting which could further reduce energy consumption by 6%[77].

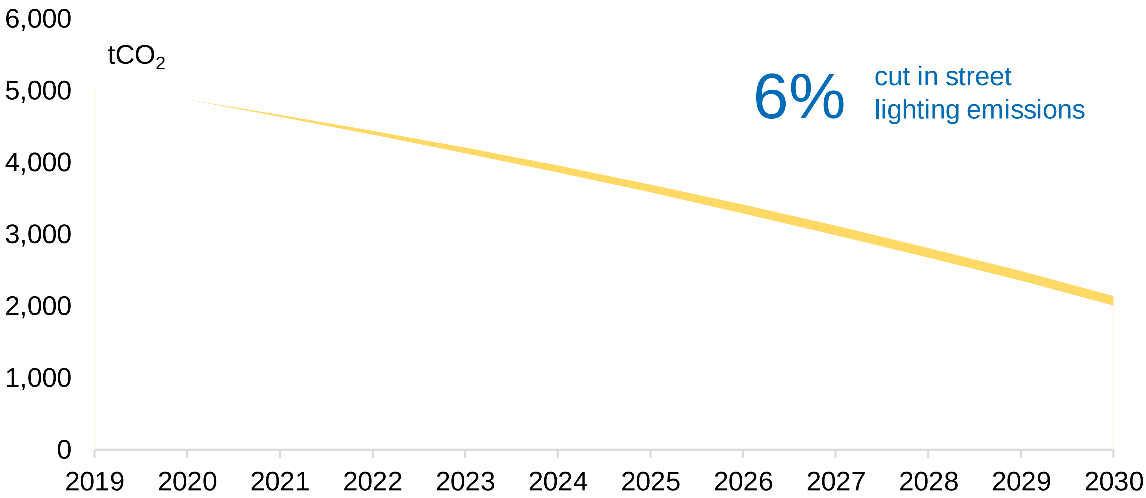
[76] Sheffield City Council Energy Management, Assessment of Current Position and Delivery Plan for Progress 2013
[77] SCC cabinet meeting briefing paper, 9th August 2019 Reducing Carbon Emissions from Street Lighting

The council has now decided to roll out trimming and dimming across the city, representing a highly efficient and modern street lighting system. We have assumed that the 6% estimated saving is replicated across the city and is rolled out in phases to 2030. There may be further additional savings from further trimming and dimming but these have not been included in the modelling[78].

7.4 Emissions impact

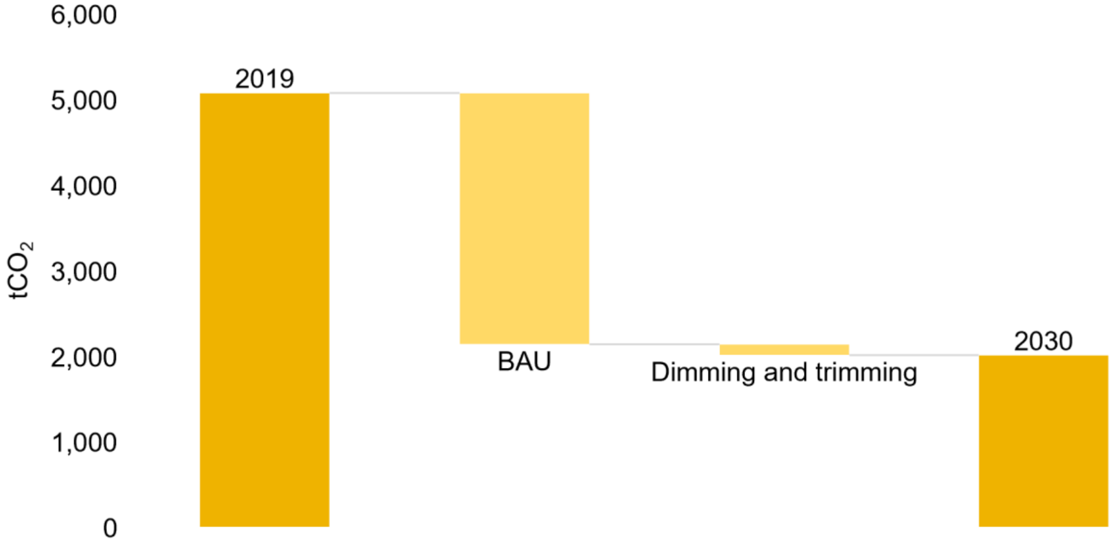
The efficiency measure included in the net zero strategy results in 6% reduction of emissions beyond the 2030 BAU, or a 40% saving compared to the 2019 baseline.

Street lighting measures emissions pathway



The waterfall chart below indicates that the additional emissions saving is small relative to the projected baseline savings. This reflects the fact that significant investment has already been made in LED lighting across the city. The measure also does not require capital investment and therefore represents a quick payback and low disruption measure.

Street lighting emissions reduction by measure



Residual emissions in 2030 are 2,009 tCO_2, which will continue to fall as the grid continues to decarbonise.

[78] Sheffield City Council Energy Management, Assessment of Current Position and Delivery Plan for Progress 2013

7.5 Cost assessment

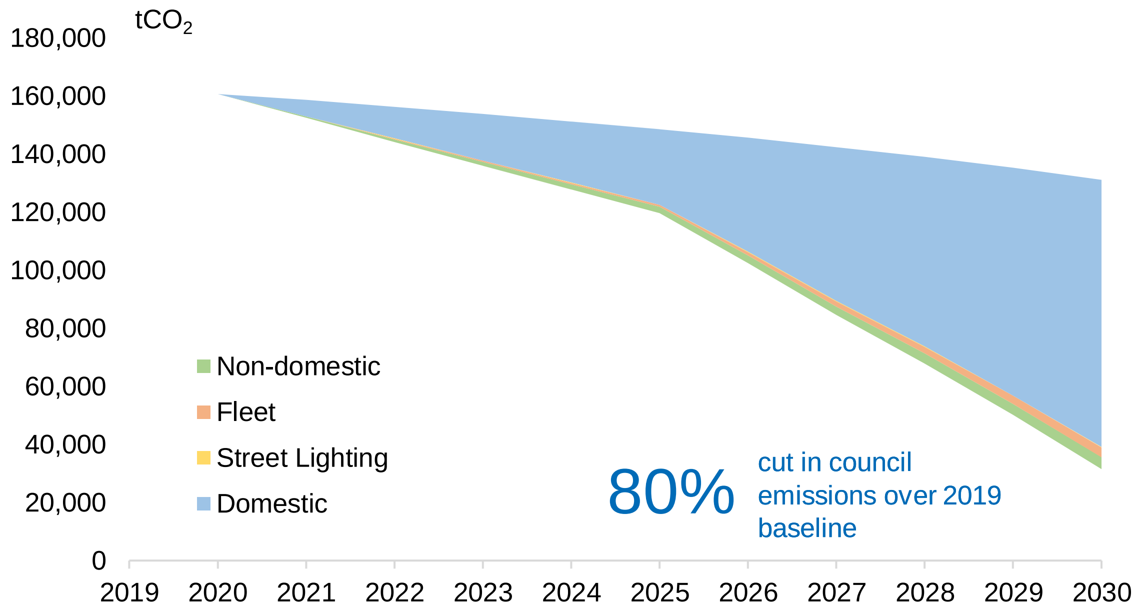
There is no capital investment required to deliver the proposed street lighting measures beyond the business as usual baseline. The trimming and dimming measures are modelled to reduce fuel costs by £0.9m cumulatively relative to the business as usual baseline to 2030.

7.6 Actions summary

The council has already undertaken measures to significantly reduce emissions from street lighting. Should its trimming and dimming pilots prove successful, they should be progressively rolled out across the city. Street lighting should be kept under review with opportunities for further energy saving adopted in future.

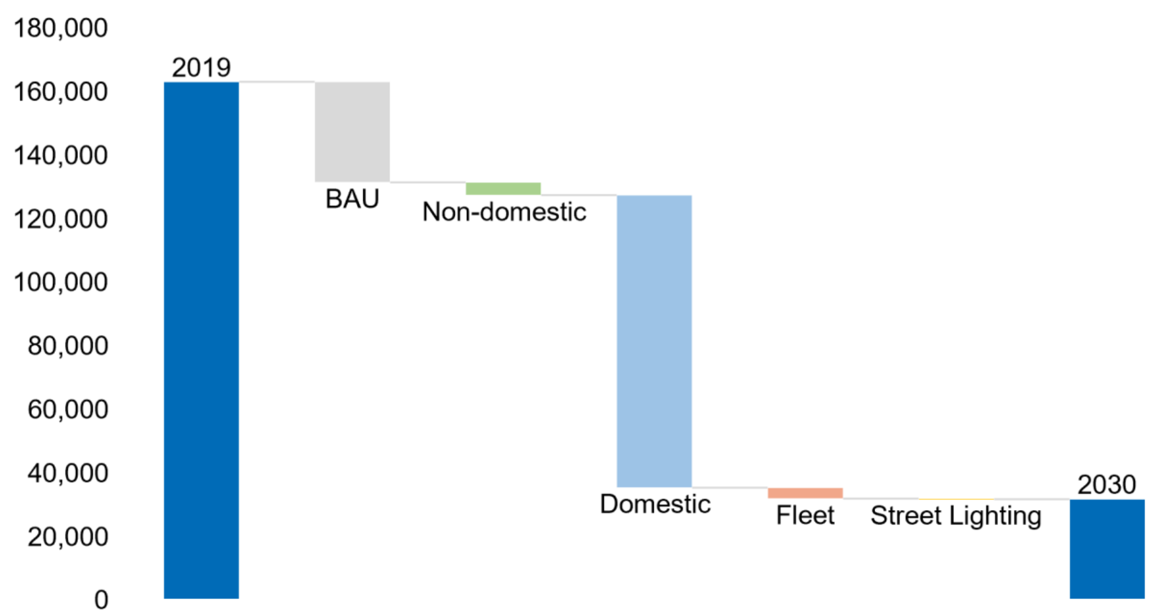
8 Emissions impact assessment

The measure proposed as part of the net zero strategy reduce emissions 76% below the baseline in 2030 to 31,498 tCO_2, an 80% overall cut from 2019.



The waterfall chart below shows the contribution of each measure category to emissions reductions. Measures to council homes account for 92% of the emissions savings beyond the BAU baseline achieved, with around 4% from non-domestic and fleet vehicles. This reflects the size of domestic emissions, rather than the potential to achieve reductions. Street lighting measures at 0.1% reflects the substantial investments already made in LED lighting.

Overall emissions reduction by sector



8.1 Residual emissions

Residual emissions in 2030 are 31,498 tCO_2 after all proposed measures have been applied. While this represents an 80.6% reduction in 2019 baseline emissions, it fails to meet the 95% net zero criteria. That this ambitious and wide ranging package of measures is not sufficient highlights the importance of carbon positive measures and energy exports in meeting the goal.

Cumulative emissions over the period from 2019 to 2030 inclusive amount to 1,340 $ktCO_2$ under the net zero pathway, or 1,482 $ktCO_2$ to 2037.

8.1.1 Solar generation

The net zero pathway expands roof top solar capacity substantially, generating 14.6 GWh per year in 2030. Solar farms owned outright by the council or bought via a power purchase agreement from a commercial developer or community group provides one potential route to securing further emissions reductions.

However, because the electricity supply is expected to continue decarbonising rapidly, the emissions reduction that can be secured (relative to the grid) shrink significantly. As a result, to close the gap to net zero in 2030 would involve 256MW of solar across 1,280 acres of land at an estimated cost of £100 million.

Expanding renewables generation is an important tool to reduce emissions that is also able to deliver a return on investment through electricity sales. It should therefore form part of the council's net zero plan. However, the scale of development involved means it is not a viable option for addressing all residual emissions.

8.1.2 Land use measures

Emissions abatement from Land Use, Land Change, and Forestry (LULUCF) was investigated as part of WP3.1 All land in Sheffield (not just SCC land) sequestered 21ktCO_2e in 2017, according to the BEIS Local Authorities CO_2 Emissions Inventory. Doubling this figure to 42ktCO_2e by 2030 is viewed as a reasonable aspiration, though the cost is difficult to predict.

Land use measures should be used to reduce city-wide emissions. However, were all of the additional carbon sequestration opportunities used to offset the council's own residual emissions, the 95% net zero criteria would still not be met. Council emissions in 2030 would amount to 10,529 tCO_2.

8.1.3 Measures outside Sheffield

The analysis indicates that it is not viable for the council's residual emissions to be fully offset within the city boundary. The council must therefore seek to identify offsets from further afield. For these to be viewed as both credible and additional, they should be sourced from as close to the city as possible, such as peatland restoration or afforestation within the city region.

9 Cost assessment

We have undertaken a high-level cost assessment to give an indication of both the total capital investment required to deliver the net zero measures and the fuel costs relative to the business as usual baseline to 2030.

The cost of each measure has been calculated factoring in the costs of equipment. In most cases the cost of installation and associated enabling works are not included, which will be significant. Key modelling assumptions have been described in the main body of the report.

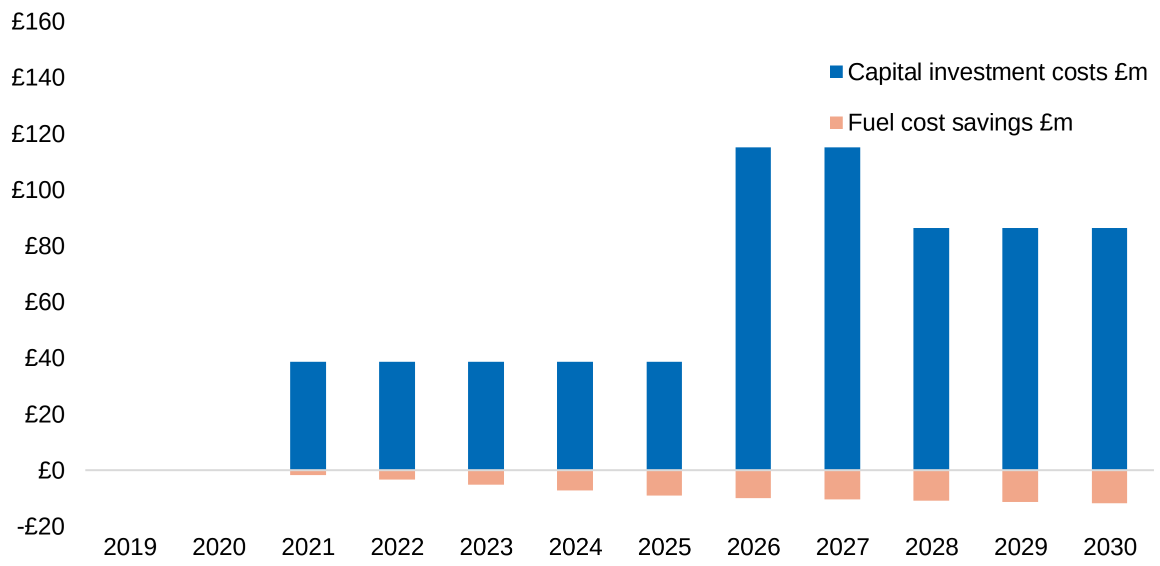
Fuel costs are calculated using a consistent set of fuel references price forecasts. Given the volatility and uncertainty related to these, the change in fuel costs between the baseline project and net zero pathway should be viewed as indicate of relative costs.

Headline cumulative cost assessment outputs to 2030

	Cost £million
Capital investment cost, undiscounted	£682
Net present cost @3.5% discount rate	£478
Relative fuel costs	-£81

The in-year figures for capital investment costs and fuel costs are presented below. The large increase in capital expenditure in 2026 is due to the domestic heating switching and the fleet switch to electric vehicles both beginning in 2026. The trend of decreasing fuel costs is caused by the efficiency improvement measures offsetting the switching from natural gas to more expensive fuels such as grid electricity.

Estimated annual capital investment costs and fuel cost savings 2019-2030



9.1 Do nothing costs

Action on climate change can help to avoid its worst impacts and avoid huge costs to society and the environment. The cost of doing nothing globally is significant and Sheffield has made a commitment to play its part.

Aside from the impacts of climate change, Sheffield City Council could potentially face a significant cost for its inaction where it lags behind national progress. Putting a cost on carbon emissions is a key mechanism for accounting for climate with the price signal influencing behaviour.

To assess this component of the cost of inaction, we have used the Government's carbon price projections to estimate the council's exposure to carbon costs, where the net zero pathway is not taken.

Residual emissions in 2030 are around 100 ktCO_2 higher in the baseline projection. The BEIS traded carbon price forecast is projected to rise from £13.15/tCO_2 in 2019 to £42.66/tCO_2 in 2030 in its 2018 central forecast[79].The annual cost to the council would be £4.25m per year.

The benefits of taking the net zero pathway would potentially grow from there. The Grantham Institute have estimated a £125–300 carbon price would be required to meet the UK's net zero 2050 target[80]. This raises the prospect of a significant long term direct cost to inaction for the Council.

10 Recommendations

The proposed interventions would need to be carried out in order for Sheffield to reach its zero carbon goal. While there are opportunities to increase the uptake of some, such as increasing the proportion of buildings switching to district heating or installing PVs, in most cases it is not possible to pick and choose which interventions to adopt.

Below are recommendations for the council in implementing the measures identified in Work Package 3.2, including overarching policies as well as specific sectoral recommendations and priority actions.

10.1 A net zero plan for the council's assets

Adopt a net zero policy for the council. It should establish a series of targets which together meet the net zero 2030 goal. It must be endorsed by council leaders with clear lines of responsibility and ownership.

Targets should identify the destination, such as a fully zero or low emissions vehicle fleet in 2030, supported by interim and subsidiary targets that ensure progress is made rapidly. In the case of fleet, a 2024 target could be set for passenger EVs could be set for example.

It would provide the framework for the decision-making, coordination and investment required to meet the targets, with a set of actions that are funded with ambitious delivery timelines agreed. This should include a review of on-going and planned projects and programmes which could also enable the net zero measures identified to be deployed.

The team's responsible for implementing the net zero plan should prepare a pipeline of projects and investments. Resources should be deployed up front on priority projects and critical enabling investments in advance of full funding being secured. Having plans, supporting evidence and partnerships in place creates a strong platform for successful funding applications.

A transparent monitoring and evaluation process would help ensure that it stays on track.

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[79] https://www.gov.uk/government/collections/energy-and-emissions-projections

[80] https://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2019/05/GRI-POLICY-BRIEF_How-to-price-carbon-to-reach-net-zero-emissions-in-the-UK.pdf

10.2 Governance

Reaching net zero for council assets will need the sustained support and engagement of officers from across the council, including housing, property, facilities and service delivery.

Net zero should be integrated into decision-making at every level. This should include day-to-day and delegated decisions for tasks like refurbishment, building change of use or parking are taken as opportunities to incorporate energy measures and do not create new barriers to net zero.

The net zero plan for the council's assets should be institutionalised within the corporate plan, financial strategy and departmental delivery. For example, net zero should be incorporated into the council's property strategy. The opportunities and challenges of making buildings net zero should be used as a 'lens' to inform decisions about property investment priorities, planned refurbishments and any disposals of existing buildings.

Specific governance proposals are presented in Work Package 4.

10.3 Skills and supply chain

Local supply chains will need to strengthen their ability to meet the new investment and service demand implied by the proposed measures. The council can work with local industries and suppliers to develop a recommended and trusted list of local installers and maintenance companies in areas such as general building and/or fabric energy efficiency specialists along with installers of technological solutions such as heat pumps, smart meters and EV charging

In-house operations and maintenance teams may benefit from undergoing additional training to familiarise themselves with new technologies. Having MCS certified installers is especially important for buildings heating systems, as we begin to move away from gas-based heating systems to heat pumps. This would also present an opportunity to develop and train in-house apprentices.

10.4 Communication with users and tenants

Some of the interventions, such as installing floor insulation, could result in major disruption to tenants and buildings users during the installation process. New systems such as heat pumps, charging electric cars and smart metering may be unfamiliar and could lead to discomfort, inefficiencies and potentially distress if they are not taught how to use them correctly. Getting buy in from user groups is critical to long term success.

This challenge will be most acute with measures in council housing. To deal with this, it is recommended that the council engage with tenants in particular to bring them on board with the changes required to their homes and provide appropriate training and support with using any new technologies. To deliver this, there will need to be sufficient internal resource and training programmes in place.

Empowering tenants and supporting tenant champions could help to create buy-in and trust amongst tenants so they have a higher level of confidence and understanding about the interventions and the changes that will be needed to their homes.

10.4.1 Summary of overarching priority actions

Below are actions that the council should take as a priority and begin without delay to create a strong platform for the transition to net zero.

Overarching priority actions	Short Up to 2022	Medium 2023-2026	Long 2027-2030
Adopt a net zero plan for the council's assets with a funded action plan to kick off its implementation	●		
Institutionalise the net zero plan for the council's assets into city planning, operations and budgeting	●	●	
Training and skills for in-house operations and maintenance teams for are being asked to implement it	●	●	
Communication with users and tenants in order to gain buy in and manage the change and disruption to come	●	●	●

10.5 Buildings

10.5.1 Planning and new buildings

All new buildings should be built to high standards of fabric energy efficiency and the use of fossil fuels should be designed out.

This should tie into new planning policies that require all new homes to be zero carbon as soon as possible and by 2030 at the latest.

Opportunities for rooftop solar should be maximised, to meet building electricity demand but also to export zero carbon electricity to offset residual council emissions.

New buildings create an opportunity to push forward a wide range of net zero goals which can benefit the community and city. Opportunities for publicly accessible EV chargers, cycle storage and mobility infrastructure should be taken. Where extending the district heating network would make it possible for other significant heat loads to also connect, a connection could provide the catalyst for wider heat decarbonisation. Temporary heating plant can be used prior to a planned network extension. This can help overcome plant replacement and infrastructure sequencing issues.

10.5.2 Net zero retrofit pilots

Meeting the net zero goal in buildings requires a comprehensive programme of building energy efficiency measures with fuel switching to either a low carbon heating network or a heat pump system. The speed and scale of action required make this a particularly challenging task.

The council should rapidly identify candidates for net zero retrofit pilots, covering a range of domestic and non-domestic architypes found in Sheffield. This would include a comprehensive package of fabric, heating and services measures delivered in an integrated way. Learning by doing would help to build organisational capacity and provide practical experience which could be carried forward to future retrofit projects.

10.5.3 Heat network expansion and connection

Expand the number of council buildings that are connecting to existing low carbon heat networks. This should be undertaken in all cases where the building is in proximity to the network and the existing heating plant is nearing end of life. In addition, it should also be considered:

- Where extending the district heating network would make it possible for other significant heat loads to also connect, acting as a catalyst for wider heat decarbonisation.
- Where retrofitting heat pumps to a building is anticipated to be highly disruptive or costly, connection to a district heating network can be a viable low carbon alternative.

- Temporary heating plant can be used prior to a planned network extension. This can help overcome plant replacement and infrastructure sequencing issues.

The charges for connection to the city centre network are viewed as a barrier to its expansion and there are instances of buildings being disconnected due to costs. The council must view heat networks as critical city infrastructure and should proactively engage with operators to ensure it is supporting the city's net zero goal.

10.6 Domestic

10.6.1 Detailed surveys

There will likely be a number of technical challenges that need to be addressed before some of these interventions can be adopted at scale across all council homes. It is understood that housing stock surveys are carried out on the properties, however, these focus on making sure that properties are safe and to reduce hazards. Whilst these surveys are important, they do not necessarily provide sufficient information to understand the where the opportunities are to incorporate zero carbon measures. As such, additional housing stock surveys and detailed technical studies will need to be carried out with a focus on achieving zero carbon.

10.6.2 Summary of domestic priority actions

Below are actions that the council should take as a priority and begin without delay to decarbonise social housing.

Domestic priority actions	**Short** Up to 2022	**Medium** 2023-2026	**Long** 2027-2030
Launch a programme of detailed energy surveys and technical studies to underpin the zero carbon retrofit measures.	●	●	
Develop an intensive programme of works on Council-owned domestic properties to kick-start an increased local delivery pipeline.	●	●	
Require that all new social homes are zero carbon	●	●	
All Council acquisitions to be brought up to zero carbon standards		●	●
Secure funding from BEIS via innovation and/or energy programmes, such as the Social Housing Fund, Whole House Retrofit Programme, and the forthcoming and Net Zero Innovation Programme.	●		
Scale-up a whole house approach to net zero retrofits, delivering a comprehensive package of measures together.		●	
Initiate discussion with local electrical infrastructure providers to understand how capacity impacts on meeting zero carbon target (such as electrified heating) and develop a programme of strengthening works.	●	●	
Work with commercial partners in district heating sector to develop a detailed heat study for expanding heat networks	●	●	

10.7 Non-domestic

10.7.1 Increased energy intelligence

The council's Transport & Facilities Management already report building energy consumption quarterly and benchmark performance to identify the worst performers sites. This data provides a good basis for targeting energy efficiency projects.

Access to more detailed half hourly metered energy & building data across the estate would provide the basis for more targeted carbon management and provide additional certainty that planned investment in energy measures would payback. It aides decision making, reduces risk and can identify opportunities for 3rd party financing of measures.

This could include new BMS, Automated meter readings and submetering. All new heat pumps should be installed with Metering and Monitoring Service Package (MMSP), that includes heat and electricity meters can verify system performance and as an optimisation tool.

Temporary energy loggers can be used to collect high quality site telemetry data. Battery powered sensors are non-intrusive and can be installed without interfering with the site's energy systems. They can be deployed tactically to collect energy data & telemetry needed to inform energy measures site energy masterplanning. This can create a strong basis for energy investment decision making. They can also be used to identify where permeant submetering can provide the most value.

10.7.2 Energy masterplanning

Developing long term energy masterplans that integrates heat, power and transport energy vectors is the lowest cost route to new zero for areas of the city with large or complex energy needs. It is an effective pre-requisite for both existing building clusters and new strategic development, such as Heart of the City II.

An understanding of how the net zero energy needs of the site can be met enables a flexible phased approach to be undertaken which can respond to changing technology and opportunities over time. For example, the need for more EV charger in future can be designed in from the outset., Or additional space for heat pump plant room can be safeguarded.

Energy masterplanning also creates opportunities for the development to provide energy infrastructure for nearby buildings in a cluster, but also neighbouring communities and the wider city.

10.7.3 Summary of non-domestic priority actions

Below are actions that the council should take as a priority and begin without delay to decarbonise its stock of non-domestic buildings.

Non-domestic priority actions	Short Up to 2022	Medium 2023-2026	Long 2027-2030
Deploy BEMS, AMR, permanent submetering and temporary energy loggers on all buildings. Use data analysis to target energy management and low-cost building energy measures.	●		
Develop an intensive programme of works on Council-managed non-domestic properties to kick-start an increased local delivery pipeline.	●	●	
Pilot whole building net zero retrofits, delivering a comprehensive package of measures together.		●	
Develop a long-term energy masterplan that integrates heat, power and transport energy vectors for a building or cluster of buildings with large or complex energy needs.	●	●	
Scale-up the existing revolving energy efficiency fund and align it with the approach to net zero buildings. This could include grant funding from Public Sector Decarbonisation Scheme and the city's investment budget.	●	●	

10.8 Fleet

10.8.1 Consolidation of the fleet

Sheffield City Council should carry out a fleet consolidation feasibility assessment of their own fleet to understand whether the fleet can be consolidated to fewer vehicles. This will involve undertaking a review of the need for vehicles from different departments within the Council, how many vehicles are required at any one time, the mileage and the type of vehicle required. From this, it should be possible to determine whether there are any opportunities to downsize the fleet and develop a strategy indicating the approach and timeframe of the consolidation exercise. This might be based around the vehicle replacement programme, with some vehicles being withdrawn rather than replaced when they are scheduled to be taken out of service.

10.8.2 Electrification of the fleet

The development of an electric vehicle strategy will be a key action to plan out the decarbonisation of the council's fleet and their subcontractors. As with a consolidation strategy, a feasibility assessment would need to be carried out to ensure that EVs in the fleet would be fit for purpose. The feasibility assessment can be used to develop a strategy setting out which vehicles could be prioritised for electrification and over what timescale in order to spread the cost. It is recommended that a strategy includes targets for EV penetration within the fleet and sets out how these will be achieved. Given the fast development of technology in this area, it is recommended that the strategy should be reviewed and updated every 2 years.

The strategy would be best developed in collaboration with key stakeholders, such as the Distribution Network Operator (DNO) and charge point suppliers to understand what charging infrastructure will be required and at what cost. If the strategy is to cover contractors as well as the council fleet, it is recommended that they are also consulted during the process.

The Council could consider technology trials prior to switching the fleet to ensure technologies are suitable and usable by employees.

10.8.3 Behaviour change programmes

It will be important to set out your ambition to decarbonise your fleet (and wider council travel) to employees so that this can be addressed in workplace culture. As part of this, it is recommended that the travel policy is reviewed, encouraging where possible active travel or public transport modes. Where car travel is necessary, car sharing or trip consolidation and use of EVs should be strongly encouraged ahead of single occupancy use of petrol / diesel cars. Encouraging employees to use the fleet of EVs rather than their own vehicle would also minimise emissions from the grey fleet.

Telematics could also be used to understand fleet driver behaviour and whether council would benefit from running eco-driving training courses for staff. More economical driving would help to reduce emissions prior to electrification of the fleet.

10.8.4 Procurement and contractors

It will be important to engage with key contractors such as Amey and Veolia during the review of vehicle policy and zero carbon targets. The council can use its influence over purchasing decisions and longer term fleet composition plans to accelerate existing ultra low emissions vehicle procurement.

More broadly, it is recommended that the council reviews its procurement policy to consider greater coverage and accountability of environmental and decarbonisation objectives and targets by its suppliers. This could build upon the existing use carbon benchmarking to include net zero carbon provisions.

10.8.5 Longer term innovation

In the longer term it is expected that new technologies will come into play that could further support decarbonisation of the fleet or reduce the cost of implementation. We recommend that the council considers carrying out a feasibility study into long term electrification technologies, e.g. vehicle-to-grid. This could be done in partnership with subcontractors or with research institutions and/or the DNO to identify opportunities for trialling new technologies and the time horizon for different technologies entering the mainstream market. These could be incorporated into the EV strategy at a later stage.

10.8.6 Summary of fleet priority actions

Below are actions that the council should take as a priority and begin without delay to decarbonise fleet vehicles.

Fleet priority actions	**Short** Up to 2022	**Medium** 2023-2026	**Long** 2027-2030
Build the evidence base for action - Undertake a fleet consolidation and electrification feasibility assessment	●		
Roll out behaviour change programmes	●		
Begin to accelerate the electrification of all cars and vans	●		
Work with key contractors to align their vehicle policy with the council's zero carbon targets		●	
Commit to trialling low carbon large and specialist vehicles as they become available, in preparation for a complete switch away from diesel.		●	

10.9 Funding

Implementing these interventions will need significant additional funding at a scale that is not currently available within council budgets. It is therefore important that the council's finance officers are fully aware of the scale of investment required and treat it as a priority for the council.

Securing external sources of funding will help to establish and scale-up the programme of actions that have been identified. Below are existing or proposed funding opportunities which could contribute to net zero budgets.

10.9.1 Domestic

Unlike the private sector, the council is not able to increase rents to cover the cost of these interventions and as the majority of tenants pay the energy bills directly to the energy providers, they are also unable to benefit from paybacks from energy saving interventions.

Additional funding may become available from government grants however, the council will need to be prepared and have a plan in place so that when the funding is available they can apply for it for it within the deadlines and ensure that the money is being used to support the zero carbon objectives.

The council should also investigate alternative funding models and investors. These alternative funding routes may help support installing PVs at scale through community auctions, crowd funding or 'rent-a-roof' style schemes.

10.9.1.1 Social Housing Decarbonisation Fund

The government committed £3.8 billion in its manifesto to a Social Housing Decarbonisation Fund, to retrofit energy measures at scale over a 10 year period.

The Social Housing Decarbonisation Fund Demonstrator is currently open for applications. It aims to demonstrate innovative approaches to retrofitting social housing at scale. The This £50 million competition is open now and takes a whole house approach to retrofit, deploying packages of measures in a coordinated way.

10.9.2 Non-domestic

There are several funding schemes which support the implementation of energy improvement measures in buildings that could be utilised.

10.9.2.1 Salix

Salix provide interest-free Government funding in the form of loans that are available to the public sector to improve energy efficiency, reduce carbon emissions and lower energy bills. There are currently over 100 technologies supported by Salix funding. Examples include improved boiler burner management, BMS, biomass CHP, cavity wall insulation, compressed air upgrades, energy efficient chillers, and solar PV.

The council already operates a revolving Salix fund which is used to deliver efficiency measures. Salix funding should be deployed, where possible, in a coordinated way to deliver the measures identified in this report.

10.9.2.2 ESCOs (Energy Supply Company or Energy Service Company)

The ESCO model is where a third party pays for the heating system and then owns and operates it on behalf of the council. They would supply energy to the council through a long-term contractual arrangement. The ESCO would be responsible for maintenance, guaranteeing supply of energy. This is usually over a defined period of time typically between 10 and 20 years.

The advantage of this model is that the council does not need to find the capital for the purchase of the system and does not take on the risks associated with its operation. This can be particularly effective for new heating technologies, where specialist skills and expertise do not exist within the council.

10.9.2.3 EPCs (Energy Performance Contracts)

These contracts adopt a similar model to those of the ESCOs, but they look to cover a slightly different type of measure. Typically these will capture energy efficiency measures, either individually or as a group of measures. EPC providers are again involved in the maintenance of the equipment and are therefore FM providers. The market is still very new to the UK and has mainly been trialled by NHS Trusts. Contracts tend to last for 10 to 15 years and would focus on the implementation of measures where the contractor is able to calculate savings, such as LED lighting replacement.

10.9.2.4 Public Sector Decarbonisation Fund

The manifesto notably includes a £2.9bn public sector decarbonisation fund and £9.2bn to improve energy efficiency across schools, hospitals and social housing.

The government's proposed Public Sector Decarbonisation Fund is expected to provide billions to improve energy efficiency in large public sector campus sites and across schools, hospitals and social housing. Limited details are available at present, but the scale of funding is potentially on a scale relevant to the investments required and is therefore an important funding opportunity.

10.9.3 Fleet

It is recommended that the council carries out a review of the availability of EV grants to SCC and contractors to support fleet electrification. However, The Office for Low Emission Vehicles (OLEV) have a workplace charge point scheme to support charging infrastructure in depots and at offices. There is also an equivalent home charging scheme which could be used to support employees.

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