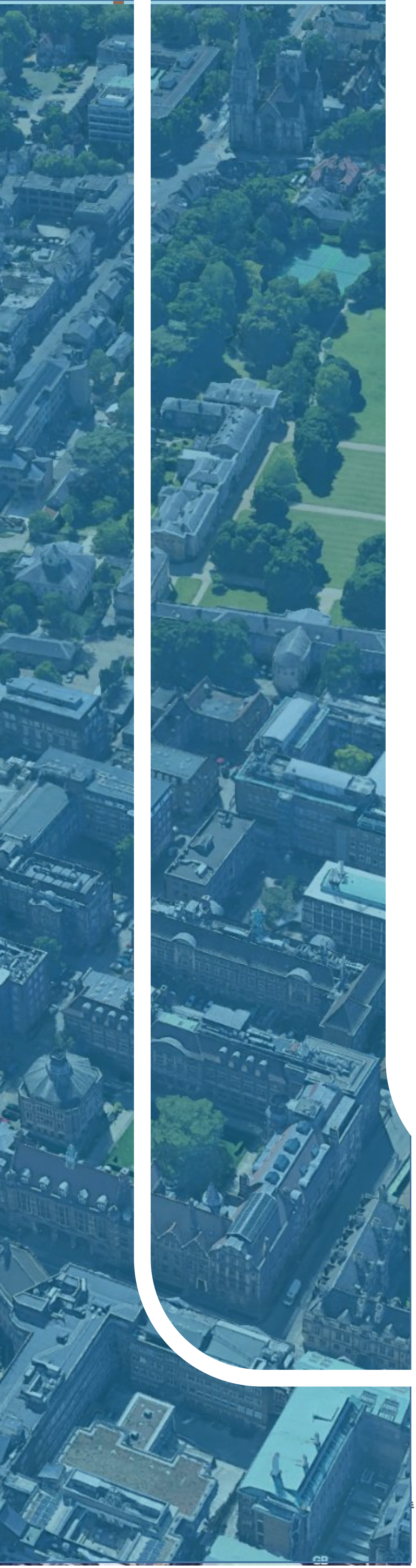
Cambridge City Council Net Zero Carbon Assessment

Contents

Revision	Author	Checked	Version	Issue Date
1	AWI	MME	First Draft	



Part 1: Introduction

1. Introduction

1.1. Overview

Cambridge City Council has declared a climate emergency and is considering committed to decarbonising their building stock by the year 2030. The Council has engaged with Bouygues Energies & Services Solutions Ltd (BYES) and requested a high-level net zero carbon assessment of their existing corporate buildings portfolio to identify opportunities and challenges associated with their journey to decarbonisation and to quantify the level of funding required to achieve their goals.

BYES has developed a net zero carbon model which should be viewed in conjunction with this report. This report documents the findings and recommendations of the investigation and outcomes of the model. It supports the key deliverable of this work, namely a bespoke tool, which provides a numerical assessment of the impacts associated with various combinations and scenarios of deployment of low-carbon heat generation technologies across the Council's corporate estate. This is a dynamic model which the Council can utilise in the future to assess the effects energy reduction projects will have on total carbon footprint.

1.2. Project scope & deliverables

Summary Scope of Work

The Council provided BYES with a list of buildings from its corporate portfolio which were to be included within the scope of the study. This included leisure centres, office spaces, car parks, sheltered housing spaces, temporary housing schemes, event spaces, community centres and a crematorium. This study primarily focuses on reducing the Council's carbon emissions associated with gas consumption and heating rather than electricity. This is because the Council has already invested heavily in reducing its electricity consumption through solar PV and LED lighting. Furthermore, the electricity grid is becoming less carbon intensive due to the installation of renewable energy projects. This trend is forecasted to continue with the grid predicted to be largely decarbonised by 2050.

The study is also to assess the viability of possible heat sharing schemes with local energy consumers. The study was to culminate in a numerical model and a written proposal outlining several interrelated sections. These are set out as follows:

- **Task 1: Opportunities** – primarily a data gathering exercise on the Council's corporate assets, works programmes and energy baselines.
- **Task 2: Options** – identifying technology options for building-level reduction of energy that could be implemented. Consideration should also be given to energy efficiency and building fabric improvements.
- **Task 3: Numerical Model** – A high-level assessment of the options identified in Task 2 to quantify the impacts of implementation in comparison to business as usual over the next 20-30 years in terms of carbon, capex and opex costs, and timeframes for implementation. The model should seek opportunities to prioritise implementation based on several criteria.
- **Task 4: Barriers and constraints** - Potential barriers to implementing the menu of option along with recommendations on how the Council can avoid or overcome these barriers.
- **Task 5: Further recommendations** - a series of recommendations on next steps, including additional work that the Council should carry out or commission, for example further studies needed to inform the development of site-specific solutions.

Deliverables

The core deliverables of this project are set out in the original tender brief and include:

- A numerical model of options, which are feasible for delivery within the next 20-30 years, for the purposes of significantly reducing the Councils carbon emissions. Each option should be quantified in terms of capital (implementation) cost, operational (ongoing) costs and potential carbon savings. Ideally, the menu of options should be interactive, allowing the Council to explore the cumulative impact and costs, over the short, medium, and long term, of any given combination of options.

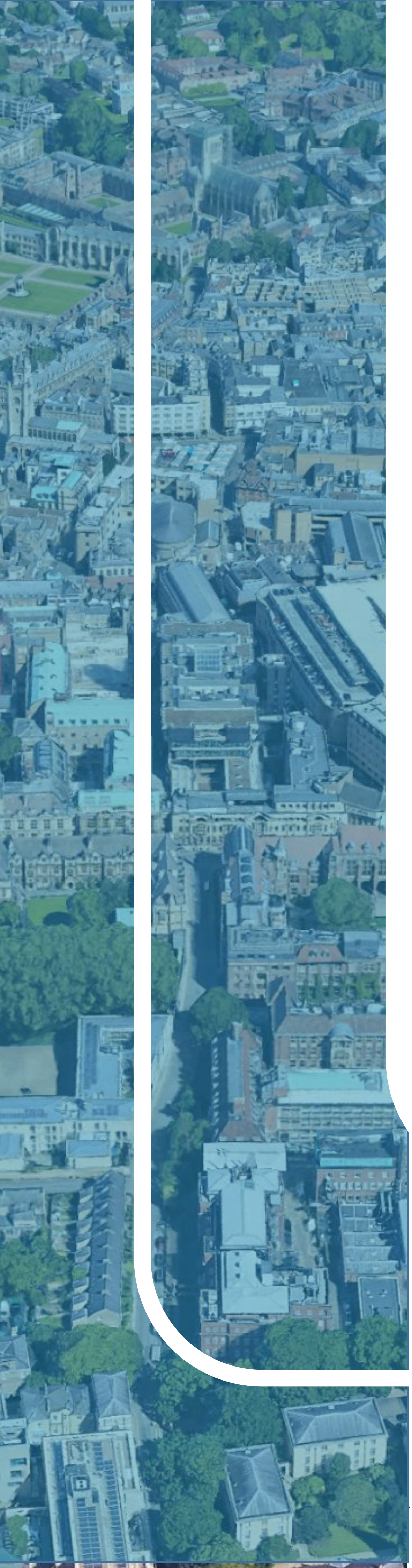
- A written report detailing the findings of the numerical model, explaining assumptions, and informing the Council of our decision-making process to allow the Council to develop their Net Zero Carbon Strategy.

As may be expected, the format and structure of deliverables of the project have evolved in line with the scope of work, albeit that we are confident that they still align with the above requirements. The deliverables are summarised below:

- **Net Zero Report** – this document; a detailed narrative of the activities and outcomes of the project, including the risks, barriers, recommendations, and next steps.
- **Numerical Options Tool** – an excel-based model that satisfies all of the above requirements. This incorporates risks and barriers at site level, as revealed via the survey work and desktop review of asset data and information provided by the Council

Scope Limitations & Exclusions

- At an early stage in the project, it was agreed that BYES would focus on a selection of the Council corporate portfolio based on energy consumption. Sites with low consumption were excluded from the study as the majority of carbon savings and capital costs would be required in the larger energy consuming assets.
- The scope of this assessment does not include consultation with third-party stakeholders, such as the electricity distribution network operator, local planning authority, conservation officers, building control, environment agency, regulated water industry companies, or other prospective consultees.
- Whilst initial recommendations are provided on technical solutions and performance expectations, it is acknowledged that this is based on desktop studies, benchmarking information and, for selected sites, high-level survey information. Further development work is required to investigate technology options in greater detail, determine technical feasibility and develop designs.
- Implementation and operational costs are based on benchmark information, informal engagement with manufacturers and supply-chain and pricing data. Whilst endeavours have been made to account for site-specific factors that may affect costs, the actual cost may only be established through more detailed assessments into each specific application.
- While BYES has visited several the included sites in the past, the intention was to visit any sites which had not been surveyed before. This was unfortunately hindered by the national lockdown that came into effect at the beginning of January 2021.



Part 2: Policy Context

2. Policy context

2.1. National Policy

Climate Change Act and Net Zero legislation

The Climate Change Act was passed in 2008 and established a legally binding obligation on the UK to reduce its CO_2 emissions by at least 80% by 2050 compared to 1990 levels. In July 2019 an amendment to the Climate Change Act was passed requiring a more ambitious emissions reduction to net zero by 2050. Under the Climate Change Act, the government must set five-yearly carbon budgets, covering the period to 2050, twelve years in advance. The 5th carbon budget covers the period between 2028 and 2032 and was set in 2016 to represent a 57% reduction in emissions compared to 1990 levels. The UK is on track to meet its 3rd carbon budget (2018-2022) but is projected to exceed its budget during the fourth and fifth periods[1]. An acceleration of the pace of decarbonisation through significant additional policy is required to meet these and subsequent budgets, and ultimately for the 2050 net zero target.

Committee on Climate Change Net Zero Technical Report

The UK net zero target is consistent with the advice given to the Government by the Committee on Climate Change in its report *Net Zero – The UK's contribution to stopping global warming*[2]. To accompany this report, the Committee on Climate Change also published their *Net Zero Technical Report*[3], which outlines the analysis behind their recommendations on a sector by sector basis, and details scenarios that could achieve the UK's 2050 net zero target. Under its 'Further ambition' scenario, necessary to achieve a 2050 net zero target, the report states that full abatement of emissions from non-residential buildings by 2050 can be achieved via a combination of energy efficiency measures, heat networks and heat pumps, with a small amount of remaining gas use (for peaking) switched to hydrogen. The analysis also finds that while full decarbonisation of the buildings sector is possible, it remains costly, with a total annual cost relative to the business as usual counterfactual of approx. £15 billion in 2050. However, significant cost-effective potential for heat networks and off-gas grid buildings is identified.

Clean Growth Strategy

The Clean Growth Strategy[4] sets out the Government's ambitions for achieving emissions reductions across all sectors of the economy whilst maintaining economic growth. 'Clean growth' aims to deliver benefits from low carbon opportunities while meeting carbon budgets. The Strategy notes that the action from non-governmental actors, including higher education organisations, will be necessary to achieve the UKs targets. A selection of the most relevant policies and proposals are summarised below:

Leading in the Public Sector

- Voluntary wider public sector carbon reduction targets
- New funding for public sector energy efficiency across the UK
- Support a local approach to reducing emissions

Improving Business and Industry Efficiency and Supporting Clean Growth

- Support businesses to improve their energy productivity by at least 20% by 2030
- Improve energy efficiency in new and existing commercial buildings
- Phase out high carbon fossil fuel heating in businesses off the gas grid
- Industrial Energy Efficiency scheme and new industrial heat recovery programme

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[1] *Updated energy and emissions projections 2018*, April 2019, Department for Business, Energy and Industrial Strategy
[2] *Net Zero – The UK's contribution to stopping global warming*, Committee on Climate Change, May 2019
[3] *Net Zero – Technical Report*, Committee on Climate Change, May 2019
[4] *The Clean Growth Strategy: Leading the way to a low carbon future*, HM Government (2017)

Revised National Planning Policy Framework

The revised National Planning Policy Framework (NPPF) was released in February 2019 and sets out the Government's planning policies for England. It acts as framework within which plans for development can be drawn up at a local authority level. Regarding heat provision, the revised NPPF makes specific reference to decentralised energy supply and suggests that *'in determining planning applications, local planning authorities should expect new development to comply with any development plan policies on local requirements for decentralised energy supply unless it can be demonstrated by the applicant, having regard to the type of development involved and its design, that this is not feasible or viable'*. However, the revised NPPF does not make provision for other low-carbon heating systems (e.g. heat pumps, hybrid heat pumps, hydrogen and biomass boilers) to replace traditional gas boilers and direct electric heaters. Nor does the revised NPPF *'require applicants to demonstrate the overall need for renewable or low-carbon energy'*.

It is worth noting that although the NPPF makes no explicit reference to the low-carbon heating technologies outlined above (e.g. heat pumps), their uptake may be supported through energy efficiency clauses in Local Plans. If more stringent energy efficiency requirements are imposed on a development, only a combination of high fabric energy efficiency and efficient heating technologies, such as heat pumps, may meet these. So, the uptake of heat pumps, for example, may be supported implicitly if Local Plans require energy efficiency standards that exceed Building Regulations, as they are able to via the Energy Act. However, it should be noted that the revised Building Regulations Part L, currently out for consultation, propose prohibiting local authorities from requiring higher standards.

Energy Innovation Needs Assessments

The Department for Business, Energy and Industrial Strategy has commissioned a set of reports, published in November 2019, identifying the key innovation requirements across the UK's energy system. The findings will inform the prioritisation of future government investment in low carbon innovation. The Assessments include separate reports considering various 'sub-themes'. Several of these are particularly relevant to the decarbonisation of heating:

Heating and cooling

The heating and cooling sub-theme identifies innovation requirements across five main areas.

Heat pumps

- New system designs with reduced capital and ongoing costs
- Smart control systems to facilitate demand side response and more efficient use of hybrid systems
- Potential to recover waste heat, or exploit potential for cogeneration of heating and cooling

Heat networks

- Low temperature network development to facilitate integration of low-carbon heat sources
- Optimisation of network design to improve customer experience

Heat storage

- Innovative materials (such as phase change materials) for intraday heat storage
- Thermochemical storage for medium/long timescales (inter-seasonal)

Hydrogen boilers

- Component improvements (e.g. flame failure detection) to arrive at a packaged system which matches the performance of natural gas boilers.
- Innovations which reduce the requirement to replace existing pipework in buildings.

Cooling

- Smart control systems
- Integration of cooling systems with heating systems and thermal storage to improve efficiency.

Hydrogen and fuel cells

The hydrogen and fuel cells sub-theme report covers a broad range of technologies relevant to the production, delivery and end-use of hydrogen. Innovations relevant to hydrogen boilers themselves though, are treated in the 'Heating and cooling' report (see above). The production section includes consideration of innovation requirements in each of natural gas reforming (steam methane and autothermal reforming), gasification, and electrolysis. The delivery infrastructure included considers storage and road vehicle refuelling stations as well as pipelines, cryogenic tanks etc. The key innovation needs identified across these sectors include:

- The integration of hydrogen production from fossil sources with carbon capture and storage
- Advances in electrolyser and fuel cell manufacturing
- Proving the feasibility of repurposing the gas network to deliver hydrogen

Building fabric

The building fabric sub-theme identifies various areas in which further innovation would be most valuable. Of these, two are particularly relevant to this study:

Guaranteed performance

Closing the performance gap between design and real-world energy use is potentially a large source of emissions reductions[5]. Advances in modelling and testing of low carbon innovations, design for manufacture and assembly (DfMA), and prefabricated retrofit envelopes are put forward as key innovations for closing this gap.

Low embodied carbon materials

Innovations in this category would reduce carbon emissions of materials across their whole lifecycle, including their manufacture and disposal. Example of potentially important innovations include cost reducing advances in low embodied carbon materials and the improved assessment of actual lifecycle costs and carbon emissions of building fabric elements.

Ofgem's Decarbonisation Action Plan

The UK energy regulator, Ofgem has just released its 'Decarbonisation Action Plan, February 2020' to align with the UK's legislated target of net zero carbon emissions by 2050. Ofgem acknowledges that there are 'great challenges ahead', specifically in relation to electric transport and the need to transform how homes and businesses are heated. Ofgem notes that additional costs are expected in the short term in order to decarbonise but stresses that not acting today will led to significantly higher costs and far greater challenges in the future.

Whilst Ofgem states that it will 'facilitate the most effective path to net zero at the lowest cost to consumers', it notes that 'in many areas the most cost-effective pathways to net zero are still uncertain and consequently the investment needs are unclear' and that in relation to heating, there are a number of potential decarbonisation pathways. The plan suggests that 100% of non-domestic buildings should be heated from a low carbon source by 2050 but notes that there is unlikely to be a single low carbon heating solution across the UK but that there is likely to be a role for heat pumps, hydrogen boilers and district heating. Further, the plan regards energy efficiency as a low regrets option that 'will be beneficial regardless of what technologies come to the fore in the future'.

2.2. Local Policy

Cambridge City Council climate emergency declaration

Cambridge City Council declared a climate emergency in February 2019. The declaration included a call on the Government to provide the necessary funding and policy changes which would allow Cambridge to reach net

[5] Committee on Climate Change, 2019. *UK Housing: Fit for the future?*

zero carbon emissions by 2030[6]. In particular the Council drew attention to policy and funding gaps at a national level with regards to:

- Investment in infrastructure for decarbonising the generation of electricity and heat
- Funding for energy efficiency improvements in buildings
- Public transport and electric vehicle uptake

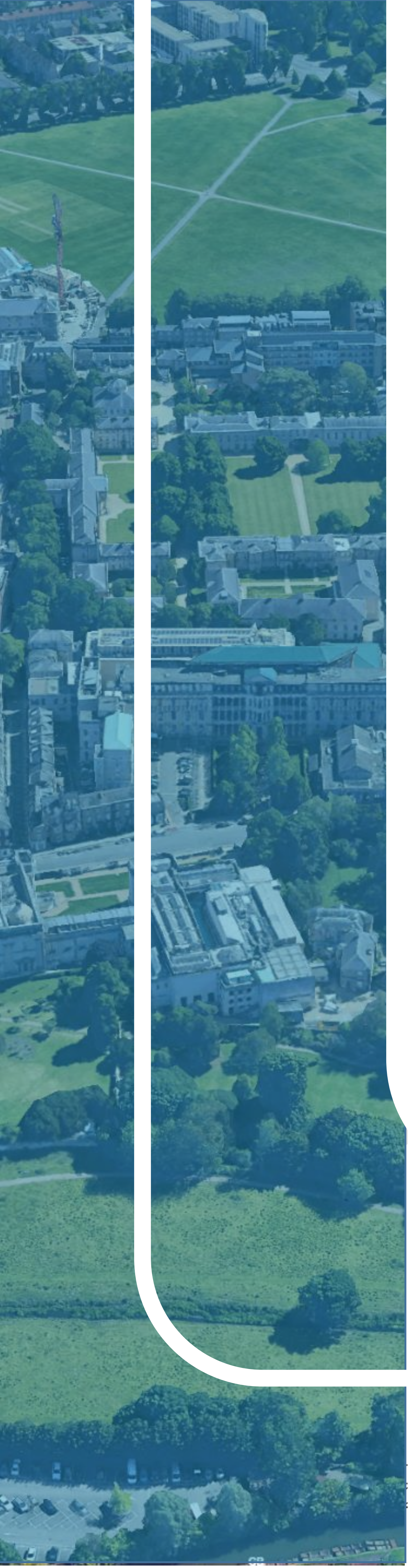
The Council also reaffirmed its commitment to emissions reductions from its own estate and operations in line with the plans set out in its Carbon Management Plan.

Carbon Management Plan 2016-2021

The Council's Carbon Management Plan was adopted in January 2016 and sets out how it intends to reduce carbon emissions from its estate and operations over the period 2016-2021. The plan notes that such a reduction will contribute to Council's wider climate change strategy, as well as potentially cutting expenditure and providing local leadership on the issue. A target is included to reduce emissions by 15% from 2014/15 levels by 2020/2021, with the aspiration to achieve a 20% reduction. The Council's annual greenhouse gas report[7] shows that this target was achieved by 2018/19, with emissions during this period 25% lower than the 2014/15 baseline. The plan describes how emissions reductions will be achieved over the period covered and includes projects covering lighting, heating system, insulation, and vehicle fleet improvements.

[6] See the Council press release, available at https://www.cambridge.gov.uk/news/2019/02/22/cambridge-city-Council-declares-climate-emergency

[7] *Cambridge City Council Annual Greenhouse Gas Report 2018-19*. Available at: https://www.cambridge.gov.uk/media/7668/greenhouse-gas-report-2018-19.pdf



Part 3: Data Gathering

3. Data Gathering

The project included a range of data gathering exercises to determine the state of the existing and future estate, the baseline heating demand and costs, and the building characteristics, risks, and suitability for future measures. This section details at a high level the method and key findings for data gathering and site surveys.

3.1. Previous studies / datasets

BYES has a strong partnership with the Council and have successfully delivered energy projects at many sites across their portfolio. There are also numerous ongoing projects included in the scope of this report where Investment Grade Proposals (IGPs) are currently being prepared. This means there is already a good amount of data held about the following sites:

- Cambridge Guildhall
- Mandela House
- Parkside Pools
- Abbey Pools
- The Crematorium
- The Corn Exchange
- Stanton House
- Ditton Court
- Rawlyn Court
- Whitefriars

The baseline energy use was determined based on historical utility energy use. The datasets provided included annual and monthly building specific meter readings:

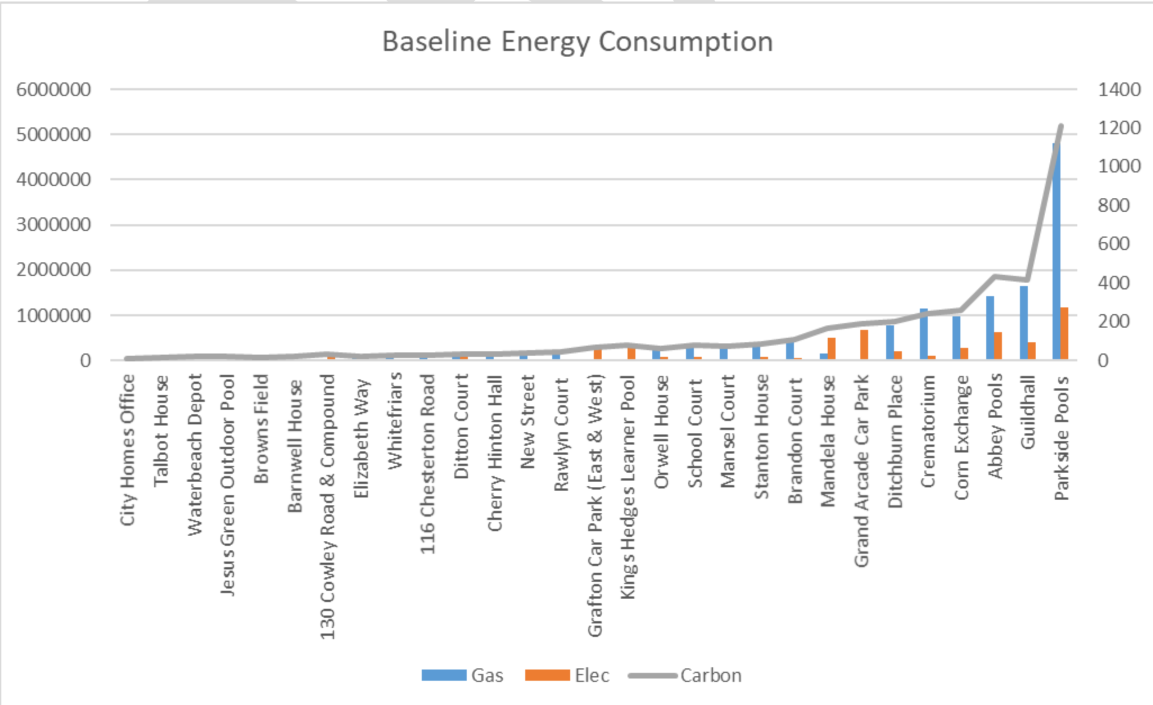


Figure 1: Baseline Energy Consumption (kWh) and carbon emissions (TCO2e) for the sites included in the scope of works

3.2. Site surveys

A series of high-level site surveys were scheduled to have been undertaken by BYES' Energy Engineers. The purpose of these surveys was to obtain physical information about the buildings, their energy infrastructure, and their surroundings. This information would aid in understanding the potential opportunities, barriers, constraints, and risks associated with the implementation of the technologies under consideration. A knowledge of the condition of the existing energy infrastructure would also enable prioritisation of upgrades and identification of pilot schemes.

Sadly, due to a national lockdown we were unable to access a number of sites, once the lockdown restrictions have been lifted, we recommend visiting the below sites:

- Clay Farm Community Centre
- Brandon Court
- Ditchburn Place

BYES' Energy Engineers sought to capture the following information as part of the surveys:

Heating & Hot Water System Details

- Fuel Sources
- Plant location
- Plant capacity, make & model etc.
- Plant conditions
- Emitters / distribution system
- Operating temperatures

Electrical Infrastructure

- Incomer capacity
- Spare capacity
- Condition

Site Details

- Plant access / space
- Adjacent properties / points of interest
- External available space
- General construction
- Notable hazards and constraints

General suitability assessment

- Ground Source Heat Pump
- Air Source Heat Pump
- Heat Network Connections

Part 4: Overview of the Cambridge City Council Estate

4. Overview of the City Council Corporate estate

4.1. Existing buildings

General Overview

With reference to asset information received, the Council's Estate comprises some 92 sites, spread across the city of Cambridge and the surrounding area. Of these 92 sites, 29 are included in the scope of this study (with the remainder either having much smaller energy demands). The most common uses are office and administrative, sheltered accommodation, leisure facilities and car parks as well as a crematorium and an event space (the Corn Exchange).

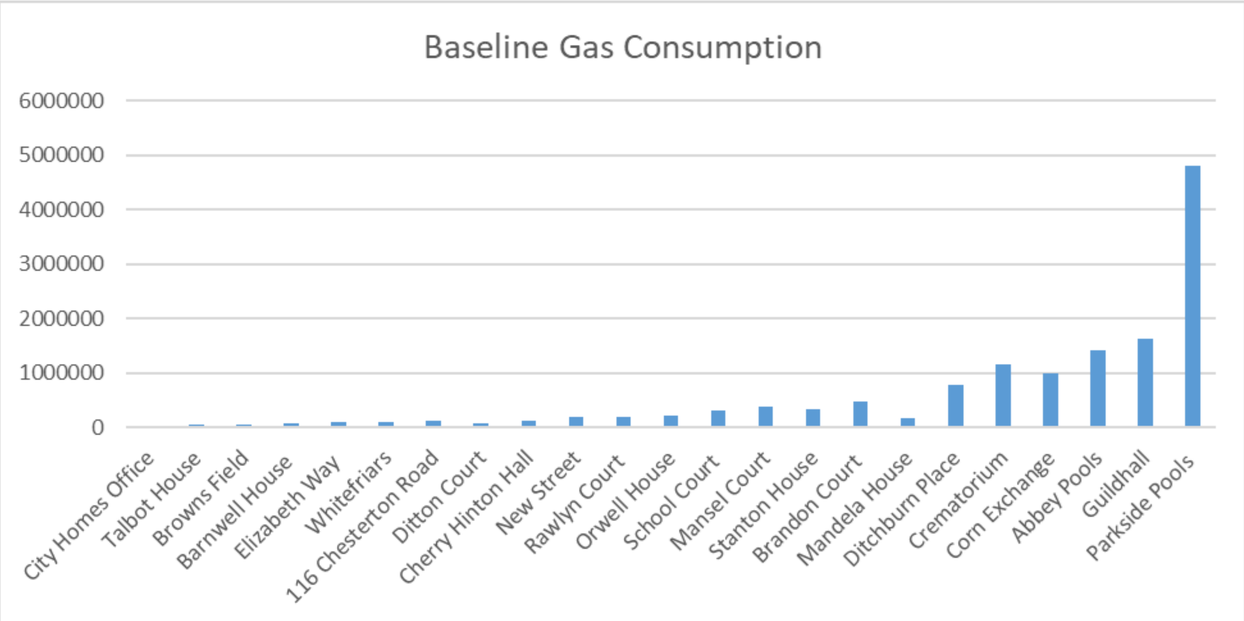
The buildings range significantly in age and construction form. The oldest construction dates to 1874 and the newest was completed within the last 10 years. The vast majority of buildings were built between the 1940s and the present day, with peak decades being the 1950s, 60s, 70s and since 2010. Buildings built since the 1940s account for almost 80% of the gross internal floor area. However, buildings built to modern standards (post 2010) account for just a quarter of the total floor area. This highlights that the thermal envelopes of most of the Council's estate are likely to fall below modern standards. The below figure sets out the number and floor area of new developments by decade.

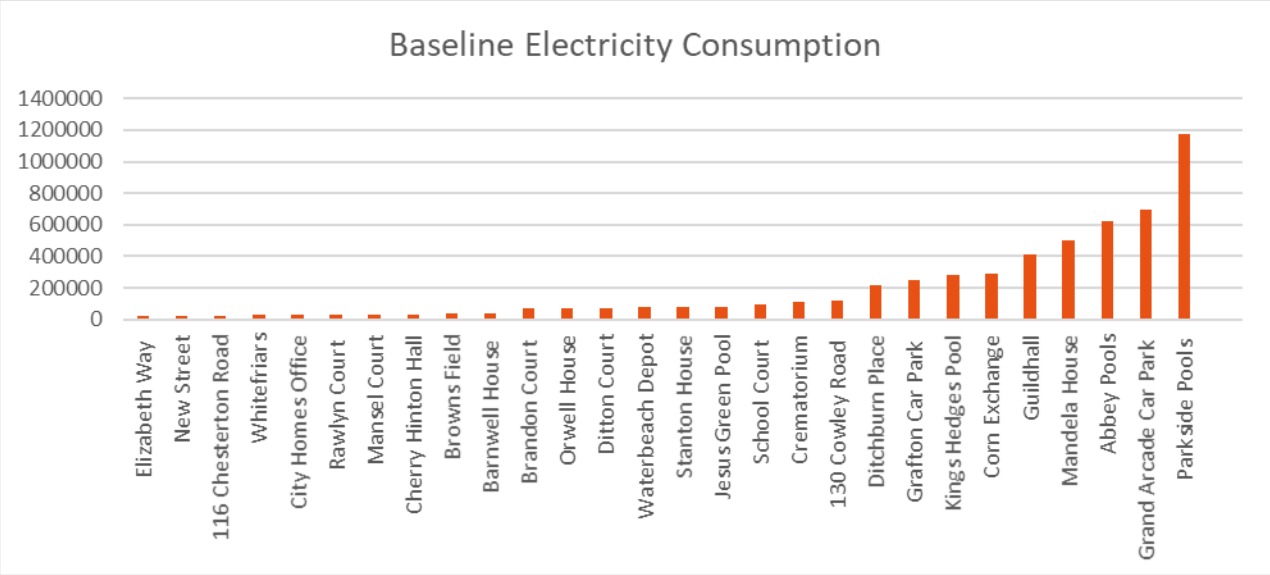
The Council has invested significantly in energy savings across their corporate portfolio, targeting a number of their high energy consuming buildings. Energy Performance Contracts have been completed or are nearing completion at Cambridge Guildhall, Mandela House, Ditton Court, Whitefriars, Stanton House and Rawlyn Court. Investment grade proposals are currently being developed at Parkside Pools, Abbey Pools, the Corn Exchange and the Crematorium.

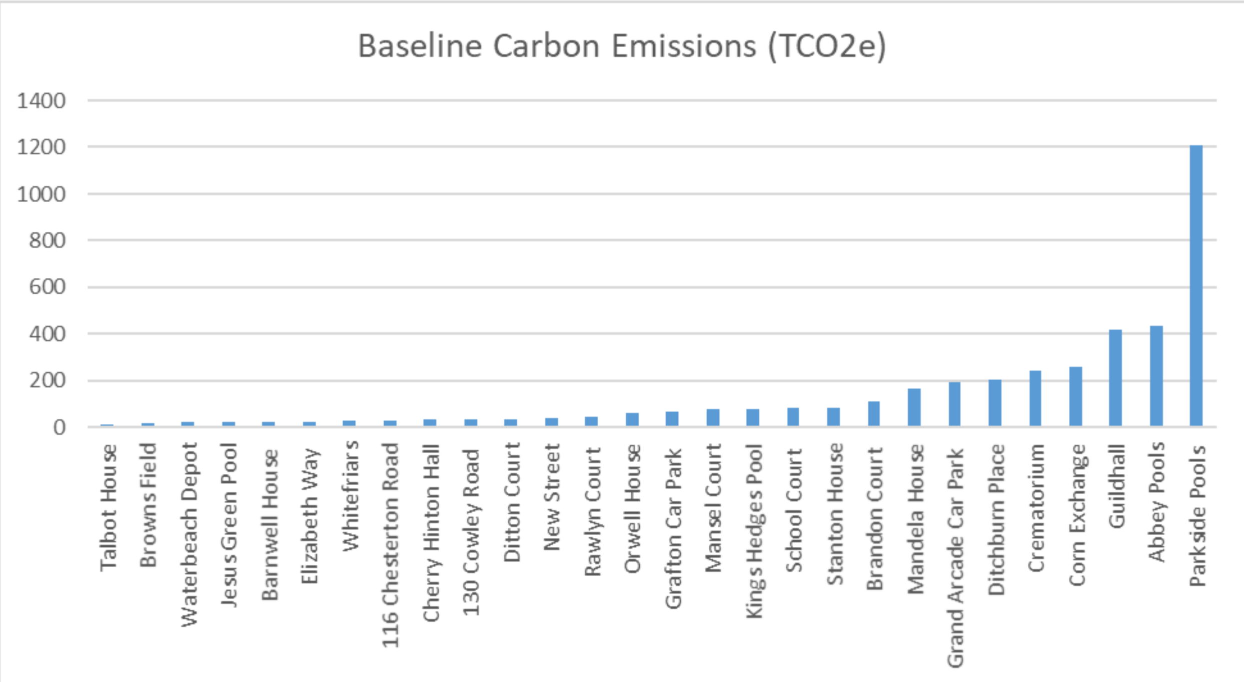
Energy Baseline

The 29 buildings in the scope of this study have a total energy demand of circa 19,838MWh/annum, of which 13,937MWh/annum is attributable to gas and 5901MWh/annum to electricity. The baselines have been normalised using the degree-day method, to eliminate impacts associated with seasonal anomalies during the baseline period. This means that the Council's Carbon baseline in 2021 is 4202 TCO_2e per annum. All the buildings heating requirements are served through gas boiler plant of varying ages which presents a significant decarbonisation challenge.

The gas and electricity baselines can be viewed below:







Most of the gas and electricity demand are attributable to a small number of large buildings. For example, just 5 buildings are accountable for over 70% of the energy consumption of the buildings in scope, as you would expect, the largest energy consumers are the large leisure centres, the older buildings (Guildhall and Corn Exchange) and the crematorium. Parkside Pools is by far the largest of all consumers and accounts for over a third of the energy consumption of the buildings in scope alone.

Parkside Pool

Parkside Pool is by far the largest energy consuming site in Cambridge City Council's portfolio. The site makes up over 31% of the energy consumption included in the scope of this project. Gas accounts for 80% of the site's energy consumption, the site currently uses gas boilers in an external plantroom and a large CHP unit to provide heat to a number of Air Handling units and underfloor heating circuits.

Parkside Pools is situated within a conservation area but has already benefitted from a large solar PV installation on the roof. There is a current development project underway to specify ASHP heating, additional solar PV, energy efficient fans, BEMS upgrades and LED lighting.

Cambridge Guildhall

Cambridge Guildhall is the second largest energy consuming asset in Cambridge City Council's Portfolio, accounting for 10.6% of the energy consumed for the buildings in the scope of this project. Gas accounts for over 80% of the site's energy use. The Grade II listed building was built in the 1930's and 40's and was designed by renowned architect Charles Cowles Voycey.

The primary heat source on site is gas boiler plant with a Combined Heat & Power unit (CHP) which is due to be commissioned shortly. Heating distribution is through an underfloor heating system throughout most of the building and a series of air handling units to serve the Council chamber. The site has recently benefitted from a new roof installation, LED lighting programme, new building management system installation, solar PV array and secondary glazing expansion.

There is a lack of available space at the guildhall for additional plant due to a lack of available roof space or space surrounding the building hence the technical challenges at the Guildhall present a barrier to decarbonisation for the Council to overcome.

Abbey Pool

Abbey Pool is the third largest energy consuming site in Cambridge City Council's portfolio. The site makes up over 10.5% of the energy consumption included in the scope of this project. Gas accounts for 80% of the site's energy consumption, the site currently uses gas boilers in an external plantroom and a large CHP unit to provide heat to a number of Air Handling units and underfloor heating circuits.

Parkside Pools is situated within a conservation area but has already benefitted from a large solar PV installation on the roof. There is a current development project underway to specify ASHP heating, additional solar PV, energy efficient fans, BEMS upgrades and LED lighting.

The Corn Exchange

The Corn Exchange is the fourth largest energy consuming asset in Cambridge City Council's Portfolio, accounting for 7% of the energy consumed for the buildings in the scope of this project. Gas accounts for over 75% of the site's energy use. The Grade II listed building was built in the late 19th century and is used as an event space. The primary heat source on site is gas boiler plant in a high-level plant room. Heating distribution is through an air handling system that the Council have raised concerns about recently due to poor heating control.

Much the same as the Guildhall the corn exchange has some serious constraints due to a lack of roof space and ground surrounding the building.

Cambridge Crematorium

Cambridge Crematorium is the fifth largest energy consuming asset in Cambridge City Council's portfolio, accounting for 7% of the energy consumed for the buildings within the scope of this project. Gas accounts for over 91% of the sites energy use however it is estimated that the up to 50% of this gas is use in the cremation process and not for space heating. The primary heating on site is served by gas boiler plant and the heat emitters consist predominantly of variable temperature radiator circuits. The site has recently benefitted from a solar PV array and are currently investigating an LED lighting retrofit and controls upgrade.

The Cremator presents a unique challenge as most technologies rely on natural gas at this stage.

Sheltered Housing

Sheltered housing accounts for 12 of the 29 sites included in this project and accounts for 22% of the energy consumed of the buildings within the scope of this study. The largest energy consuming of these sites is

Ditchburn place which accounts for 6% of the overall energy consumption. The sites included in this criterion are listed below:

- Talbot House
- Elizabeth Way
- Whitefriars
- 116 Chesterton Road
- Ditton Court
- New Street
- Rawlyn Court
- School Court
- Mansell Court
- Stanton House
- Brandon Court
- Ditchburn Place

BYES has experience with Whitefriars, Stanton House, Ditchburn Place, Brandon Court and Rawlyn Court and hence know that these are served by gas boilers as their primary heating source. Unfortunately, we have been unable to survey the other properties so have undertaken a desk-based study and made assumptions that these buildings are currently using gas boiler plant to heat the building. These assumptions will be corroborated by future site surveys when lockdown restrictions are lifted.

Other Office Spaces

Other office space accounts for circa 6% of the overall energy expenditure and consists of three of the 29 sites included in the scope of this study, these are listed below:

- Mandela House
- City Homes Office
- Barnwell House
- Orwell House

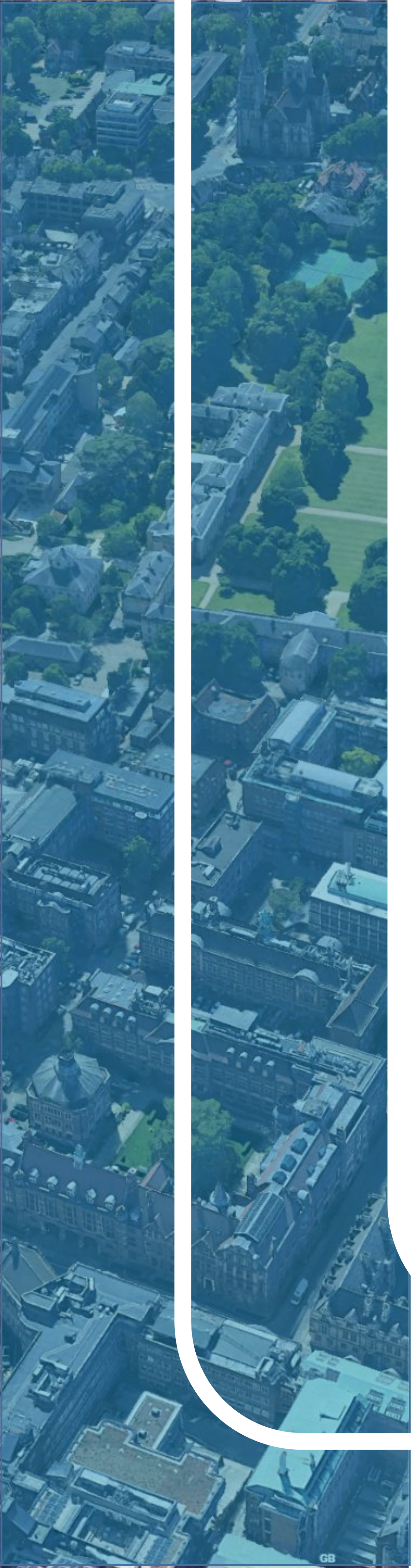
As with some of the sheltered housing sites, we have been unable to survey these so have undertaken a desk-based study and made assumptions that these buildings are currently using gas boiler plant to heat the building. These assumptions will be corroborated by future site surveys when lockdown restrictions are lifted.

Of the properties included in this study that use both gas and electricity, Mandela House is unique insofar as the building's electricity consumption is greater than its gas consumption. This is because the building already benefits from partial electric heating with the ground floor being served by gas boilers and the floors above served by VRF heating. Barnwell House and Orwell House too are unique as these are tenanted properties where the Council only pay for the heating in communal areas.

Other

Browns Field and Cherry Hinton Village Centre, while not fitting into any of the above categories were deemed to be significant enough energy consumers to be included within the scope of this survey, combined they account for 1% of the Council's energy consumption. Again, BYES has been unable to survey these so have undertaken a desk-based study and made assumptions that these buildings are currently using gas boiler plant to heat the building. These assumptions will be corroborated by future site surveys when lockdown restrictions are lifted.

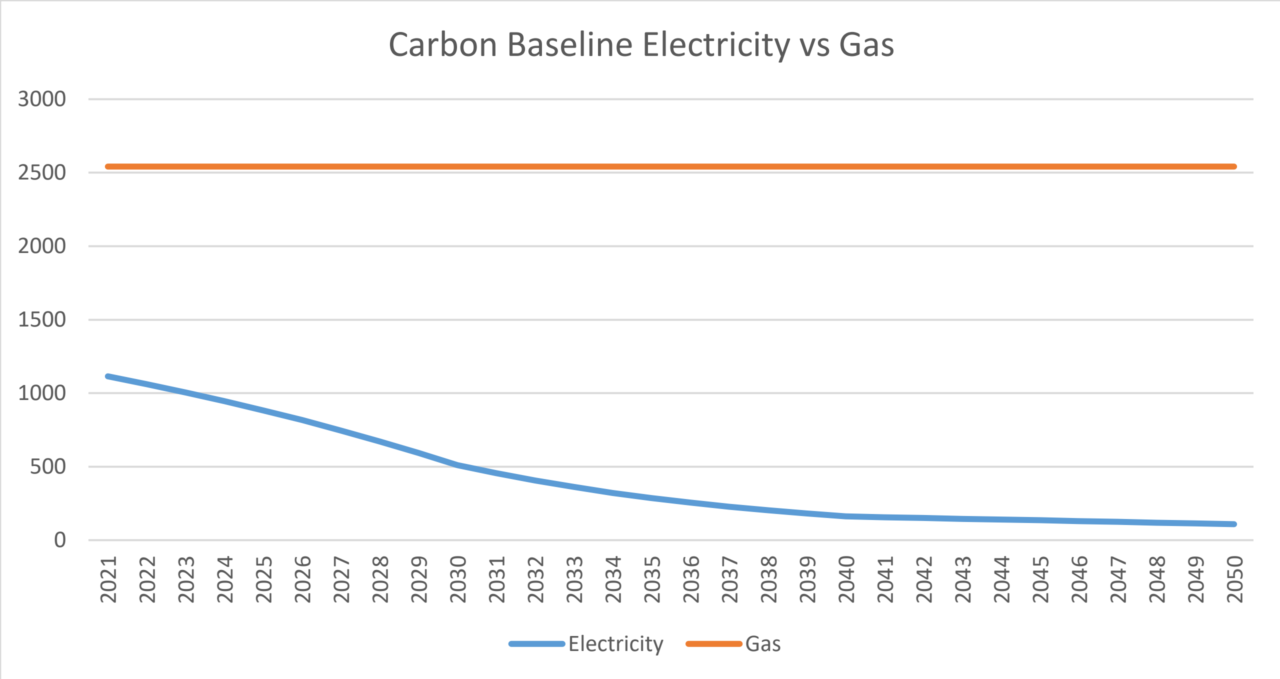
We have also included Jesus Green Pool, Kings Hedges Learner Pool, Cowley Road, Waterbeach Depot, Grafton Car Park (East & West) and the Grand Arcade Car Park into our models. While these sites do not use gas, it is important to factor in sites which have relatively high electricity consumption into our reporting to give accurate figures for the Council.



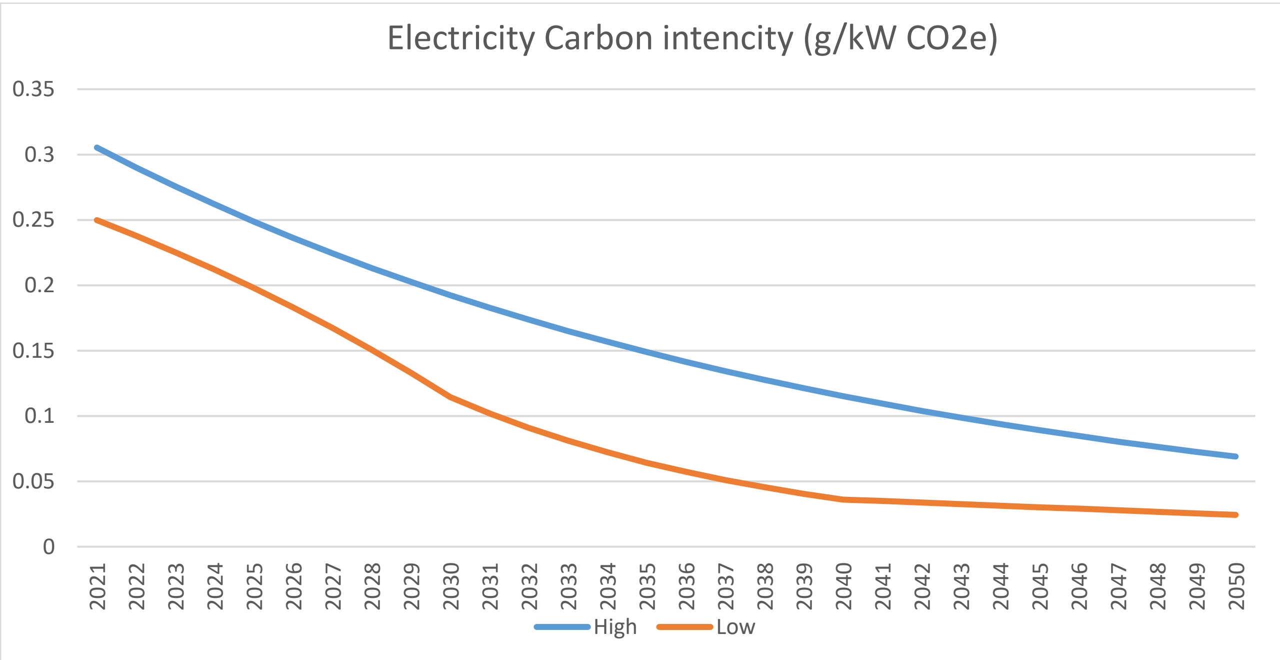
Part 5: Opportunities for Carbon reduction

5. Opportunities for Carbon Reduction

When assessing the Council's opportunities for carbon reduction it is important to differentiate between electricity and gas. While as of 2021 it appears that electricity makes up a third of the Council's corporate portfolio, by the year 2050 that will have fallen to just 4% due to the decarbonisation of electricity. While we have still included electricity in the scope of this project it is clear that gas presents the greatest hurdle the Council faces on the route to Net Zero. It is for this reason that we have identified renewable heating as the main priority and identified electricity savings where possible.



One caveat of the above statement is that these assumptions are based on the grid decarbonising in line with BEIS projections. Should there be any major deviation from this either by way of more rapid decarbonisation or by a delay this will have knock on effects on the Council's decarbonisation strategy.



In order to significantly reduce natural gas consumption for space and water heating across the estate, alternative heating technologies are required. To ensure alignment with the Council's zero carbon target, these technologies need to be zero carbon compatible. Each technology option is presented below. Building fabric energy efficiency measures could reduce the Council's overall gas use but will not allow full decarbonisation unless combined with zero carbon compatible heating technology.

5.1. Low carbon technology options

Heat pumps

Heat pumps are a form of electric heating where energy is extracted from the environment in order to provide space or water heating at a high efficiency. They operate via a cycle of vaporization and subsequent condensation of a refrigerant and typically transfer an amount of heat energy 3-4 times larger than the electrical energy used. Heat pump operation emits no greenhouse gases on site (other than any leakage of refrigerants), and their high efficiency means they can achieve very low levels of CO2 emissions from power generation when combined with overall decarbonisation of the electricity grid. Heat pump efficiency decreases with the size of the difference between the temperature of the environment and the delivered output temperature – highest efficiency occurs when the environment is warm and the output temperature is relatively low. Heat pump systems normally involve some form of heat storage such as a hot water cylinder, and often use an additional heat source to provide hot water. While heat pumps are the most common renewable heating technology domestically in the UK[8], the rate of non-domestic installation is low – less than 2000 heat pumps were installed under the non-domestic Renewable Heat Incentive between Nov. 2011 and Nov. 2019[9]. It is however noted that heat pumps for cooling and cooling/heating purposes (i.e. chillers) are very common.

There are two kinds of heat pump commonly in use in the UK – air source and ground source. Air source heat pumps (ASHP) extract heat from the outside air, while ground source heat pumps (GSHP) use heat from the soil or ground water. Of around 17,000 heat pumps installed in the UK in 2017, 80% were air source[10]. Ground source heat pumps can often operate at higher efficiency than air source heat pumps and deliver more heat per unit electricity than air source heat pumps when measured over a full year[11]. However, they have minimum space requirements for installation and are generally more expensive due the requirement for groundworks during installation.

As noted above, heat pumps are most efficient when they are operated at a low output temperature (typically 45-55°C) rather than the typical 80°C output for a gas boiler. The majority of heat pumps in operation today are therefore low temperature heat pumps. However, low temperature heating is only suitable for buildings where the existing heat distribution system (radiators, pumps and pipes) is able to provide sufficient thermal output to maintain thermal comfort, typically in well insulated buildings. Alternatively, high temperature heat pumps (operating at up to 80°C) are available and are suitable for a greater number of properties given their ability to supply the existing heat distribution system at the same temperature as the counterfactual technology that the system was designed for. The main drawbacks of high temperature heat pumps are the additional capital cost and the reduced efficiency relative to low temperature heat pumps. High temperature heat pumps are a relatively immature technology so cost reductions and improved performance is expected in the future but is currently highly uncertain.

Direct electric heating

Direct electric heating works by passing an electric current through a resistive element to generate heat. There are various systems for distributing this heat (convection heaters, infrared, electric boiler), but in each case the efficiency cannot rise above 100%. This causes the key disadvantage of direct electric heating compared

[8] Department for Business, Energy & Industrial strategy, 2019. *Energy Innovation Needs Assessment, Sub-theme report: Heating & cooling*

[9] Department for Business, Energy & Industrial strategy. *RHI monthly deployment data: November 2019*. Available at: https://www.gov.uk/government/statistics/rhi-monthly-deployment-data-november-2019

[10] European Copper Institute (2018), *Heat pumps: integrating technologies to decarbonise heating and cooling*. Available at: http://www.buildup.eu/sites/default/files/content/ehpa-white-paper-111018.pdf

[11] *Analysis of heat pump data from the renewable heat premium payment scheme*, UCL, 2017

to heat pumps; both the running costs to the consumer and the CO_2 emissions of direct electric heating are significantly higher. Electric storage heaters, which make use of cheaper, off-peak electricity mitigate this first disadvantage to some extent but do not change the associated CO_2 emissions.

However, there are advantages of direct electric heating which make it attractive in some circumstances. It typically has a considerably lower capital cost, with a cost (including installation) of around £1,200 for a domestic property, as compared to around £7,000 for an air source heat pump. In addition, it can be installed in the majority of the building stock without the need for a low temperature heating system or deep energy efficiency improvements. It is however noted that the technical feasibility of direct electric heating as a retrofit may often be severely restricted by the lack of grid capacity, given the significant loads it would create.

Biomass boilers

Biomass boilers operate similarly to a conventional gas boiler, providing both hot water and space heating by the combustion of fuel to heat water. However, rather than using natural gas as fuel they use wood pellets or logs. On combustion, carbon in the wood combines with oxygen in the air to form the same amount of carbon dioxide which was absorbed from the atmosphere during that wood's life. As a result, the burning of biomass can be considered carbon neutral, although only when replenishment of the tree or plant is assumed, when any required transportation is net zero, and when emissions are considered over a long enough time period. Because of the lower energy density of wood fuel, biomass boilers are physically larger than gas boilers, and storage space is also required for the fuel. A biomass boiler also needs additional maintenance as compared to a traditional gas boiler – ash must be removed frequently, and the fuel store replenished.

Biomass for heating is generally unsuitable in urban areas because of adverse air quality impacts. In addition, in the long term it is likely that demand for biomass will surpass the available sustainably sourced supply, in which case only the most efficient uses at a national level ought to be pursued[12]. This would likely exclude biomass boilers, except in some limited circumstances, such as in hard-to-insulate buildings away from urban areas. In terms of the Council's planning, this means that there is uncertainty over the extent of government funding (from any successor to the non-domestic RHI) likely to be available for biomass heating in the future. While biomass boilers represent 85% of the renewable heating systems installed under the non-domestic Renewable Heat incentive[13], the Committee on Climate Change has recommended that BEIS ends support for their installation where other low-carbon options are available[14].

Hydrogen boilers

An alternative pathway for the decarbonisation of heating to the electric and biomass based options described above is the provision of low-carbon hydrogen, likely via a repurposed gas distribution network, which would be burned in boilers similar to those currently in use for natural gas. The potential benefits of such an option include low building scale costs (similar to current costs for gas boilers once produced at scale) and no additional space or building energy efficiency requirements compared to gas boilers. Additionally, hydrogen boilers would imply minimal change in user experience as compared to gas boilers.

However, the deployment of hydrogen boilers by the Council will only be possible with large scale rollout of the required infrastructure at a national/regional scale such that hydrogen supply is made available. There are significant barriers and challenges associated with the widespread use of hydrogen for heating. Hydrogen boilers are not yet a proven technology and there are concerns around safety of use and distribution, and the associated consumer acceptability. In addition, there is uncertainty over the commercial viability and optimal method of producing large quantities of low carbon hydrogen[15]. The government has not yet taken a policy

[12] Committee on Climate Change, 2018. *Biomass in a low carbon economy*

[13] Department for Business, Energy & Industrial strategy. *RHI monthly deployment data: November 2019*. Available at: https://www.gov.uk/government/statistics/rhi-monthly-deployment-data-november-2019

[14] Committee on Climate Change, 2018. *Biomass in a low carbon economy*

[15] For example, see *Options for producing low-carbon hydrogen at scale*, Royal Society

position on the future of the gas grid; the Clean Growth Strategy[16] states the government's ambition for a decision to be made over decarbonising heat, including the future of the gas grid, in the first half of the 2020s.

District heating

District heating systems, or 'heat networks', use centralised energy sources to supply heat to multiple users. Water is heated centrally, and then hot water or steam is distributed via a network of insulated pipes. Networks vary in size; they can span across large areas of a city but can also cover a small cluster of several buildings. A key advantage of district heating over building-scale heating systems is that they benefit from economies of scale and the diversity of heat demand profiles across users. They can also utilise multiple heat sources, including waste heat sources, such as from industry or power generation. A further advantage of district heating, which is of particular value for some of the more constrained sites and buildings within the Council's estate, is overcoming space constraints as plant is shared between the network freeing up space in more constrained buildings. Most district heating systems provide the desired temperature directly, but schemes exist in which distribution occurs at a lower temperature and then increased within individual buildings using small heat pumps. This has the advantage of reducing thermal losses along the network[17].

District heating is cost-effective in areas of high heat demand density, since the costs of distribution pipework and energy generation facilities are then shared between a larger number of users. They are most efficient when combined with low temperature heating systems as this reduces thermal losses along pipes. If powered using heat pumps, a low operating temperature also increases the efficiency of heat generation. However, successful space heating at low temperature requires high energy efficiency standards and will not be possible for many of the Council's buildings. In this study, district heating systems are modelled using high operating temperatures to ensure compatibility is maximised.

There are around 5500 district heat networks in the UK, and buildings in the education sector make up 26% of the non-domestic heat load served by these networks[18]. There are various options for the central heat supply facilities. These include natural gas fired boilers or combined heat and power (CHP), waste heat sources (industry, power generation, environmental), heat pumps, and biomass fired boilers/CHP. While the majority of currently operating heat networks are powered by natural gas, the proportion of networks powered by low carbon sources, such as waste heat and heat pumps, is growing[18].

5.2. Energy efficiency measures

Building fabric energy efficiency measures reduce the energy required to maintain the same internal temperature profile for a building and hence reduce the space heating demand whilst having little or no impact on the energy demand for hot water. Building fabric energy efficiency measures typically reduce thermal energy loss by improving the insulation of the walls, roof, floor and / or windows or be improving the airtightness. Heat recovery can be used to further reduce the heat loss and hence lower the space heating energy demand.

In addition to building fabric measures, efficiency improvements can be realised in the delivery of heat, namely the avoidance of excessive space conditioning, unnecessary circulation / distribution of heat (and associated systems losses) and process wastage. It is acknowledged that the Council has clearly invested heavily in this area, given that the HVAC equipment is largely controlled by concurrent TREND building energy management systems. However, control technologies and mechanical systems design philosophies are subject to continual evolution, often revealing relatively short investment return opportunities.

The associated carbon emission reduction is in proportion with the energy demand reduction, but the absolute saving will depend on the heating system supply the heat demand. As such, the impact of energy efficiency measures on reducing carbon emissions is greatest for high carbon technologies and falls to zero for absolute zero emission technologies. Beyond reducing carbon emissions, building fabric energy efficiency measures also

[16] *The Clean Growth Strategy: Leading the way to a low carbon future*, HM Government (2017).

[17] Department for Energy and Climate Change, 2016. *Heat pumps in district heating*, a report by Element Energy and Carbon Alternatives

[18] The Association for Decentralised Energy, January 2018. *Market Report: Heat Networks in the UK*

perform a second function which is likely to be more important when pursuing a rapid transition to absolute zero emissions; they facilitate the use of low temperature heating systems, which allow certain low carbon heating systems, such as heat pumps, to operate more efficiently (as discussed in Section 5.1 above).

It is noted that retrofit energy efficiency improvements will be vital in order to mitigate the impacts of any additional loads placed on local and national energy infrastructure. In particular, the seemingly inevitable increased reliance on electricity to power heat pump-based technologies must be assessed against the infrastructure limitations and in renewable electricity production and availability. In other words, such significant increase in electricity demand and consumption will result in an equally significant increase in generation, which could potentially result in higher levels of fossil-fuelled/non-renewable electricity production. Energy efficiency measures could partially alleviate the need for additional electricity production, as well as reinforcement of local infrastructure.

Part 6: Numerical Model

6. Numerical Model

6.1. Functionality

The purpose of the Numerical Model is to help the Council consider impacts of different scenarios on our recommendations. The tool has been developed to display the carbon savings we believe are feasible in terms of both cost (£) and carbon (tonnes/yr) savings. It should be used as a high-level estimate only to help determine measures and sites to consider through further, more detailed studies.

The tool models projected demand, costs and carbon for selected scenarios. The tool uses a range of different economic scenarios to allow the Council to model various scenarios and understand the effects that different economic variables have on the identified opportunities; however these values are based on data currently available (predominantly using government projections) and may not be a true reflection of what may come in the future. Nonetheless, a key functionality of the model is the ability for the Council to update values at a later date.

6.2. Methodology

Site Inputs Tab

The numerical model consists of a dashboard which takes information from site specific tabs which relate to individual buildings. This allows either BYES or the Council to add or remove sites, set expected site life (should the Council choose to sell the building) and tailor energy saving measures to each site.

Cambridge City Council Net Zero Strategy
Carbon Footprinting Tool

Site Name	Parkside Pools
Asset Lifecycle	50
In Scope	In

Site Costs

Annual OPEX Costs	59806
Annual Lifecycle Costs	48045

Energy Conservation Measures

ECM Name	BEMS	LED	PV	ASHP	GSHP	CHP Decom	Enabling
Electricity Change	58803	35281.899	63000	-366666.667	-126666.7	-796334.7	
Gas Change	480450	0		1100000	380000	2,844,052	
Capital Cost	£ 55,000	£ 42,000	£ 82,000	£ 858,000	£ 718,200	£ -	£ 78,810
Tariff Revenue							
OPEX Cost Change	£ -	-£ 150	£ 350	£ 8,500	£ 7,000	-£ 10,000	
Lifecycle Cost Change	£ 2,226		£ 1,132	£ 34,723	£ 9,914	£ -	
Year of Installation	1	1	1	1	6	6	6
ECM Lifecycle	15	7	25	15	25	0	50

Monthly Baseline

	Electricity	Gas
January	84176	542,952
February	78964	503,401
March	84946	494,536
April	80777	422,935
May	85556	354,744
June	98076	285,188
July	155620	242,228
August	158278	271,550
September	105823	321,330
October	75799	392,931
November	84836	465,896
December	83214	506,811
Totals	1,176,063	4,804,503

The user can define inputs by making alterations to selected fields in the model. These inputs include:

- Asset Lifecycle – the number of years the Council anticipates the building will fall within the Council's corporate portfolio. At present the model continues to 2050, hence an input of "9" in this space would inform the model that in the year 2030 the asset is due to be sold or demolished.
- In/out of scope – should the Council wish to exclude specific sites from the scope of this study then by selecting "out" in the drop-down box, the site will be removed from the model calculations

The model then uses the existing building energy consumption and heating systems information as well as technology cost and efficiency data to determine the cost and energy savings of each recommended ECM.

The following data is included on heating system cost and performance:

- CAPEX: Equipment and installation cost

- OPEX (O&M) Additions: ongoing operations and maintenance costs
- Lifecycle Cost Additions: cost of ownership costs and estimates of equipment lifecycle.

Dashboard

The Dashboard uses the information which is displayed in the site-specific tab and displays the results of the proposed ECMs for all sites. It then calculates the overall results of the study and displays the outputs listed below:

- Portfolio Baselines
- Cumulative Carbon Consumption
- Energy Savings
- Annual Carbon Savings
- Carbon Savings Against Baseline
- Carbon Savings Value
- Energy Cost Reporting
- Portfolio Capital Costs
- Portfolio OPEX Costs
- Portfolio Lifecycle Costs
- Reporting Ownership Cost

We have also allowed for a number of input variables which will allow the Council to further stress test the results of the study and see the effects that utility prices, inflation, carbon factors and carbon pricing would have on capital costs and carbon savings.

Part 7: Decarbonisation Opportunities

7. Decarbonisation Options

Looking at the buildings in scope we have been able to recommend measures which will dramatically reduce the carbon emissions associated on a site by site basis. We will summarise the measures and the rationale for selection in this section

Site Specific Recommendations

Parkside Pools

As the Council's largest energy consuming asset decarbonisation of Parkside Pools is a top priority. At the moment the site is served by two gas boilers which are in desperate need of replacement with a low/zero carbon heating source. The obstacles facing Parkside at this stage is that the building is within a conservation area, meaning that special attention must be paid to any visual impacts of proposed measures.

There is an IGP currently in development which will address a number of the core issues at Parkside and significantly reduce the sites carbon emissions. The proposal includes for the removal of the external boiler enclosure and the condemned boiler plant in the plantroom and the installation of dedicated heating and DHW ASHPs as well as a backup boiler that will be used to top up heat if the exiting CHP and the ASHP require additional capacity. The proposal also includes for a series of efficiency improvements including fan replacements for the Air Handling Units (AHUs) and a new BEMS which will dramatically reduce the sites energy consumption. Finally, an additional solar PV array is proposed to add additional capacity to the 50kWp array currently in place.

The last challenge the Council will face will be the decommissioning of the CHP and the installation of a renewable heat source to satisfy the demand that was previously being served by it. While a CHP is classified as a low carbon heating source by generating electricity from gas and utilising the heat which is usually wasted by traditional electricity generation. This low carbon classification only remains true while the carbon factor of electricity remains high. As the carbon factor of electricity reduces year on year there are questions over how much longer the technology will be classified as low carbon. Since the two ASHPs already proposed will have utilised all available space for ASHP we have proposed a GSHP be installed with boreholes surrounding the leisure centre to satisfy the sites remaining heat renewably.

The Guildhall

As previously mentioned, the Council have invested heavily in reducing the energy consumption and carbon emissions from the Guildhall as far as economically possible. Nevertheless, the Guildhall presents a significant challenge for decarbonisation owing largely to its location. A central Cambridge landmark the Guildhall has some significant spatial constraints which limit renewable heating options dramatically. Other than Market Square, the Guildhall is surrounded by historically significant buildings with very little in the way of open space, hence a GSHP cannot be considered. Furthermore, there are spatial constraints surrounding the building and on the roof, which would prevent the Council from being able to install an ASHP. Finally, the grade II listing of the building and the fact that it sits within a conservation area means that dedicated renewable heating solution for the Guildhall is considered not to be feasible.

The location of the Guildhall and the proximity of a number of other major energy consumers who face similar dilemmas does afford the Council an opportunity to look at a community district heating scheme. There are a number of major energy users including the Corn Exchange, Grand Arcade shopping centre, University sites and many other commercial properties that surround the Guildhall. Should these properties wish to meet their renewable obligations then a shared heating network will likely be the best way to meet these requirements.

Our recommendations for the Guildhall at this stage consist of a proportional contribution towards a heat network that will supply the Building and a BEMS upgrade when the technology has advanced to a point where further efficiencies can be achieved through the system.

Abbey Pools

Abbey Pools is another top priority decarbonisation site for the Council and is currently the third largest energy consumer in the portfolio. Again, the Council has already invested heavily to reduce the buildings energy consumption but more is required to reach net zero. The site already benefits from a rooftop solar PV array and receives some renewable heating from a Solar thermal system.

In 2020 a Public Sector Decarbonisation Scheme (PSDS) application was made for Abbey pools to install a GSHP system which is predicted to satisfy 50% of the sites heating requirements. This would work in conjunction with the condensing gas boiler plant to satisfy the buildings heat requirements in the short term. The application also included for a new Building management system and replacement fans for the air handling units to minimise on site energy consumption.

Should the PSDS application be successful and these measures be implemented on site then we would recommend the installation of an ASHP to offset the remainder of the on-site gas use. It has also been noted that there are still some fluorescent light fittings on site which could be replaced with LED lighting to further reduce the sites electricity consumption.

The Corn Exchange

The Corn Exchange suffers from many of the same challenges that the Guildhall does in terms of decarbonisation. The building is grade II listed and within a conservation area and space is as constrained if not more so than at the Guildhall hence neither a dedicated heat pump solution for the Corn Exchange at this stage is not feasible. There are opportunities to improve the efficiency of the building in its current state. We would propose the installation of a new BEMS to maximise the efficiency of mechanical plant and ventilation systems. The installation of efficient LED lighting and the replacement of the exiting air handling system and modification to the heating distribution system in the building.

There are currently significant issues with thermal comfort when the building is being used as an arts venue owing to the rudimentary ventilation layout and the banked seating arrangements. The ventilation system must work extremely hard to provide heating to floor level which leads to significant overheating for those seated at the back of the building directly beneath the heating vents. This means that the windows need to be opened at the back of the building to maintain thermal comfort which naturally leads to significant energy wastage.

Once these issues have been addressed then the Corn Exchange could too benefit from a centralised heating network targeting the main energy consumers within the immediate location. Hence, we have included again for a proportional contribution towards the installation of a heat network to serve the building.

The Crematorium

The Crematorium poses a unique decarbonisation challenge which is associated with the building's cremators. While there are opportunities in the short term for controls improvements and mechanical modifications to get the heat recovery unit operational, a renewable solution to the cremators will be necessary to fully decarbonise the building. At present there is the facility in place to recover heat from the cremators which is currently not being utilised. Once this function can be fully utilised the gas consumption associated with heating the building will dramatically drop. The proposed BEMS install will be able to work in conjunction with the heat reclamation to maximise the energy savings.

Once a renewable cremation technology has been identified we can see whether this heat recovery system can be retained or whether a renewable heating technology will be required. At this stage we have proposed the installation of an ASHP to provide heating to the building in the absence of heat recovery.

City Homes Office

The City Homes office is a small office building that is the lowest energy consuming asset included in this study. We have previously surveyed this building for solar PV installations and LED lighting, but the building was seen to be a low priority due to its size. Unlike some other sites included in this study the city homes office is has a more straightforward solution. We have recommended the installation of a new BEMS and LED Lighting to minimise energy consumption on site, Solar PV to generate renewable electricity and an ASHP to satisfy the sites heating demand. The only area of concern that could complicate the ASHP install would be the incoming supply capacity of the building which would need to be confirmed prior to install.

Stanton House

Stanton house is a sheltered housing scheme that consists of 25 dwellings which contributes 2.33% of the energy consumption included in the scope of this report. At present the Council is currently deliberating over a suite of energy saving and renewable energy technologies that would dramatically reduce the sites associated carbon emissions. We have proposed the installation of LED Lighting to reduce on site electrical demand, the installation of solar PV for renewable electricity generation and the installation of separate ASHPs for each flat. The purpose of individual ASHPs would be that the Council should be able to benefit from Domestic RHI Tariff revenues as long as the system is commissioned by the end of March 2022. A separate project is currently underway to assess the feasibility of individual ASHPs to assist the Council with the delivery of these measures.

Mandela House

Mandela House acts as one of the City Council's administrational centres and is situated in central Cambridge. Mandela house contributes nearly 4% of the energy consumption included in the scope of this study but unlike most buildings, electricity use seems to be greater than gas. The building already benefits from a solar PV array and has already had a full LED lighting install to reduce electricity consumption. However, we have identified some LED lights on site which appear to have been over specified, while these fitting are not inefficient we have recommended that the Council look at replacing these LED lights at the end of their asset lifecycle with more efficient LED fittings. We have also similarly recommended the installation of an upgraded BEMS when the technology has advanced to allow greater control.

There are some spatial constraints which limit opportunities for a GSHP for Mandela house but there is available roof space to consider an ASHP. It's likely that there will need to be some structural reinforcement to allow the ASHP to be sited on the roof and there may need to be upgrades to the site's electrical capacity. While this is the option we have put forward in this proposal there are also possibilities for a heat network with a borehole array situate on Parkers Piece that could supply heat to the surrounding energy consumers including Mandela house, Parkside Pools, Parkside College and others.

Ditton Court

Ditton Court is a sheltered housing complex that contributes 0.9% of the energy consumption included within the scope of these works. The site has been previously surveyed to identify opportunities for LED lighting, but this was found to be limited. We have proposed the installation of a BEMS to minimise the sites energy consumption and the installation of solar PV and an ASHP to generate renewable energy. Further survey will be needed to obtain information about the site's main electrical incomer and to assess suitability but there does appear to be space to install an ASHP.

Ditchburn Place

Ditchburn Place is one of the Council's largest sheltered housing facilities and is in a building which was built over 100 years ago and was used previously as a maternity hospital. The site is currently served by centralised gas boiler plant with heat being distributed to each dwelling. We surveyed this site as part of this study and have identified opportunities for the installation of a BEMS and LED lighting to reduce energy consumption. We would also recommend installing a solar PV array to generate renewable electricity and install an ASHP to replace the gas boiler plant and fully decarbonise the building. Like many of these sites there are spatial constraints that preclude the installation of a GSHP but there are numerous possible locations for an ASHP. Again, a further survey of the main electrical incomer will be required to confirm suitability.

Elizabeth Way

Elizabeth Way again is a sheltered housing scheme made up of two separate properties (1 and 44) and is one of the smallest energy consumers in the portfolio. Unfortunately we have not been able to survey the building at this stage so we cannot make any assumptions on energy efficiency measures but it is possible that the site could benefit from any combination of LED lighting, cavity wall/loft insulation or solar PV. At this stage we have proposed the installation of separate domestic ASHPs to bring the building off the gas network. Proposals for this site will be finalised when surveys are allowed to resume.

Mansell Court

Mansell Court is a larger sheltered housing scheme with a relatively high gas consumption in comparison to other comparable schemes. Again, unfortunately we have been unable to access the site, but we have proposed the installation of a BEMS to reduce the existing gas consumption and an ASHP to heat the building renewably. These assumptions have been made using a desktop study and will be corroborated with a site visit when permitted.

New Street

New street is a collection of 18 separate dwellings each with their own electricity and gas incomers. While a suite of energy efficiency measures including LED lighting, solar PV and insulation may be possible in individual houses we are confident that domestic ASHPs will be compatible with each of these dwellings with minimal alterations. Individually these properties make up a fraction of the Council's carbon footprint, hence we would recommend these measures are made in line with proposed asset upgrades. These assumptions have been made using a desktop study and will be corroborated with a site visit when permitted.

Rawlyn Court

Rawlyn Court is a sheltered housing scheme which contributes 1.3% to the Council's corporate estate carbon footprint. This was included in a programme of works to install Solar PV and LED lighting. Knowing that energy saving technology is already in place we have proposed an ASHP to offset the gas consumption of the building.

Whitefriars

Whitefriars is another sheltered housing scheme which has benefitted from a solar PV and LED lighting install. While there is a large grass central foyer, we do not believe that this space is large enough to consider a GSHP. Therefore, we have selected an ASHP to decarbonise heating for the building. Again, a further survey of the main electrical incomer and heat emitters will be required to confirm suitability.

School Court

School Court is another larger sheltered accommodation complex in Cambridge, unfortunately we have been unable to visit site to confirm measures, but we have undertaken a desktop study and assessed the building and proposed measures that we have encountered in similar buildings. There is a large roof space, so solar PV has been recommended, we have also included for a BEMS and LED lighting to reduce energy consumption. Finally, again there is a lack of open space, so we have discounted a GSHP and recommended an ASHP to supply renewable heat to the building. A further survey of the main electrical incomer and heat emitters will be required to confirm suitability.

Orwell House

Orwell house is an office complex that contributes 1.7% of the City Council corporate estate's energy consumption. As yet we have been unable to visit the site, but we have undertaken a desktop study and made assumptions based on the type of building to recommend measures to reduce the building's carbon emissions. We have proposed prioritising the installation of LED lighting, a BEMS and a solar PV array to reduce the sites energy consumption in the short term with an ASHP proposed to offset the sites gas consumption. The location of the site however does have some potential for somewhat larger schemes, a large carpark adjacent to Orwell house at Cowley Road depot could be used to house a large ground loop for a GSHP and a solar car port for renewable electricity generation if scheduled in with car park resurfacing. Similarly, there is a large sewage works to the northeast which could be utilised as a heat source should there be a large local appetite. There are a number of local large energy consumers that could make either proposal viable but at this stage we have recommended the ASHP for simplicity and because the Council would not have to engage with other stakeholders to decarbonise the building.

Brandon Court

Brandon Court is the Council's second largest sheltered accommodation by way of energy consumption and is accountable for over 3% of the corporate portfolio's overall energy consumption. We undertook a brief survey of the building as part of this project and have identified opportunities for a BEMS and LED lighting upgrade in the short term with an ASHP to follow to decarbonise the sites heating. The site is currently served from a large centralised gas boiler plantroom and already benefits from a substantial solar PV array. The site is quite constricted for space which could prevent the installation of an ASHP as it would need to sit within one of the internal courtyards. Hence, we would recommend the specification of a low noise model to minimise the impact on residents. Another alternative due to its location would be to connect the site into the previously mentioned heat network proposal identified for Parkers Piece.

Cherry Hinton Hall

Cherry Hinton hall poses a unique challenge to the City Council for decarbonisation. While one of the lower energy consuming assets the historic building is grade II listed and there can be some difficulty in operating heat pumps at low temperatures in historic buildings. To maintain the aesthetic of the building we have not recommended LED lighting or Solar PV and have focussed in the short term on improving efficiency with a BEMS. This can then be followed with a GSHP to satisfy the heating load from the building. This has been selected as once the manifold pipework has been made good there is no visual impact associated with a GSHP that would impact the building. We have been unable to survey the building at this stage, our assumptions will be corroborated with a site survey when permitted

Barnwell House

Barnwell house is a small office block near Cambridge Airport. It has one of the smallest energy consumptions included in the scope of this project and contributes 0.6% of the energy consumption included in this assessment. We have undertaken a desk top study to identify possible ECMs and have proposed the installation of a BEMS to gain maximum efficiency from the existing plant. We would then recommend the installation of an ASHP to decarbonise the buildings heating. We have also proposed a solar PV array to generate some renewable electricity but the building's proximity to the airport would mean that a glint and glare assessment would need to be completed prior to installation

Browns Field

While we have been unable to survey Brown's field, our desktop study suggests that the building has been designed with sustainability in mind with a sedum roof. To complement this, we have proposed the installation of a solar PV array and LED lighting. Since there is ample space surrounding the building, we have also proposed a GSHP to supply renewable heat to the building. Our assumptions will be confirmed when we are able to resume survey work.

Talbot House

Talbot House is a sheltered accommodation complex that contributes just 0.4% of the energy consumed by the buildings within the scope of this project. We have been unable to survey the site but based on our desktop assessment we have recommended the installation of a solar PV array and an ASHP to decarbonise the building as far as possible. Our assumptions will be confirmed when we are able to resume survey work.

116 Chesterton Road

116 Chesterton Road is a temporary housing property. Unfortunately we have not been able to survey the building at this stage and due to the property being a domestic dwelling we cannot make any assumptions on energy efficiency measures but it is possible that the site could benefit from any combination of LED lighting, cavity wall/loft insulation or solar PV. At this stage we have proposed the installation of separate domestic ASHPs to bring the building off the gas network. Proposals for this site will be finalised when surveys can resume.

Grand Arcade Car Park

The Grand Arcade car park currently uses the second most electricity in the Council's corporate estate. As an unheated space there is no gas use to be mitigated, hence we could only consider measures to reduce on site electricity consumption. We have proposed the replacement of the existing air handling unit fans with EC plug fans to reduce the sites electricity consumption. The Council has already invested in low carbon technology on site and has installed energy efficient LED Lighting. While there is a large open roof space which could be used to house a solar carport tied into the building structure, we have not included it in the core proposal at this stage. Another low carbon technology which the Council could deploy to further the transition to net zero carbon on site would be a rollout of EV charging, again this has not been included in this proposal.

The Grafton Car Park

The Grand car park (East & West) car parks again are unheated hence have no associated gas consumption. The Council have already installed LED Lighting at both Grafton East & west car parks. Again, while we could look to install building integrated solar car ports to mitigate some of the site's baseline electrical consumption, we have not included this within our core proposal.

Kings Hedges Learner Pool

Kings Hedges Learner Pool is one of the few sites in the Council's portfolio that already benefits from renewable heating. The building is currently heated by ASHP with no natural gas plant on site, hence the relatively high electrical consumption for its size. A solar PV array has already been installed on site by the council in a recent round of renewable energy projects.

130 Cowley Road/Cowley Road Depot

We have incorporated the electrical consumption of these two sites into the numerical model to capture the residual electrical load. We have previously identified the car park at Cowley Road as a good opportunity for a Solar Car Port, the generation from this if exported to the grid could be used to offset some of the council's residual electricity consumption.

Jesus Green Outdoor Pool

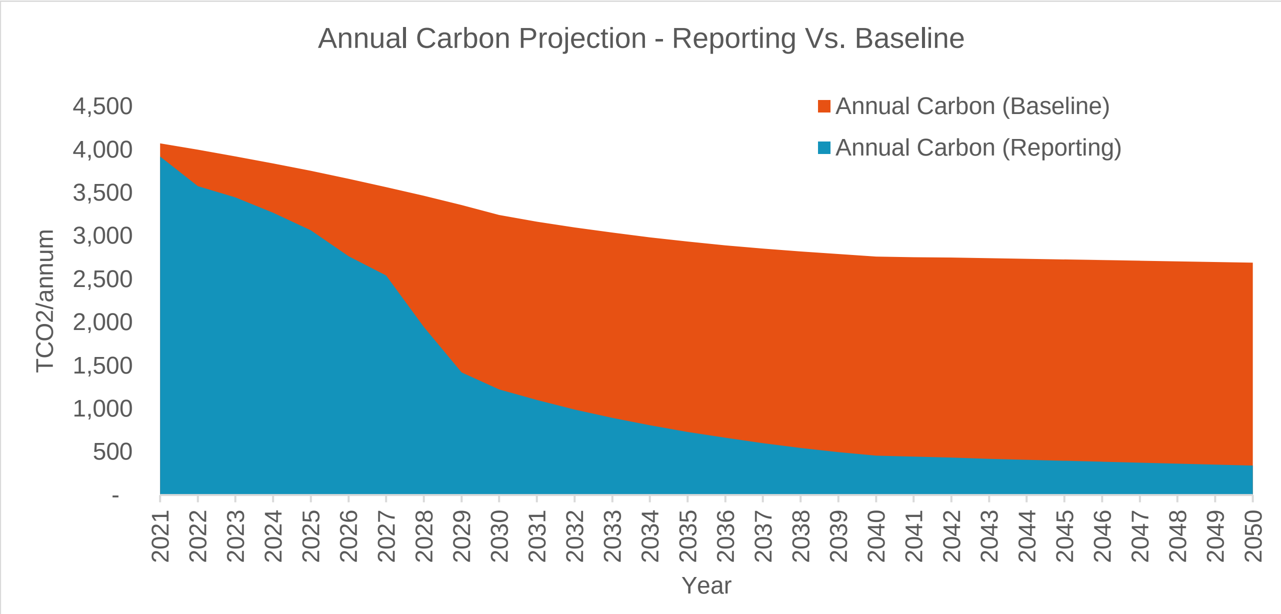
We have incorporated the electrical consumption of this site into the numerical model to capture the residual electrical load. The pool is currently unheated however we are aware that there may be proposals to heat the pool to keep the facility open for a greater percentage of the year. We would recommend installing either a GSHP or ASHP to satisfy this heat demand as the low temperatures required to heat the pool would be easily achievable with either technology.

Waterbeach Depot

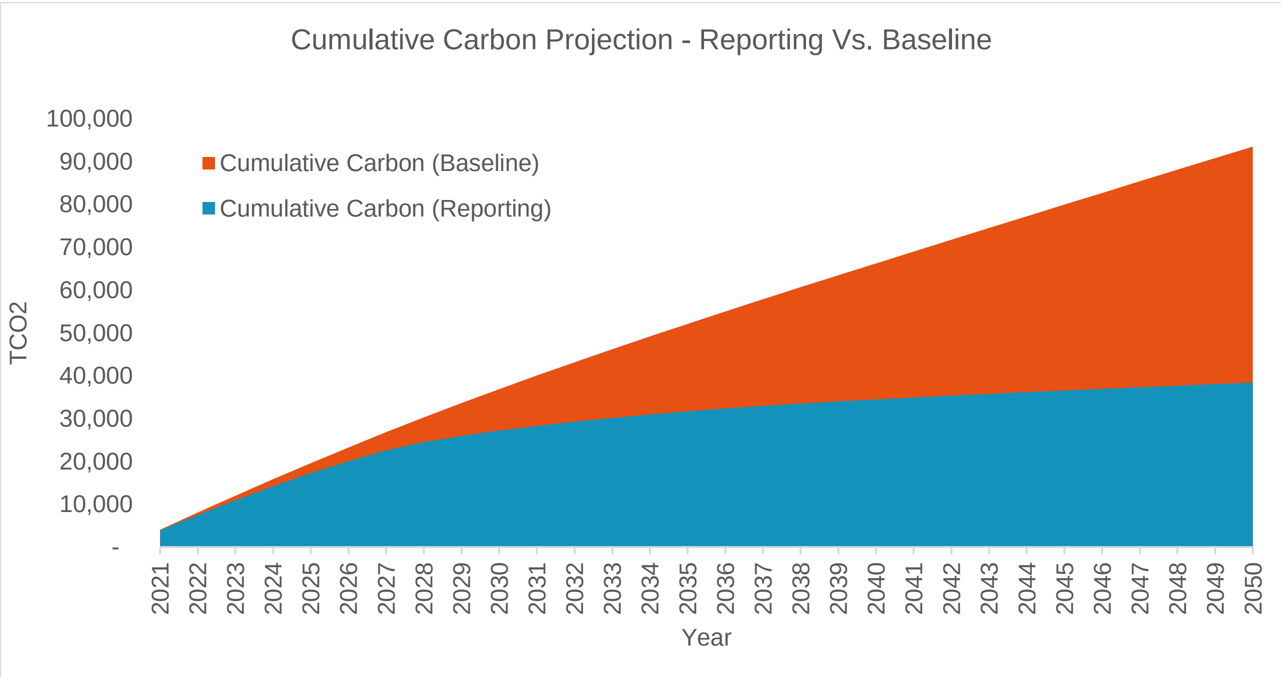
As with Kings Hedges Learner Pool, Waterbeach depot benefits from an ASHP for heating and has a 30kWp Solar PV array on the roof. A proposal is currently being developed to replace the existing T5 and CFL lighting with energy efficient LED. As with Cowley Road there is an opportunity on site to install a Solar Car Port on site which could be used to charge electric waste vehicles but this has not been included within the core proposal.

7.1.1. Summary of results

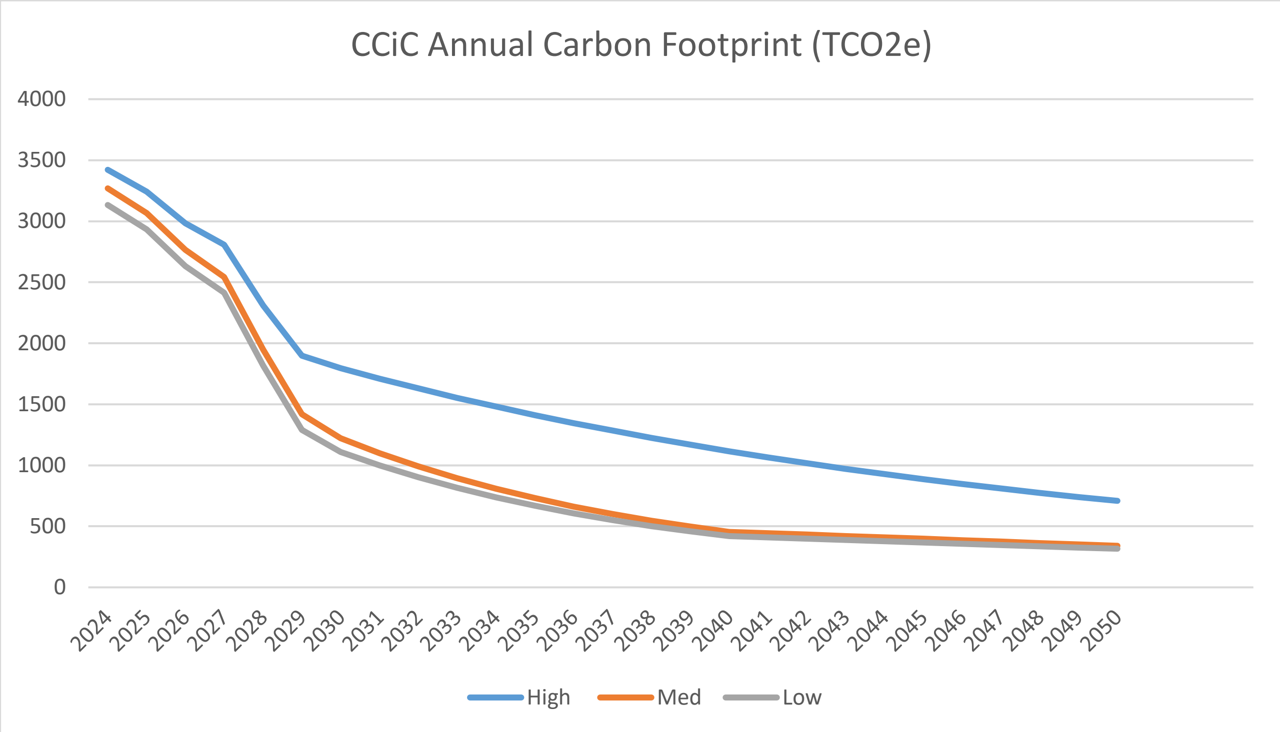
The results of the proposed measures outlined above at each site would have a dramatic effect on the sites overall carbon footprint. We have modelled the Council's carbon footprint to 2050 and are pleased to report that these measures will result in a 66% reduction by 2030, 89% reduction by 2040 and 92% reduction in the Councils carbon footprint by 2050. Of this remaining Carbon, 1/3 would be associated with the residual gas used in the cremation process. We have assumed the medium carbon factors and utility prices for electricity and gas.



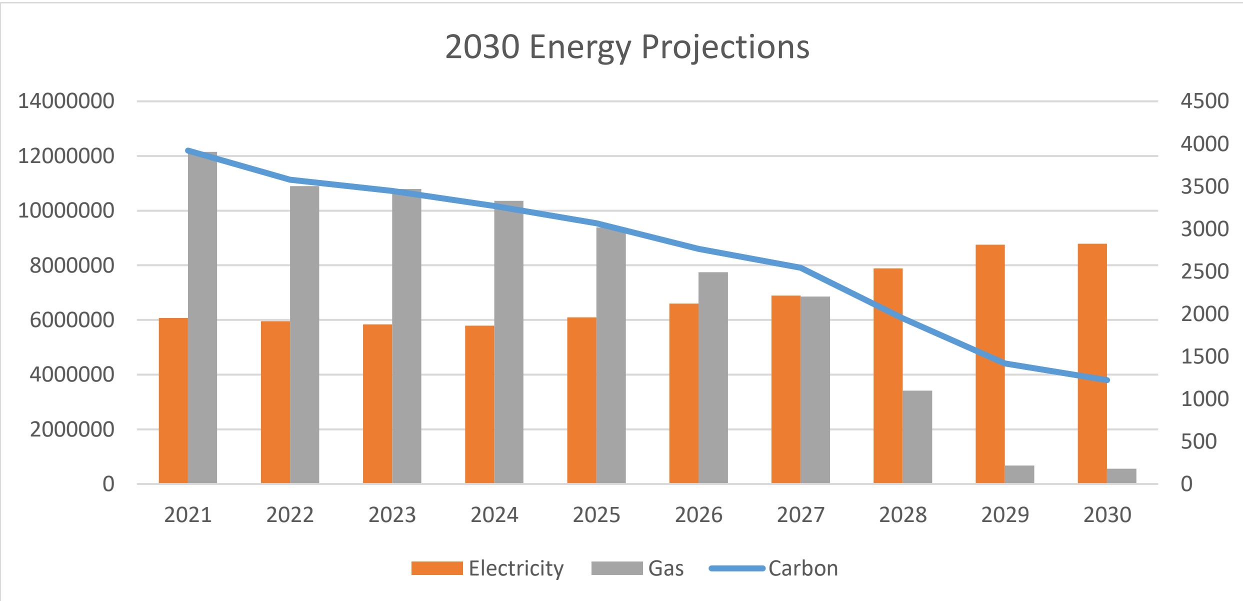
Based on the above we have modelled the Council's cumulative carbon emissions (below) , this is the amount of carbon that the Council is projected to offset by the year 2050 by implementing the measures that are outlined in this report. We can see some divergence happening in the first 5 years however this becomes increasingly clear as we pass the year 2030. Our model suggests that by the year 2050, the council will have offset over 60% of its cumulative carbon baseline, this amounts to nearly 56,000 tonnes of CO2 over the next 30 years.



We have undertaken sensitivity analysis on the above based on the speed at which the electricity grid is likely to decarbonise and the results are positive. Even with the most pessimistic projections of grid electricity decarbonisation the Council will still have offset over 75% of its 2021 baseline carbon emissions. This is broadly in line with other decarbonisation projects we have evaluated.



The Council has set itself ambitious targets for decarbonisation and are considering a commitment to decarbonise by the year 2030. The measures identified in this report suggest that 69% of the carbon emissions from the buildings within the scope of this study can be avoided, with the remainder requiring a form of carbon offset. There is set to be some residual gas consumption in 2030 due to the residual gas consumption remaining at the Crematorium.



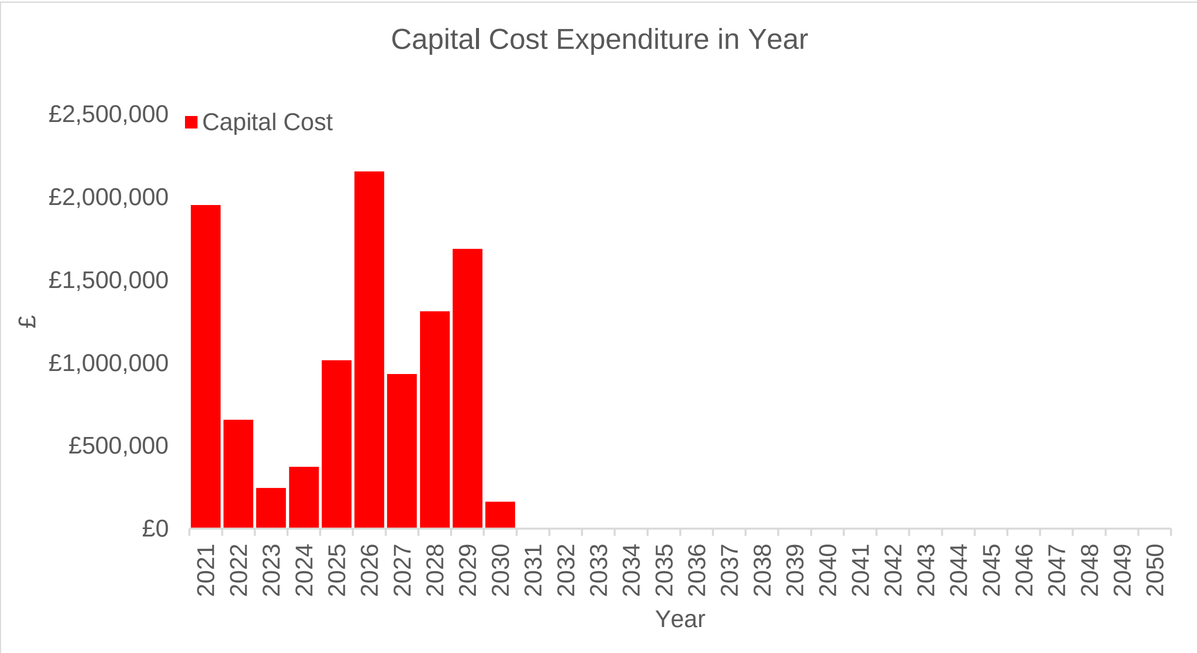
It is projected by 2030 electricity consumption in the Council's corporate portfolio will have risen from 5,515MWh to 8,795MWh. The Council's corporate gas consumption conversely is projected to fall from 13,817MWh to just 555MWh. If the council wishes to fully decarbonise by 2050 then a method for offsetting this remaining electrical load would be required. As mentioned previously, while electricity is rapidly decarbonising, electricity from the grid is not projected to reach zero before the year 2050, hence the Council will not be able to achieve absolute net zero without considering some form of carbon offsetting.

There are many methodologies where organisations can offset carbon emissions ranging from investing in tree planting or carbon capture schemes through to directly offsetting electricity on site with local electrical generation and battery storage. While all methods of decarbonisation should be encouraged, it can be difficult to include offset carbon through tree planting or carbon capture schemes directly into annual reports. Conversely, looking at building level decarbonisation is likely to be either not feasible (in buildings such as the Guildhall, Parkside Pools etc.) or not cost effective. Hence, we would recommend the Council looks for opportunities for local renewable electricity generation.

If the Council were to follow this route, there are several benefits beyond offsetting carbon emissions that should be considered. If an appropriate Power Purchase Agreement customer can be identified, then installations can have attractive IRRs and be a valuable revenue generating asset. Furthermore, these types of renewable electricity generating schemes directly impact the carbon factor of the grid as the more renewable assets are brought online the lower the grids associated carbon emissions become. Finally, these installations allow for the integration of other low carbon technologies such as electric vehicle chargers to further enable the transition to net zero.

We have identified some such opportunities in this report, Cowley Road car park offers the opportunity for a 700kW-1MW solar car port which would offset between 7-10% of the sites remaining electrical consumption by 2050.

With the council's commitment to minimising carbon emissions by 2030 we have prioritised works to be delivered the end of the decade. Below we have broken up the annual capital cost expenditure predicted each year to meet the projected carbon savings.



At the moment the year 1 capital projection is including a Public Sector Decarbonisation Scheme grant application the Council has made and is waiting for approval for. The model suggests that the City Council will need to invest £10,500,000 over the next 10 years to achieve the 87% carbon savings that are outlined in this study. With further costs necessary to offset the remaining electricity demand by 2050.

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