Heat Decarbonisation Plan Approval

Throughout the HDP creation process, regular meetings were held every Wednesday with the project team, including the Net Zero Consultant managing the project, as well as Sophie Fox, Capital Projects Sustainability Coordinator, and Mark Arkwell, Deputy Chief Fire Officer (and Project Sponsor), and any technical specialists as and when needed. This allowed for review of the progress of the project against the proposed programme to Salix, and has ensured that the report is complete and signed off well in advance of the 28th March 2024.

The milestone for the initial draft (02.10.2023) was met, with feedback given to allow for further revision of the report based on the Service's needs, and the specific quality assurance feedback rating. This HDP has been approved as relevant and applicable by Sophie Fox and Mark Arkwell, and will guide the route for the Service to start the works to reach Net Zero within an aspirational yet realistic timeframe.

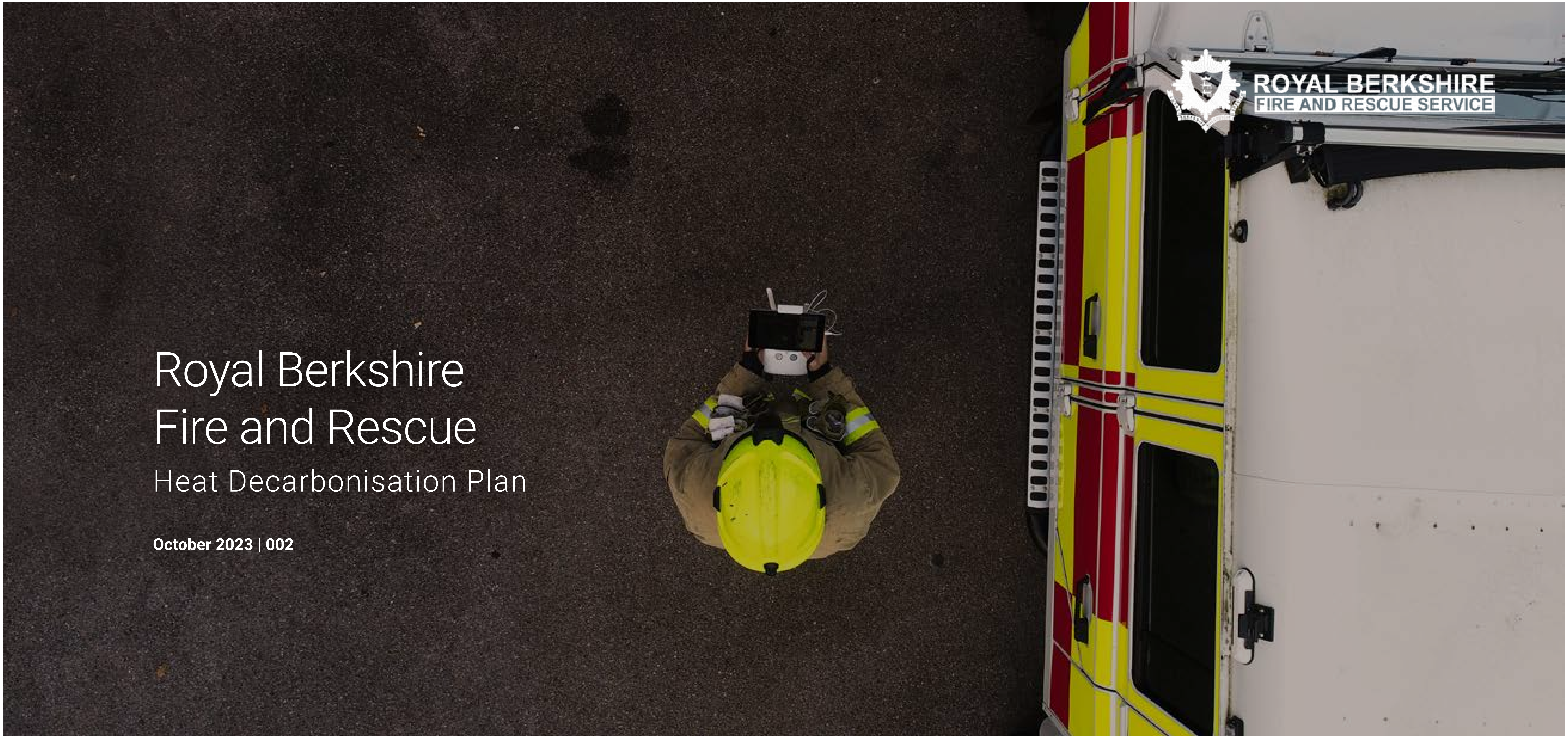
Signed: ……………………………………………………

Date: 15.11.23 ……………………………………………………..

Royal Berkshire Fire and Rescue

Heat Decarbonisation Plan

October 2023 | 002



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SAFETY

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Executive Summary

Meeting the UK Government's target for Net Zero Carbon emissions will involve a major transformation of existing buildings, transport and energy infrastructure. This transformation will impact every sector of the economy and will be shaped by national policy and regional resources.

Royal Berkshire Fire and Rescue Service (RBFRS) has requested Faithful+Gould to develop a roadmap to achieving Net Zero Carbon for 11 fire stations out of an estate of 17. The 11 sites that have been selected for this roadmap have been prioritised on the annual energy usage, fossil fuel utilisation for heating, building age and condition of the buildings including the current and ongoing maintenance costs. The purpose of this plan is to assist RBFRS in achieving Net Zero by 2050, in line with the UK government target. The sites feature a number of end-of-life heating system which are considered a priority for decarbonisation. This plan considers the scenarios of decarbonisation by 2030, 2040 and 2050. This report predominantly focuses on Scope 1 and 2 emissions and the decarbonisation of heat. For the purposes of this analysis, Net Zero Carbon has been defined as:

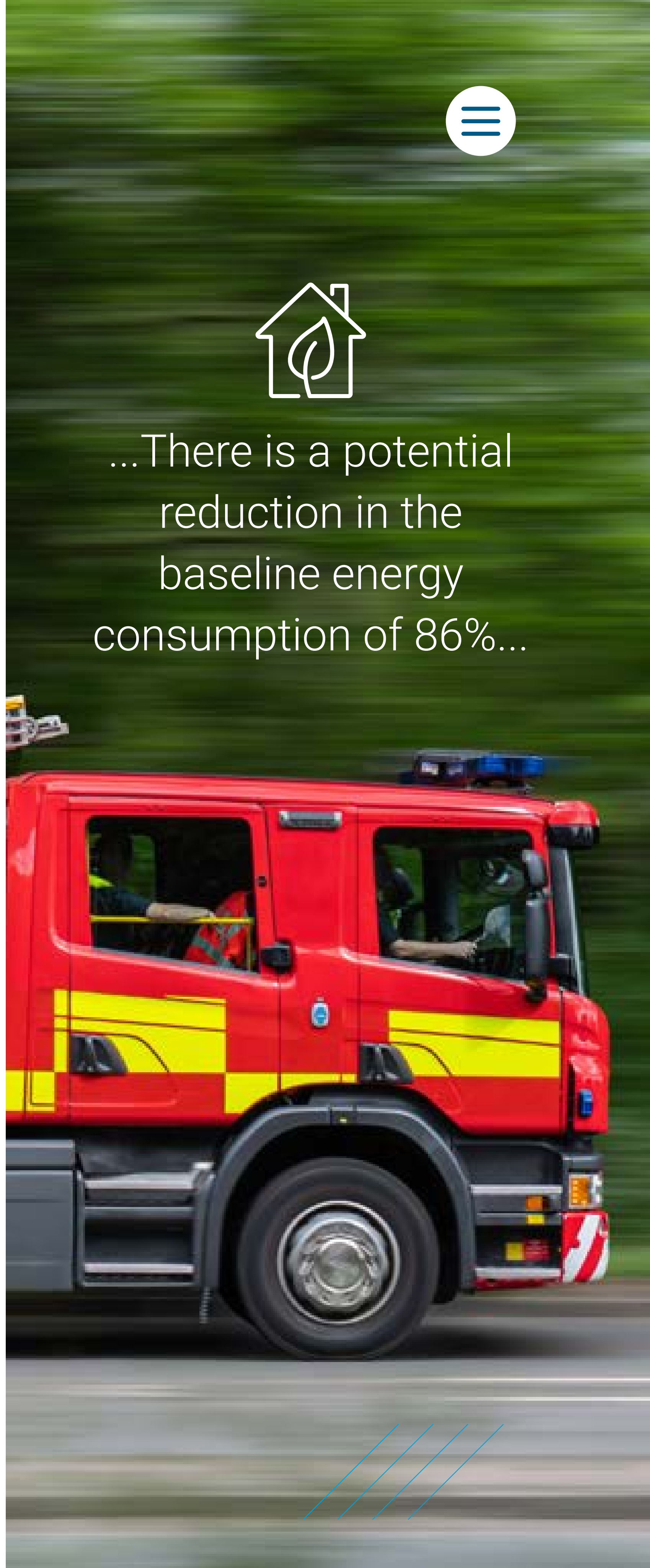
"The carbon emissions associated with operational energy consumption across the estate are zero or negative on an annual basis. The majority of fuel and power is supplied from on-site and off-site renewable energy sources, with any remaining carbon balance offset."

The strategy applied is a 'whole building' approach which involves reducing the demand for energy before decarbonising the HVAC equipment and installations. Reduction in demand is achieved by; implementing energy saving behaviour change, improving the thermal performance of existing buildings; improving the control and operation of HVAC systems and replacement of existing equipment with higher efficiency alternatives.

The replacement of fossil fuel HVAC systems is then considered for replacement with low carbon alternatives, generally in the form of heat pumps. To support the replacement of fossil fuel with electricity, the strategy seeks to strengthen on-site renewable generation, typically by installing solar PV arrays on suitable roof areas.

Through implementation of this heat decarbonisation plan, there is a potential reduction in the baseline energy consumption of 86%, from 2,185,833kWh to 295,405kWh across the 11 sites. This would see carbon emissions reduced from 406 tCO_2 to 15 tCO_2 in 2030 with grid decarbonisation. Fabric improvement measures, Air Source Heat Pump install and PV install across the site will provide the largest reduction in consumption, reducing consumption by 545,572kWh, 534,218kWh and 402,622kWh respectively.

The national grid continues to decarbonise by using more renewable technologies, this will further reduce the carbon emissions. As the carbon emissions do not reach Net Zero, there is the opportunity to offset any remaining carbon by considering investment into off-site solar PV and large-scale wind turbines, or through purchasing "green electricity", moving to an 100% REGO (Renewable Energy Guarantee Origin) backed electricity contract to reach a Net Zero Carbon status.



The capital cost for delivering this heat decarbonisation plan for the three scenarios is estimated to be circa £4,593,493 over 7 years for the 2030 scenario, £5,103,882 for the 2040 scenario and £5,577,813 for the 2050 scenario. If interventions are implemented by 2030, accounting for 6.5% inflationary increases in energy prices, it is predicted that RBFRS will see an annual save of £150,099 on utility bills by 2030. Savings will then increase annually as energy prices continue to inflate.

RBFRS can seek funding through the Salix PSDS scheme or can look to fund the works internally. Sites can be prioritised in several ways. Priority sites can be determined through looking at total carbon saved, through prioritising sites with end-of-life systems that are in need in replacement, or through site specific funding available. The PSDS application for the estate is currently being progressed by Faithful+Gould and the details of this are available on request.

Approaches and additional recommendations that should be considered to support delivery and drive efficiency into Net Zero programmes include:

- Implementing fast-track "quick wins" for carbon reduction e.g., Behaviour Change.
- Incentivising carbon reduction through KPIs for FM suppliers.
- Securing capital funding for delivery of decarbonisation measures .
- Undertaking Life Cycle Costing of capital proposals to ensure whole life value of investments is considered.
- Realising wider community benefits for carbon reduction through adopting a social value framework for delivery of a Net Zero Carbon programme.
- Undertaking feasibility studies to ensure that solutions allow future flexibility and adaptability.
- Measuring the co-benefits of interventions, e.g., air quality, positive impacts on staff and building users for talent attraction, wellbeing and quality of construction.

1. Introduction

Royal Berkshire Fire and Rescue Service (RBFRS) covers 16 fire stations and 1 HQ/Fire Control across the county of Berkshire. This report focuses on the decarbonisation of 11 sites within the building stock (forming the 'estate' within this report).

The purpose of the report is to detail the steps that RBFRS could take to decarbonise and reach Net Zero carbon for the estate by 2030, 2040 and 2050. In particular it will set out how to replace fossil fuel systems with low / zero carbon alternatives (e.g. heat pumps), identify suitable retrofit technologies to improve the thermal performance of the building fabric, reduce energy demand and/or grid energy use and implement the controls and analytics for the building to track and manage its energy consumption.

RBFRS are in the early stages of their journey towards Net Zero, with a target of 2050. RBFRS have already taken steps towards meeting this goal with an LED rollout is being undertaken across the estate and with the environmental projects team working on a PV schedule. This report aims to provide a Net Zero strategy for the RBFRS estate by 2030 ahead of their target, with additional information provided for 2040 and 2050 scenarios to allow for comparison.

Scope

Faithful+Gould have been requested by RBFRS to produce a roadmap for their estate to achieve Net Zero Carbon emissions for the site, with particular attention being paid to decarbonising the end of life heat source. This works has been funded by the Low Carbon Skills Fund.

The agreed key **deliverables** for this project are as follows:

- **Review of existing documentation,** including energy data.
- **Provide current baseline** energy position.
- **Detailed proposal** for the recommended/preferred Net Zero Carbon implementation plan.
- **Prioritised options** for maximising carbon reduction potential whilst delivering a cost effective and value for money solution.
- **Estimated savings,** capital costs, return on investment and payback.
- **Provision of methodology** applied to all calculations and details of any assumptions made.
- **Potential impacts** to incoming utility supplies and bills.
- **Identification of the scope** of any specialist surveys and consultants that may be required to support the evaluation of the recommended decarbonisation measures.

A site audit was undertaken, and report prepared for the site. The site auditors collected data on the existing building condition; existing equipment and services; and identified effective ways of decarbonising the site. This site audit report information was used to create a model which contains energy saving calculations associated with introducing the proposed carbon saving measures at the site. The detailed calculations are represented in tabular and graphical format throughout this report.

The report includes a review of the suitable technologies and next steps to decarbonise the site. It provides a narrative on the current and projected position in terms of carbon use and energy intensity of the building. The report outlines a logical and evidence-based action plan based on reducing demand, optimising energy management and improving efficiency. It identifies the actions that should be taken, key timescales, indicative costs and the intended outcomes.

> This report delivers a roadmap to achieve the decarbonisation and energy reduction targets.

2. Definition of Net Zero

Definition

The built environment has been identified as one of the most significant contributors to global GHG emissions, accounting for 39% of annual emissions worldwide.

From a UK perspective, the built environment is accountable for approximately 25% of the country's GHG emissions. Operational energy GHG emissions contribute for about 75% of the UK-built environments' GHG emissions, with emissions from gas boilers identified as the primary contributor. The remaining 25% of GHG emissions are associated with embodied carbon emissions during construction.

The UK Government agreed upon the net-zero pledge in 2019 in response to the Intergovernmental Panel on Climate Change (IPCC) report published in 2019. This report highlighted that the world is on track to overshoot the Paris Agreement's 1.5°C limit before 2050, which would have catastrophic consequences for humanity. Hence, to combat this issue, the UK Government published world-leading emergency climate goals under the Climate Change Act 2008 and Carbon Budget Orders, which set legally binding pledges to reduce UK net GHG emissions from 1990 levels by:

57%
Net Zero by 2030

78%
Net Zero by 2035

100%
Net Zero by 2050

Net Zero Carbon has a range of definitions. This section aims to provide clarity on the definition of Net Zero Carbon. It may be defined differently depending on the application of the term nationally, to the built environment, or in its application to a particular estate portfolio. The relevant definitions are reviewed below to set the context for how the framework definitions are applied to RBFRS.

In this report we have used the widely accepted definition provided by the Science Based Targets initiative (SBTi). The SBTi defines and promotes best practice in science-based target setting to support corporates in setting net-zero targets that are aligned to meet societal climate goals. Its focus is to accelerate companies to halve emissions before 2030 and achieve net-zero emissions before 2050.

To reach net-zero at a corporate level, organisations must deeply reduce emissions and counterbalance the impact of any emissions that remain. The SBTi Net-Zero Standard defines corporate net-zero as:

- **Reducing scope 1, 2, and 3 emissions to zero** or a residual level consistent with reaching global net-zero emissions or at a sector level in eligible 1.5°C-aligned pathways; and
- **Permanently neutralising any residual emissions** at the net-zero target year and any GHG emissions released into the atmosphere thereafter.

2. Definition of Net Zero

In accordance with the GHG Protocol, GHG emissions scopes 1, 2 and 3 are defined as:

Scope 1: Includes direct emissions (gas and oil) from sources owned/controlled by the organisation;

Scope 2: Comprises indirect emissions from the organisation's purchase of electricity energy; and;

Scope 3: Is an optional reporting category and is all other indirect emissions that result from activities within the organisations but not sources owned or controlled by it.

To help develop a shared understanding of what Net Zero Carbon means for the construction sector, the UK Green Building Council (UK-GBC) published a framework definition that encompasses three further scopes: construction; operational energy and whole-life.

The formal UK-GBC definitions of Net Zero for each scope are given below.

Net Zero Carbon – Construction
(for new buildings and major renovations):

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

Net Zero Carbon – Operational Energy
(for all buildings in operation):

"When the amount of carbon emissions associated with the building's operational energy on an annual basis is zero or negative. A Net Zero Carbon building is highly energy efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balancing offset."

Net Zero Carbon – Whole Life:

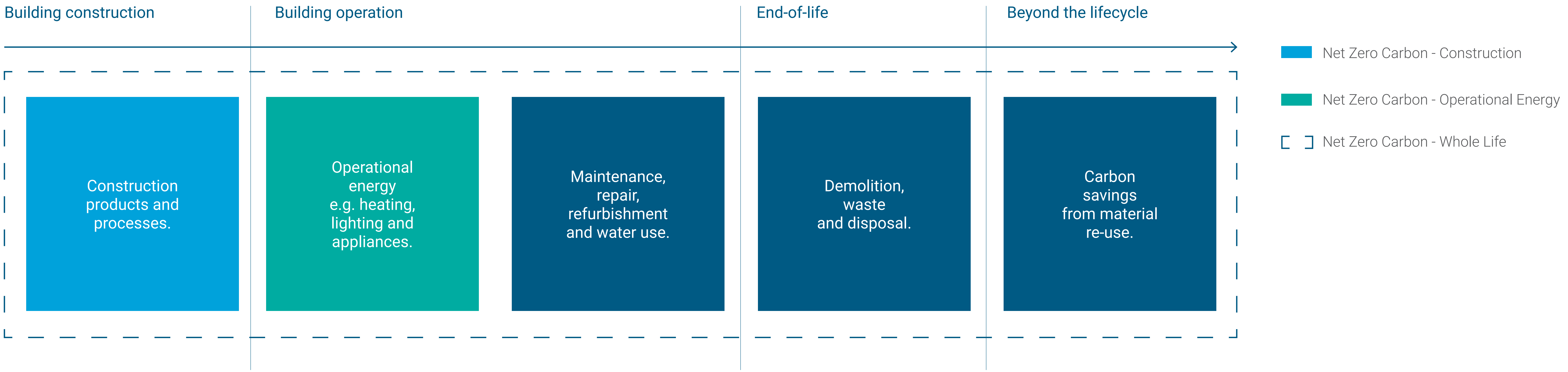
"When the amount of carbon emissions associated with a building's embodied and operational impacts over the life of the building, including its disposal, are zero or negative."

The three UK-GBC scopes are illustrated in Figure 1 on the next page.

From a UK perspective, the built environment is accountable for approximately 25% of the country's GHG emissions.

Figure 1.

UK-GBC framework definition of Net Zero Carbon buildings



This framework helps to identify the practical steps that can be taken to reduce emissions at each stage of the building lifecycle:

1. **Construction:** A the construction stage, materials with low or zero "embodied" carbon should be selected. On-site construction impacts can be reduced by using local suppliers of materials and by reducing waste.

2. **Operational Energy:** Reducing operational carbon should begin with reducing energy demand through correct operation of the building, high standards of insulation; energy-efficient lighting, plant, and equipment; and effective building controls. The remaining energy demand can be satisfied by using a decarbonised source (changing from fossil fuels to electricity), by using renewable energy technologies e.g., solar photovoltaic (PV) panels and by offsetting any remaining demand by using "green" electricity.

3. **Whole Life:** Designing buildings to be flexible for adaptation to changes in use and for disassembly at end of life supports whole-life carbon reductions. Effective maintenance and management practices will ensure that operational carbon savings are maintained.

In this report we look to reduce emissions associated with operational energy and therefore define Net Zero RBFRS as:

"The GHG emissions associated with operational energy consumption across the estate are zero or negative on an annual basis. The majority of fuel and power is supplied from on-site and off-site renewable energy sources, with any remaining carbon balance offset."

The modelled scenarios and Net Zero Carbon tool identify operational carbon emission savings alone for the site. The calculations exclude assessment of:

- **Embodied carbon** associated with new construction, major refurbishment, and on-going operational maintenance activities.
- **Emissions associated with end-of-life** scenarios, for example demolition.
- **Transport** – replacement of fleet with Ultra-Low Emission Vehicles (ULEVs) and provision of charging/refuelling infrastructure for ULEVs. We note that whilst this is excluded, where data has been discovered on transport as part of our assessment, we have noted this in our report for future reference.

3. Net Zero Roadmap Framework

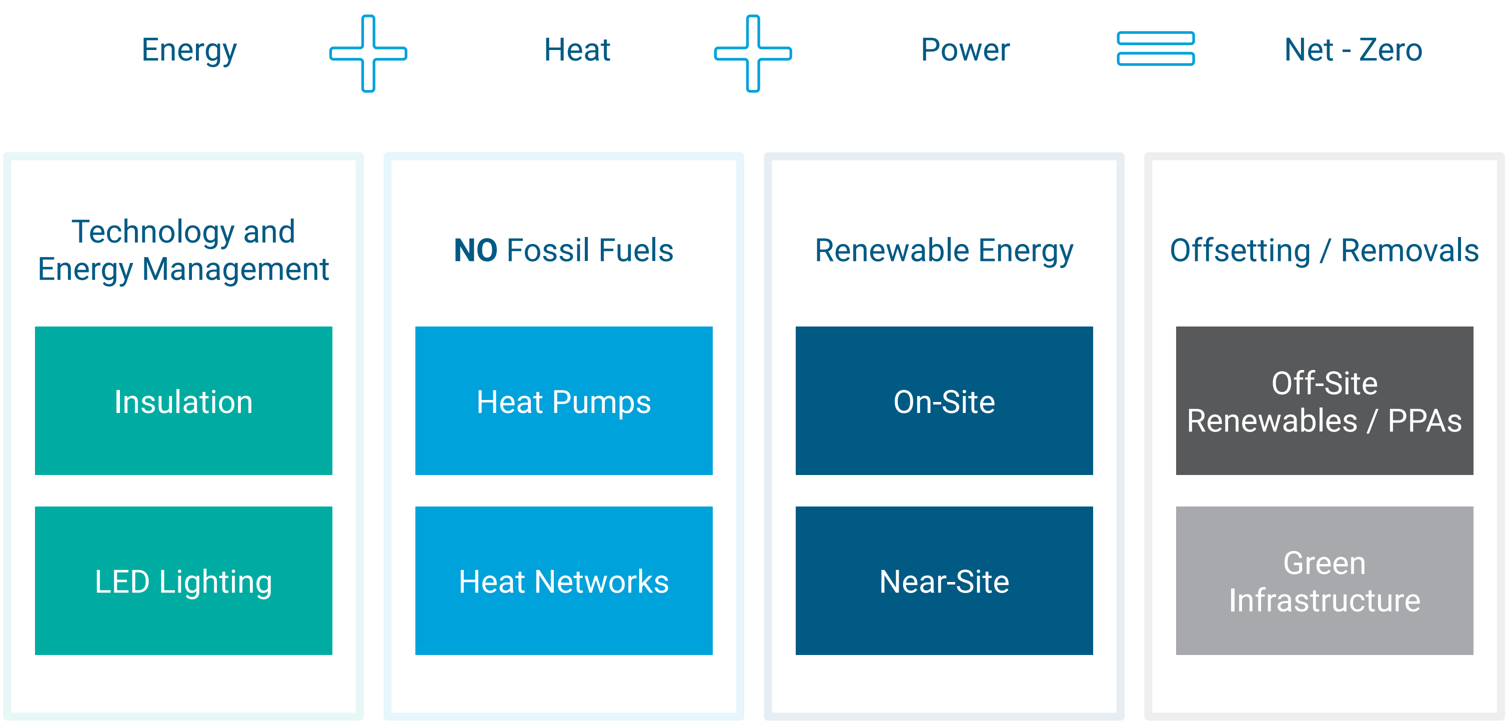
Following the definition of Net Zero Carbon introduced above for RBFRS, we can identify three key elements of this roadmap:

1. **Energy Efficiency: Increasing energy efficiency by reducing demand** is achieved through a range of approaches, including improved energy management practices (e.g., conducting regular energy audits); introducing behavioural change programmes (e.g., encouraging building users to operate the building efficiently) and replacement of equipment with more energy efficient equipment (e.g., replacing older lighting systems with LEDs). Demand is also reduced by improving controls to operate the building in a more efficient manner.
2. **Heat: Decarbonising heat.** The main alternatives to fossil fuel heating are heat pumps and low-carbon heat networks. These technologies need to replace the existing fossil fuel heating plant in the building.
3. **Power: Increasing renewable energy supply.** There are a range of renewable energy technologies that can be used to generate clean power. Solar photovoltaic (PV) panels are an established technology that can be readily installed on roofs across the building to generate carbon-free electricity from the sun.

The diagram below shows how all these element's link together and identifies what Net Zero means in practice for buildings.

Figure. 2

Process towards Net Zero Carbon buildings



The following approaches and technologies have been recommended. These key technologies are discussed in more detail in the following sections.

- Behaviour change.
- Building fabric thermal insulation.
- LED lighting.
- Fans, Motors, and Pumps.
- BEMS and Energy Metering.
- Heat pumps.
- Solar PV.

4. Building Information

Generic Building Information

The RBFRS estate, included in the proposal, comprises of 11 sites, all active fire stations generally comprising a main building and appliance bay where the vehicles are kept.

In addition to this, Caversham Road includes a driving school, workshop and occupational health building (all included within report); Slough includes a storage building; and Whitley Wood includes 2 blocks which comprise office space, training areas and staff accommodation.

Apart from Lambourne, the sites are wholetime fire stations, running 24/7,often with multiple shifts within the station. Lambourne is an on-call station which means that it is subject to a lower level of occupancy and therefore has a much lower energy consumption. There are variations in the usage of the appliance bays, mainly regarding heating, however the service confirmed that heating was being phased out across the estate, with frost protection remaining.

The sites are occupied by the service and the service is responsible for the energy consumed within the buildings. RBFRS are responsible for all utilities and report on the carbon usage annually. The site list follows:

Table 1.

Site list

Site Name	Total Consumption (kWh)	Area (m^2)	Annual Elec (kWh)	Annual Gas (kWh)	Total kWh/ m^2	tCO_2e
Ascot Fire Station	34,129	400	17,885	16,244	85	6
Bracknell Fire Station	192,046	720	50,151	141,895	267	36
Caversham Road Fire Station	381,709	1,191	70,423	311,285	320	70
Lambourne Fire Station	61,076	183	7,474	53,602	334	11
Langley Fire Station	231,989	774	46,889	185,100	300	43
Maidenhead Fire Station	230,254	1,144	91,276	138,978	201	43
Newbury Fire Station	235,335	832	55,535	179,801	283	44
Slough Fire Station	283,763	1,103	77,084	206,679	257	53
Whitley Wood Fire Station	367,081	1,864	224,019	143,062	197	69
Windsor Fire Station	34,940	223	16,203	18,737	157	7
Wokingham Road Fire Station	133,512	409	32,466	101,046	326	25

Baseline Energy Data:

To characterise the site, the following data was provided by RBFRS:

- Energy data – records of electricity and gas associated with the asset list.
- Information on recent energy improvement projects which have already been undertaken or are proposed. This relates to the heating replacement, building fabric remedials and historic overcladding.
- Display Energy Certificates.
- Planned alterations to the building which should be considered as part of the heat decarbonisation exercise (advised no changes). No planned alterations highlighted to F+G.
- Other supporting information, including high-level information about previous projects.

The energy consumption data for each site was provided in the format of monthly consumption data. Data was provided to cover a whole year of consumption, with the date range being April 2021 – April 2023. Using the most recent years' (2022-2023) consumption data gives a good indication of current energy usage across the site.

RBFRS provided the latest gas and electricity prices in use. The calculations within this report have been based on these fuel prices which are listed in Table 2.

Table 2.

Fuel prices.

Fuel Type	p/kWh
Electricity	15.2 Apr-Sept, 25 Oct-March
Gas	2.0 (8.5 before Levy support)

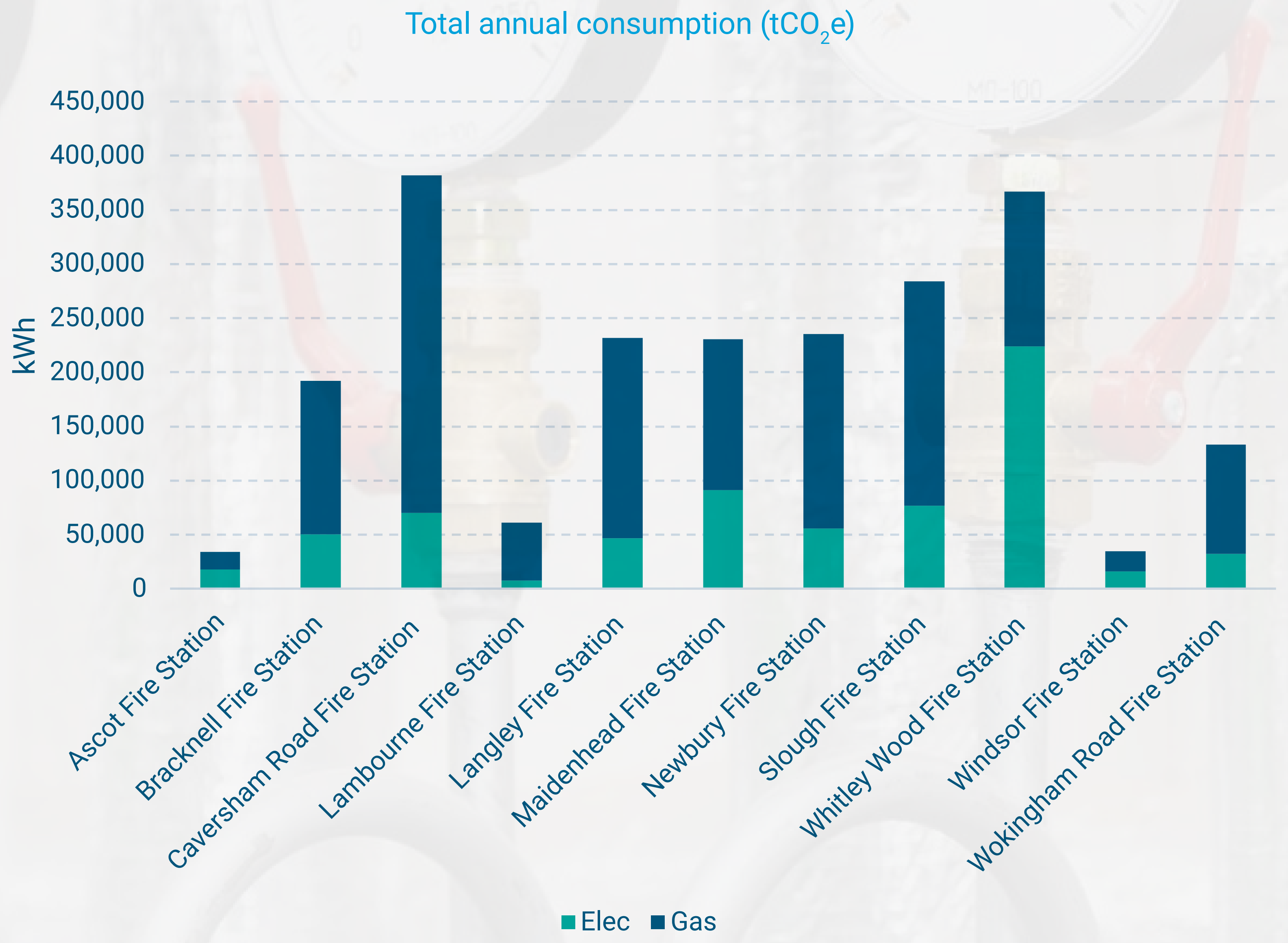
The energy baseline data is summarised in the following graphs:

Table 3.

Annual energy consumption.

Fuel Type	Total kWh	tCO_2e	Annual Spend
Electricity	689,405	133	£104,914
Gas	1,496,429	273	£30,527
Total	2,185,833	406	£135,441

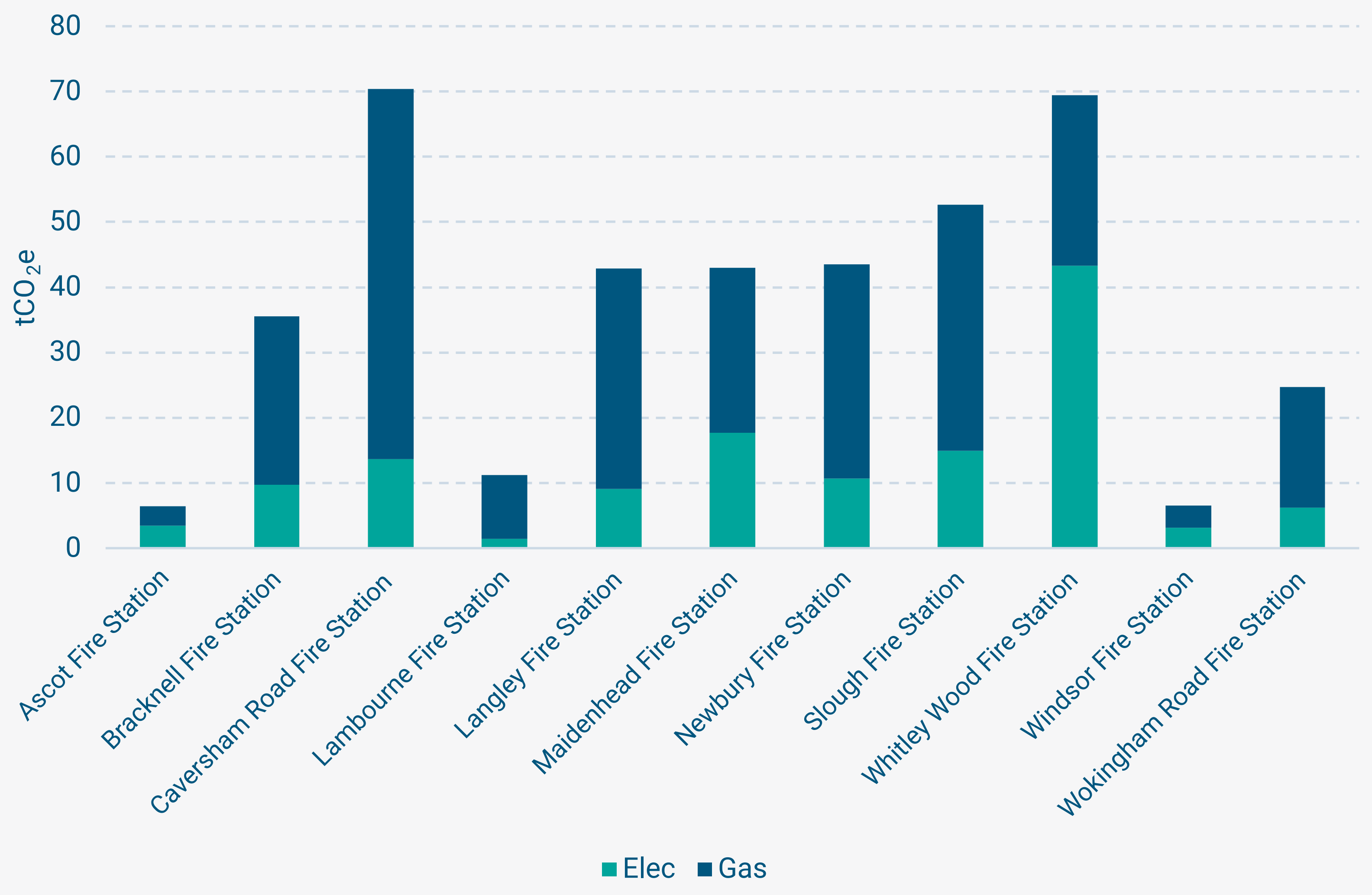
Figure 3.



The total annual consumption across the estate is 2,185,833kWh and this is split at 1,496,429kWh for gas and 689,405kWh for electricity. This equates to 406tCO_2 emitted annually, with 273tCO_2 from gas and 133tCO_2 from electricity. In total, RBFRS spends roughly £135,441 on operational energy consumption across the site. £30,527 is spent annually on gas and £104,914 is spent on electricity.

Figure 4.

Total annual consumption (tCO_2e)



Figures 3 and 4 highlight that, generally, gas accounts for the majority of energy consumption across the estate which is to be expected due to the sites operating 24 hours a day and therefore needing constant heating. Caversham Road has the highest overall consumption, 381,709kWh, which is to be expected due to its much larger footprint and the differing usage to the more typical fire stations. On the other end of the scale, Ascot has the lowest energy consumption of 34,129kWh. Generally, the energy usage across the estate is proportional to the individual site footprints which is to be expected.

Figure 5.

Gas, electric and total consumption by site (kWh)

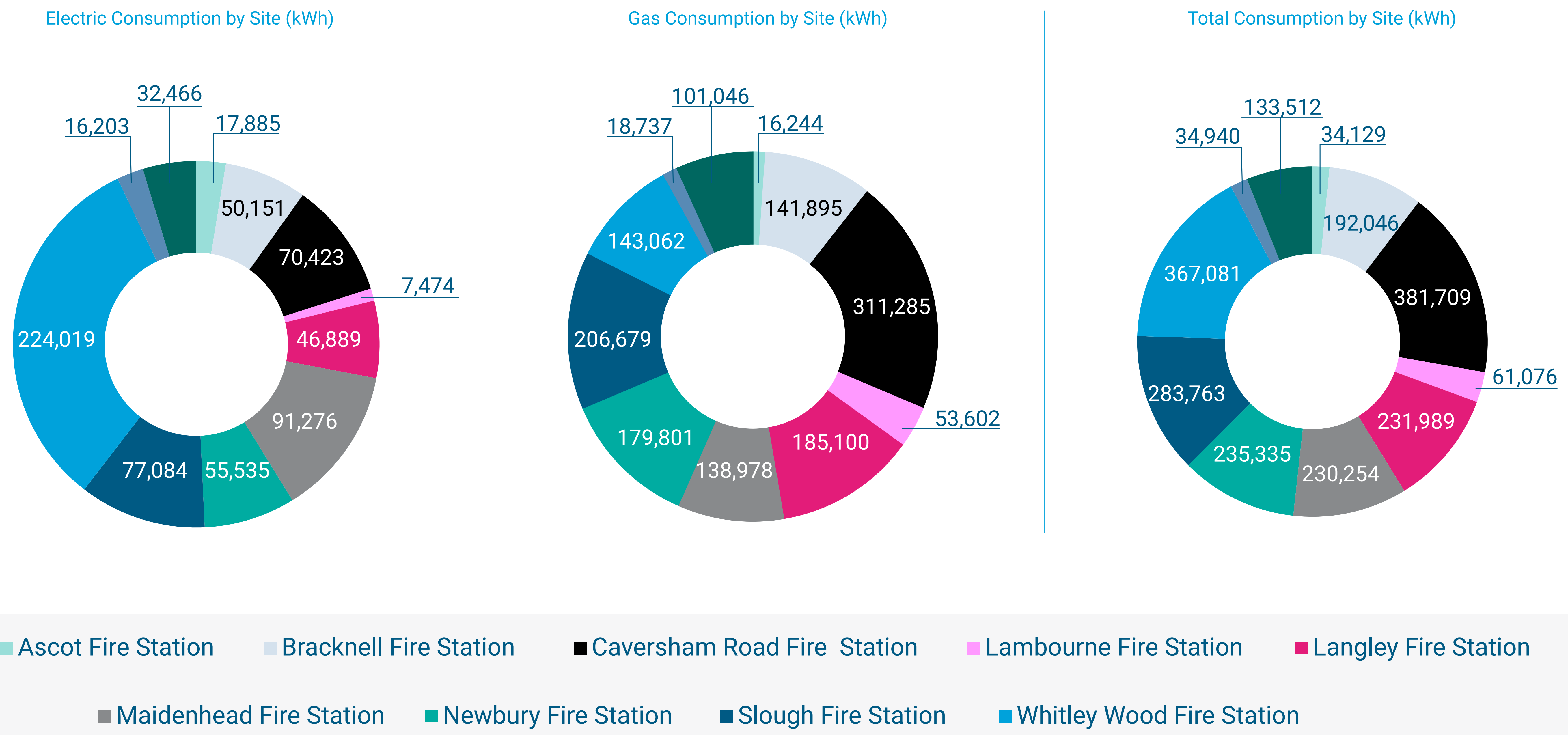


Figure 6.

Floor area and Consumption by site

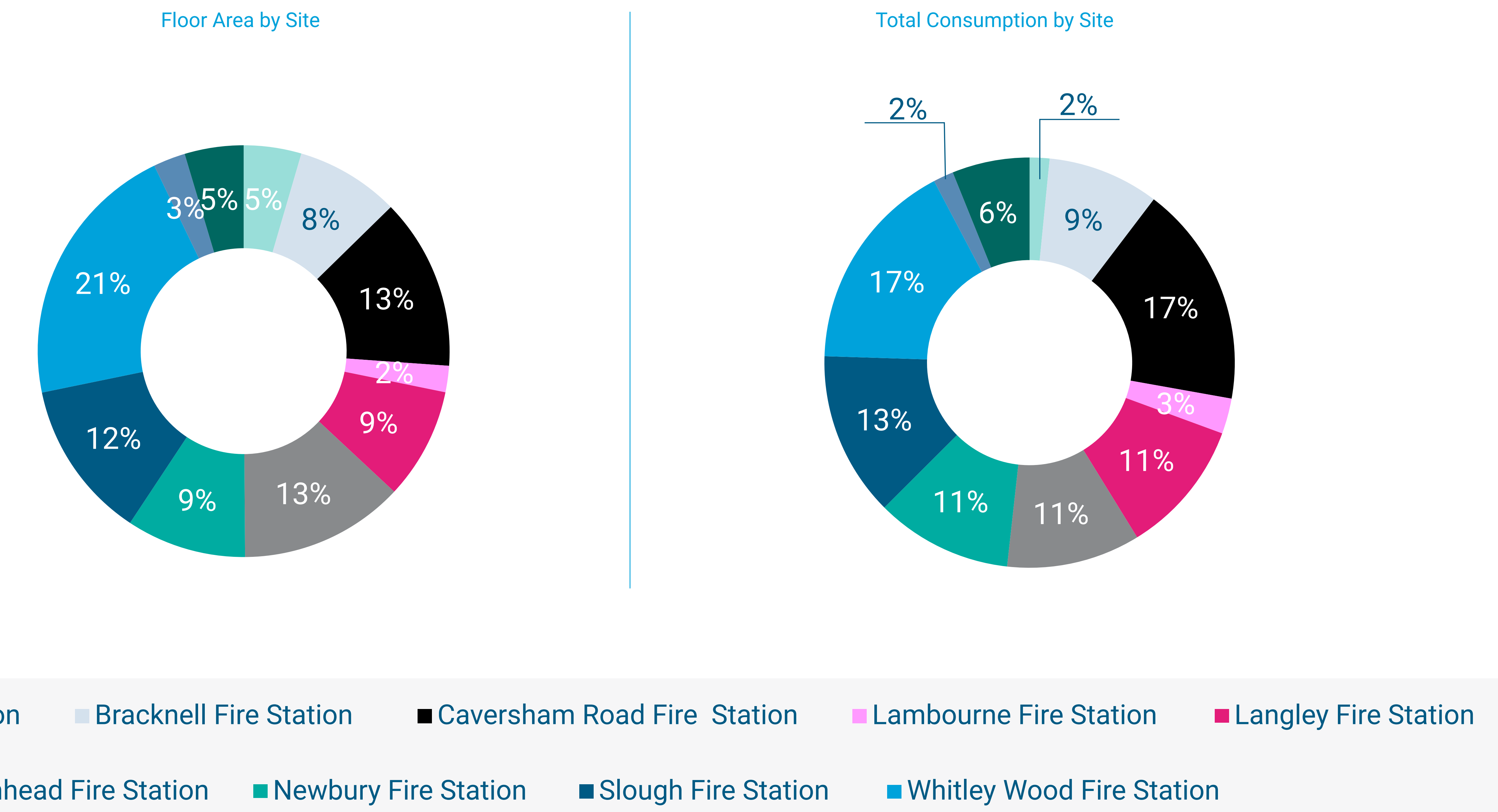


Figure 7a.

Breakdown of total energy consumption for the site (kWh)

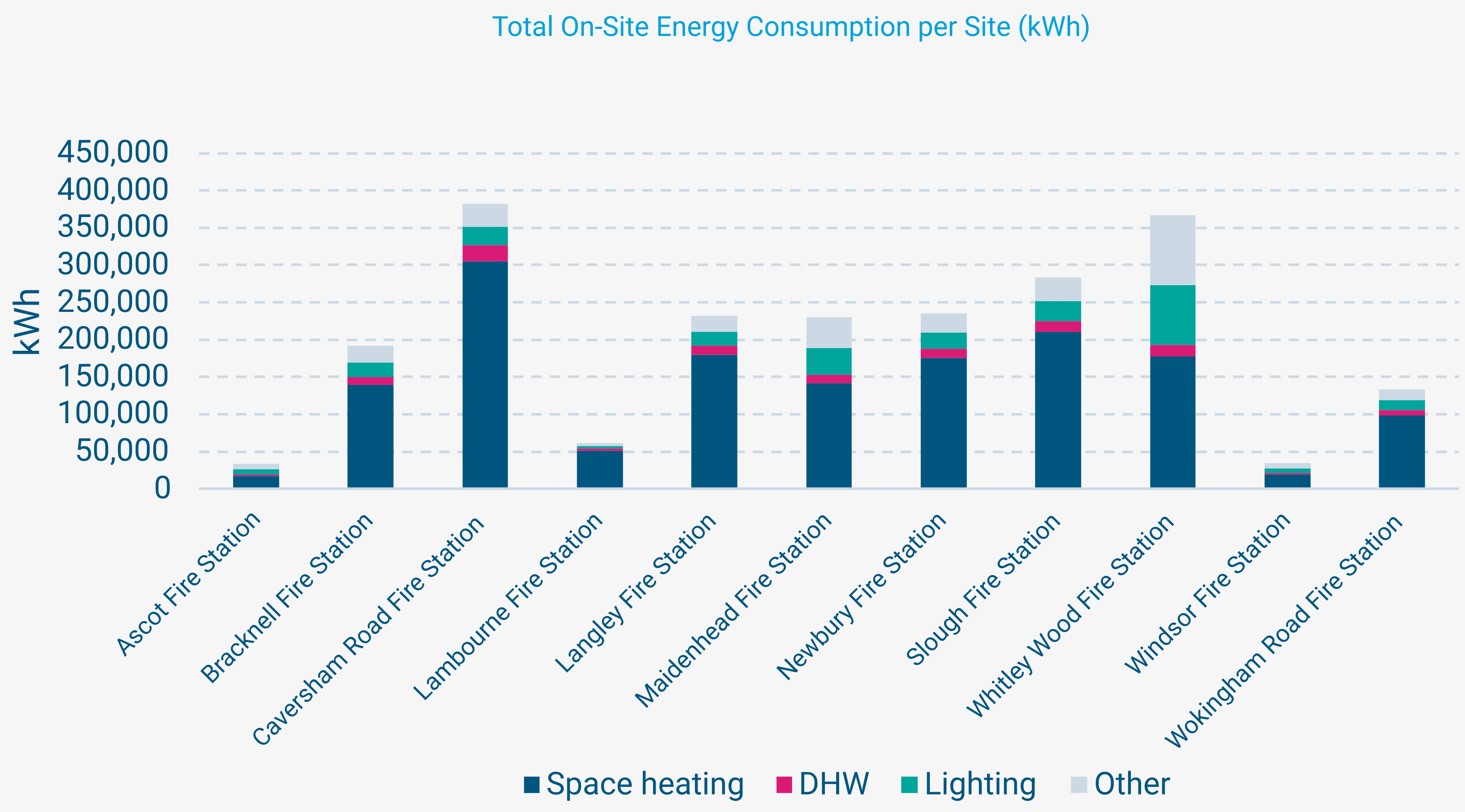
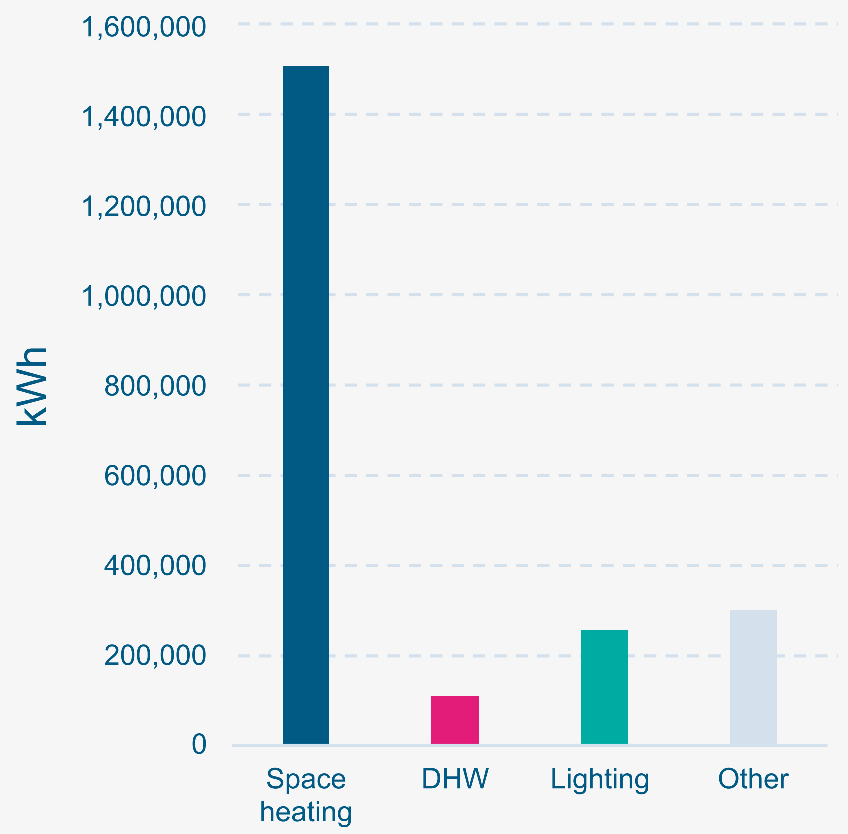
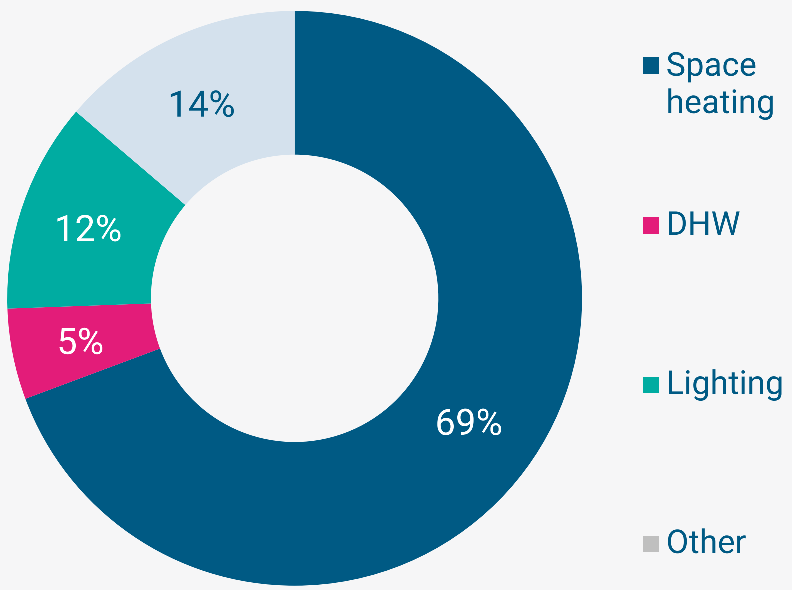


Figure 7b.

Breakdown of total energy consumption for the site (kWh)

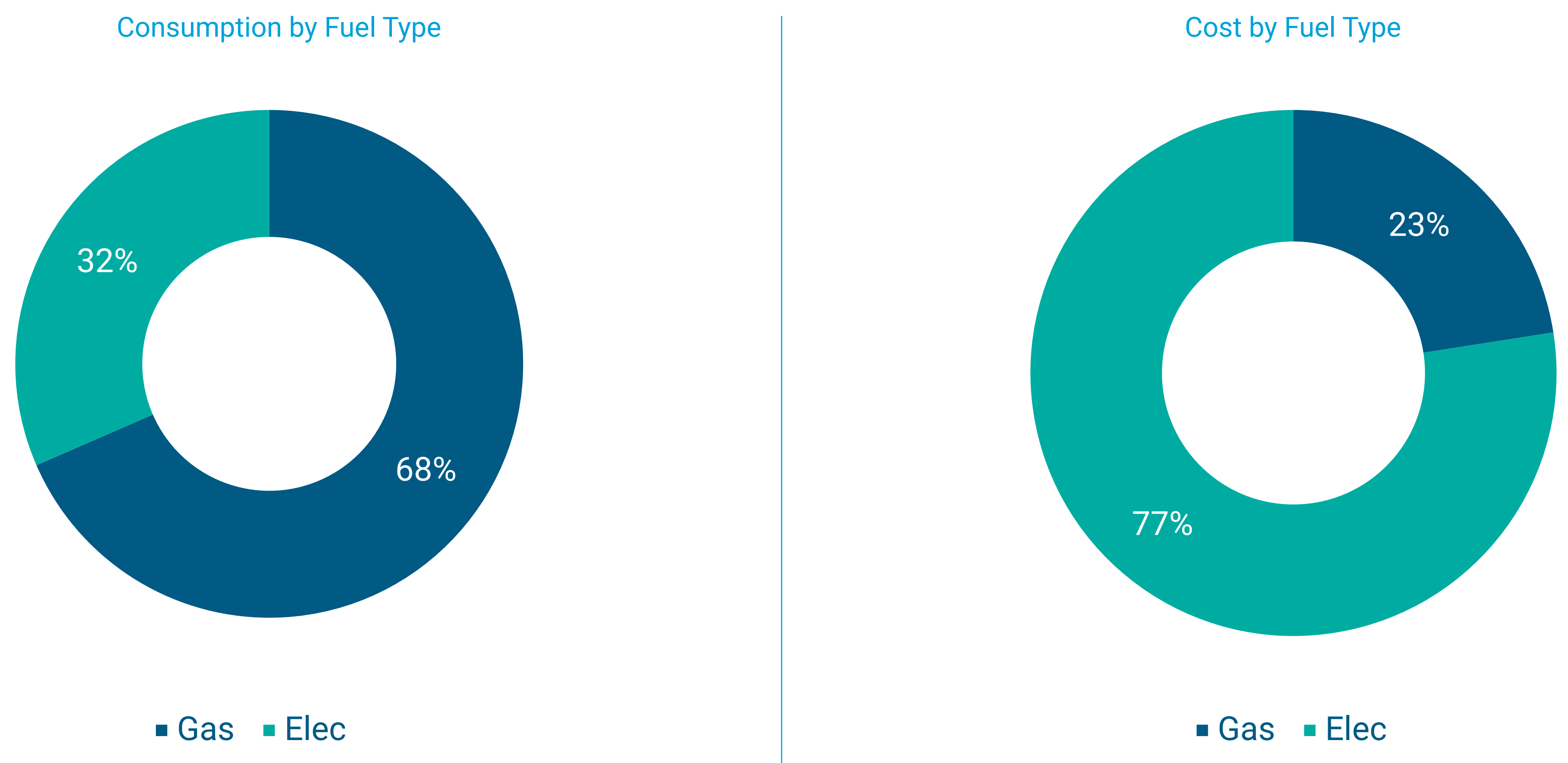




Looking at the breakdown of energy consumption across the site (Figure 7), space heating is the highest contributor accounting for 69% of total energy consumption. This is expected due to the energy required to heat up the appliance bay space. Lighting accounts for 12%, and domestic hot water accounts for 5%. The remaining 14% is attributed to other services, such as kitchen appliances and computers. This breakdown has been estimated using certain percentages depending on building type.

Figure 8.

Consumption and cost by fuel type.



Display Energy Certificates (DEC)

A DEC provides an 'operational rating' on a scale of A to G, with 'A' being the most efficient and 'G' being less efficient (similar to domestic white goods energy labelling). The score gives a comparative rating, assessing the consumption against industry benchmarks for a particular type of building. The DEC also shows the associated annual CO_2e emissions.

A DEC is also accompanied by an Advisory Report which gives recommendations for improving the energy performance of the building (e.g., upgrades to the building fabric or services, and opportunities for the installation of low and zero carbon technologies).

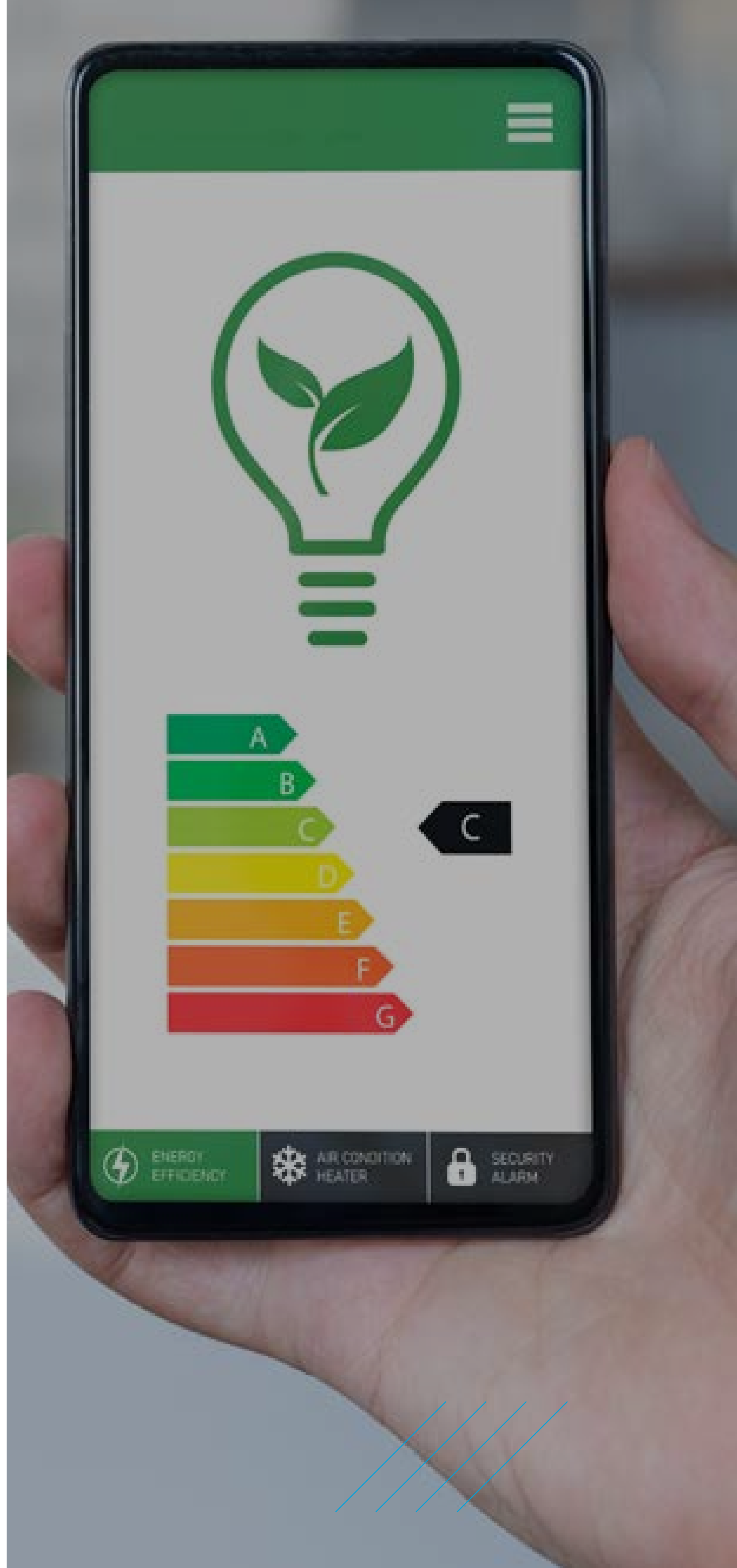
An expired DEC for the building was found on the government DEC database which gave the building a F rating which is poor. The typical operational rating score for a public building is 100. This typical score gives an operational rating band of "D". Buildings with lower band ratings (E-G) offer a greater "potential" for energy savings.

As the recommended measures in this report are undertaken, DEC ratings will improve, highlighting the improved energy performance and reduced consumption of the buildings.

Table 4.

Display Energy Certificates for the RBFRS estate.

Site	Postcode	DEC
Ascot Fire Station	SL5 7HF	Not available online
Bracknell Fire Station	RG12 7AN	D
Caversham Road Fire Station	RG1 8AD	D
Lambourne Fire Station	RG17 8YT	Not available online
Langley Fire Station	SL3 7HS	D
Maidenhead Fire Station	SL6 8PG	D
Newbury Fire Station	RG14 1LD	D
Slough Fire Station	SL1 2XA	D
Whitley Wood Fire Station	RG2 8FT	D
Windsor Fire Station	SL4 4LS	C
Wokingham Road Fire Station	RG6 1LT	D



5. Resources

The RBFRS estates and environmental projects team will be responsible for overseeing the implementation of the decarbonisation plan for the building.

Both teams have been involved in the data provision for this HDP, with oversight from Sophie Fox, Capital Projects Sustainability Coordinator.

The estates team are appropriately qualified, experienced, and trained to manage the required works, however additional human and financial resources will be required to deliver the retrofit interventions. These required resources for the project are illustrated in the following table against the RIBA plan of work stages. The additional resources required will depend on the funding available which will determine the project scope.

Table 5.

Required resources for the delivery of decarbonising retrofit interventions

0. Strategic Definition	1. Preparation & Briefing	2 . Concept Design	3. Spatial Co-ordination	4. Technical Design	5. Manufacturing & Construction	6. Handover	7. Use
			M&E Design Engineers				
			Architect / Building Surveyor				
			Quantity Surveyor				
			Structural Engineer				
			Specialist Consultants				
			Planner				
Finance							
	Stakeholder						
					Contractor		

The estates team are appropriately qualified, experienced, and trained to manage the required works...

6. On-Site Opportunities

This section of the report provides an overview of the technologies considered to be most relevant to the decarbonisation of the site, in line with the three key elements:

Energy Efficiency: Increasing energy efficiency by reducing demand.

Heat: Decarbonising heat.

Power: Increasing renewable energy supply.

Stage 1 – Energy Efficiency

Behaviour Change

Behaviour Change and Internal Policy is the first step in energy demand reduction and is a key driver in facilitating and embedding an energy saving culture. An effective behaviour change policy focuses on internal policy, culture, and changing everyday behaviour to improve efficiencies. Behaviour change interventions are generally the least financially intensive and therefore represent quick wins. There is potential for a behaviour change scheme to be undertaken across the full estate, having far reaching benefits across all of RBFRS's buildings.

Energy Conscious Organisation (EnCO) provides a good framework for this initiative which should be explored. The EnCO process analyses the current position of the organisation in terms of energy awareness and performance and provides a framework / programme to drive change and deliver energy savings.

There can be large gaps between the design energy use of a building and that achieved through its management and use.

- The need for correct operation and maintenance is crucial. It is recommended that guidance material / practical workshops are given to relevant members of the facilities management teams to assist the planning, operating, and maintaining energy efficient sites.
- 'How to' guides should be issued to site decision makers, highlighting roles and responsibilities and outlining key energy saving opportunities, demonstrating how simple actions can result in energy savings. This will promote preventative and planned maintenance. These documents should be written for the target audience, ensuring understanding by different profiles of staff.
- In a corporate setting, green teams can be developed with the aim to spread best practice actions to staff. These staff networks can provide a platform to share ideas, as well as feedback on plans and actions. These networks can also act as a bridge between RBFRS sustainability team and the wider staff across the estate.
- Staff education and behavioural change campaigns should also look to be undertaken. These should inform and educate staff on best behaviours and help develop an understanding of how their behaviour can help RBFRS achieve its overall net-zero targets and improve carbon literacy to staff. These campaigns should be coupled with communication materials outlining the benefits of energy efficiency measures. Through the introduction of actions such as inductions, posters, campaigns and regular correspondence staff awareness of RBFRS Net Zero strategy can be continuously improved.

Behavioural change highlights that RBFRS's most important asset for the delivery of reducing carbon is its' people. Raising awareness and increasing knowledge and skills through a behaviour change programme will be crucial to the next steps towards decarbonisation.

Building Fabric Opportunities

Improving the existing fabric thermal performance is a key factor of energy demand reduction and has interdependencies with the delivery of the M&E interventions and in particular, the installation of heat pump systems. Increasing insulation and improving U-values reduces the heat loss from a building, which saves energy, and improves thermal comfort. There are a range of different building fabric insulation types, including cavity wall insulation, internal or external wall insulation, loft insulation, flat roof insulation and floor insulation. From a technical perspective, improving building fabric performance is a cornerstone to any energy efficiency programme.

The benefits of improving building fabric performance are summarised below:

- Passive,
- Low maintenance,
- Long life,
- Low failure rate.

However, implementation can be complex and disruptive and implementation projects do not tend to produce quick economic paybacks. As such, fabric improvement programmes are only considered appropriate for sites where there is a clear commitment to the longer-term future of the building.

Replacing older single-glazed windows with double, or triple-glazing will reduce heat loss. The payback periods for replacement windows are relatively long in comparison to other carbon reduction measures, due to the high installation costs. The benefits of replacement windows however, include the potential for improved occupant comfort, ventilation and natural daylight, which can reduce lighting energy consumption when combined with lighting control upgrades.

Cavity wall insulation is used to reduce heat loss through a cavity wall by filling the air space with material that inhibits heat transfer. This immobilises the air within the cavity, preventing convection, and can substantially reduce space heating operating costs. Without extensive surveying it's difficult to determine the presence of cavity walls. It is therefore important to complete intrusive inspections before embarking on insulation programmes. Recommendations in this project have been based on building cues from the site audit observations.

Due to the age of the buildings across the estate and condition of the building fabric, for the majority of sites it is recommended that the walls and roofs are insulated to improve their thermal performance. Full double glazing upgrades have been recommended for Caversham Road and Whitley Wood to replace the existing single glazing and poor condition double glazing. Floor upgrades have been proposed for Caversham Road; the separating floor between the appliance bay and gym will be thermally improved by applying external insulation to the soffit of the ground floor appliance bay level. There are no proposed interventions for Windsor because the building fabric features insulation and double glazing which are all in good condition. Full fabric intervention recommendations are found in the individual site Building Audit Reports.

Table 6.

Table 6. Fabric intervention costs (2030)

Site Name	Wall	Roof	Floor	Glazing	Total
Ascot Fire Station	£6,010	£8,690	£0	£0	£14,700
Bracknell Fire Station	£22,969	£142,350	£0	£0	£165,319
Caversham Road Fire Station	£60,672	£124,986	£9,350	£42,463	£237,470
Lambourne Fire Station	£7,924	£2,888	£0	£0	£10,812
Langley Fire Station	£19,833	£117,780	£0	£0	£137,613
Maidenhead Fire Station	£34,058	£34,632	£0	£0	£68,690
Newbury Fire Station	£17,920	£13,244	£0	£0	£31,163
Slough Fire Station	£37,489	£81,125	£0	£0	£118,614
Whitley Wood Fire Station	£0	£0	£0	£175,430	£175,430
Windsor Fire Station	£0	£0	£0	£0	£0
Wokingham Road Fire Station	£16,103	£57,915	£0	£0	£74,018
Total	£222,978	£583,608	£9,350	£217,892	£1,033,828

LED Lighting

LED lighting technology has developed rapidly in the last decade, delivering significant energy savings in use compared to fluorescent, sodium, and metal halide lamp types.

A programme of LED lighting replacement across the site would represent a "quick win" for reducing energy demand and operational costs. An LED upgrade involves replacing less efficient lighting systems with higher efficiency LED luminaires and, where possible, incorporating improved controls. LEDs are a highly efficient lighting technology and typically have a longer life than older lighting technologies. Due to their increased efficiency, LEDs also emit less heat and reduce requirements for cooling.

LED is known as a "quick win" because implementation is quick, and the consumption reduction realised immediately.

Currently there is a mix of fluorescent and LED lighting across the estate. Most of the sites would benefit from some degree of LED upgrade, apart from Ascot, which features full LED lighting already. An allowance has been made to replace all lighting which is not currently LED with modern LED type. This would cost an estimated £163,768, saving 69,477kWh per annum, or 13.44 tCO_2e.

Fans, Motors, and Pumps

Heating, ventilation, and cooling (HVAC) plant is used to distribute air, and hot and cold water within a building, to provide a comfortable and healthy environment.

Integral to these distribution systems are fans, motors, and pumps. Developments in fan, motor and pump technologies mean that new, more energy-efficient technologies and improved control systems are available that can reduce electricity consumption in buildings.

Cooling is provided to the majority of sites in the form of split DX cooling units. It is recommended that these systems are replaced for Newbury, Windsor, Whitley Wood and Maidenhead to ensure effective operation.

Ventilation throughout the sites is generally by local extract fans, typically wall and toilet extracts. Ideally, controlled supply and extract systems with a heat recovery facility are the optimum solution for an energy efficient solution, however this is not always practical when extract fans are remote and there are site limitations for installation of such systems. We would recommend installing Mechanical Ventilation with Heat Recovery (MVHR) units across all sites in the mess rooms, offices, toilets, showers, gyms, changing rooms and dormitory areas.

Some building have fume extract ventilation systems, with many noted as not being in use. Where these systems are in place and operational, air quality sensing could be introduced to limit the use to when they are required. Further investigations are required.

Another area for consideration at all stations is the drying room. Some sites were seen operating the heating during summer to ensure the drying rooms were functional. The most effective solution for this type of room would be a condensing dehumidification unit which uses a refrigeration cycle (split DX) to remove moisture from the air. The heat generated through the unit assists the drying process as well. Many sites have large extract fans which ejects heated air from the building and or excessive heating provision which is inefficient.

BMS and Energy Metering

A BMS is an integrated system for monitoring and controlling energy-related building services. These systems control and monitor heating, ventilation and air conditioning systems, lighting, and power systems.

A BMS provides real-time remote monitoring and integrated control of plant and equipment. A BMS can also monitor modes of operation, internal and external environmental conditions, and energy use. Hours of operation and set points can be adjusted to optimise performance and comfort. For larger buildings, or sites with multiple buildings, the integration of systems operated through a BMS, provides enhanced control with the potential to achieve significant energy savings. Metering is a key component of effective energy management and a BMS can monitor utility meters as well as sub-meters for electricity and heat.

All sites have localised controls for heating and domestic hot water, with Bracknell and Maidenhead featuring an existing BMS. We would strongly recommend upgrading to a new, remotely managed BMS that gives the Service the ability to set parameters controlling the heating i.e. what temperatures it turns on and off, as well as allowing for interrogation of plant where it is believed to be over/under worked. An example of this would be Priva BMS systems, which allows the user to view the entire estate, schematics of the heating systems, rules in place, and remotely trigger heating systems on and off. This also allows for reporting of the plant usage, an element vital for understanding the Service's energy usage.

If the BMS system is upgraded to allow for complete remote control and managing across the estate, an estimated 197,667 kWh could be saved yearly, or 36.86tCO_2eq. A BMS cost breakdown per site has been included in Appendix C.

Stage 2 - Heat

Heat Decarbonisation

Currently, the main alternative to fossil fuel heating is heat pump technology. Where viable, these technologies will need to progressively replace the existing fossil fuel heating plant across RBFRS's estate. There are limited water sources, waste heat, heat recovery or energy from waste opportunities within the estate boundaries and air source heat pumps are the most viable form of heat pump. ASHP technology is summarised below.

Air Source Heat Pumps (ASHP) –These can be Air to Air or Air to Water arrangements. Previously, only Air to Water technology was supported for Government funding but recently Air to Air has been approved for funding.

ASHP (air-water) systems operate with the greatest efficiency when delivering a low flow temperature (<55°C). They can operate at 65°C to satisfy domestic hot water demands (requiring stored water at 60°C) with an associated decrease in seasonal efficiency. They can also operate up to 80°C when a 2-stage arrangement is used and can be installed as a direct replacement for existing boilers serving heating systems which operate with higher flow temperatures (80°C). As expected, there is a further associated decrease in efficiency for these higher temperature systems.

ASHP (air-air) heat pumps have predominately been used in offices and retail buildings in the past but are becoming more common in other types of buildings due to the lower installation costs and reduced space requirements when compared to air-water heat pumps They also offer the added benefit of cooling operation when in reverse cycle operation (if this is desired). These systems are more commonly known as VRV or spit air conditioning systems.

Figure 9.

Simplified diagram of an Air Source Heat Pump

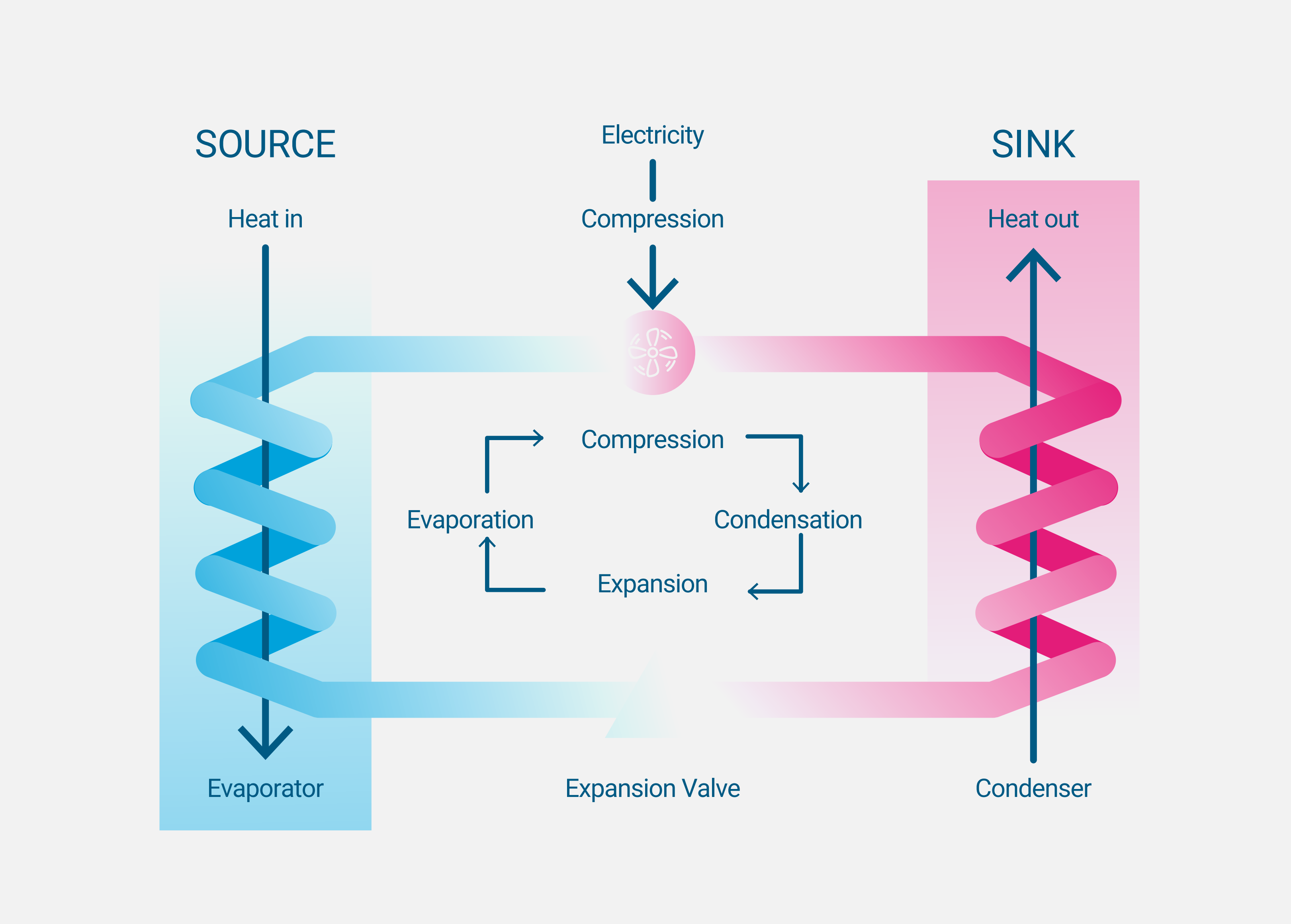


Image source: Heat Pump Association

https://www.heatpumps.org.uk/consumers/heat-pump-technical-information/the-vapour-compression-cycle/

Ground Source Heat Pumps (Open loop) – These systems require an aquifer (large body of underground water) or lake/river. These systems have a higher efficiency than air source heat pumps as the water provides a more consistent temperature low grade heat source and in winter conditions, these systems continue to operate without the need to operate "defrost cycles".

Ground Source Heat Pumps (Closed loop) – Whilst these systems operate using a more consistent heat rejection temperature (below ground temperatures of 8-12°C), these systems are significantly more expensive to install than air source heat pumps. The increase in seasonal efficiency is generally not large enough to offset the additional installation costs. These systems could be considered for any projects where an ASHP solution is not likely to be viable due to noise considerations, or where efficiency is paramount, and funding is available.

Site Specific Heating Interventions

The proposed decarbonisation solutions for the 11 sites are ASHPs with a combination of air to air and air to water systems. Air to air ASHP solutions are extremely efficient with typical seasonal efficiencies of around 400%. They are also modular and allow for excellent zoning and control of different areas, which is required throughout this site. Air to water solutions have an efficiency of around 250-300%, and allow for provision of DHW.

The main challenges with the implementation of either type of ASHPs include:

- **Noise from air source heat pumps** – heat pump systems may operate overnight/early hours of the morning. Acoustic enclosures or screens may be required in residential areas and planning is usually required.
- **Outside space required** for the air source heat pump condensers. In general, ASHPs are much larger than the boilers they will be replacing and are sited externally. The following table gives a comparison of the size and weight differences for a 50kW boiler and a 50kW heat pump.
- **If large quantities of domestic hot water are required** over a short time frame (e.g. school kitchens, showering facilities etc.) there is likely to be a requirement for water to be stored at 60°C. ASHPs which can generate water at 65°C will be required. Consideration should be given to providing local point of use electric water heaters where this is practical.
- **Gas and oil boilers are repaired** promptly though established FM supply chain arrangements. ASHPs are a relatively new technology and heating companies will need to re-skill service engineers and the industry will need to develop new supplier chain partners to ensure required components are easily available. This position is changing rapidly.

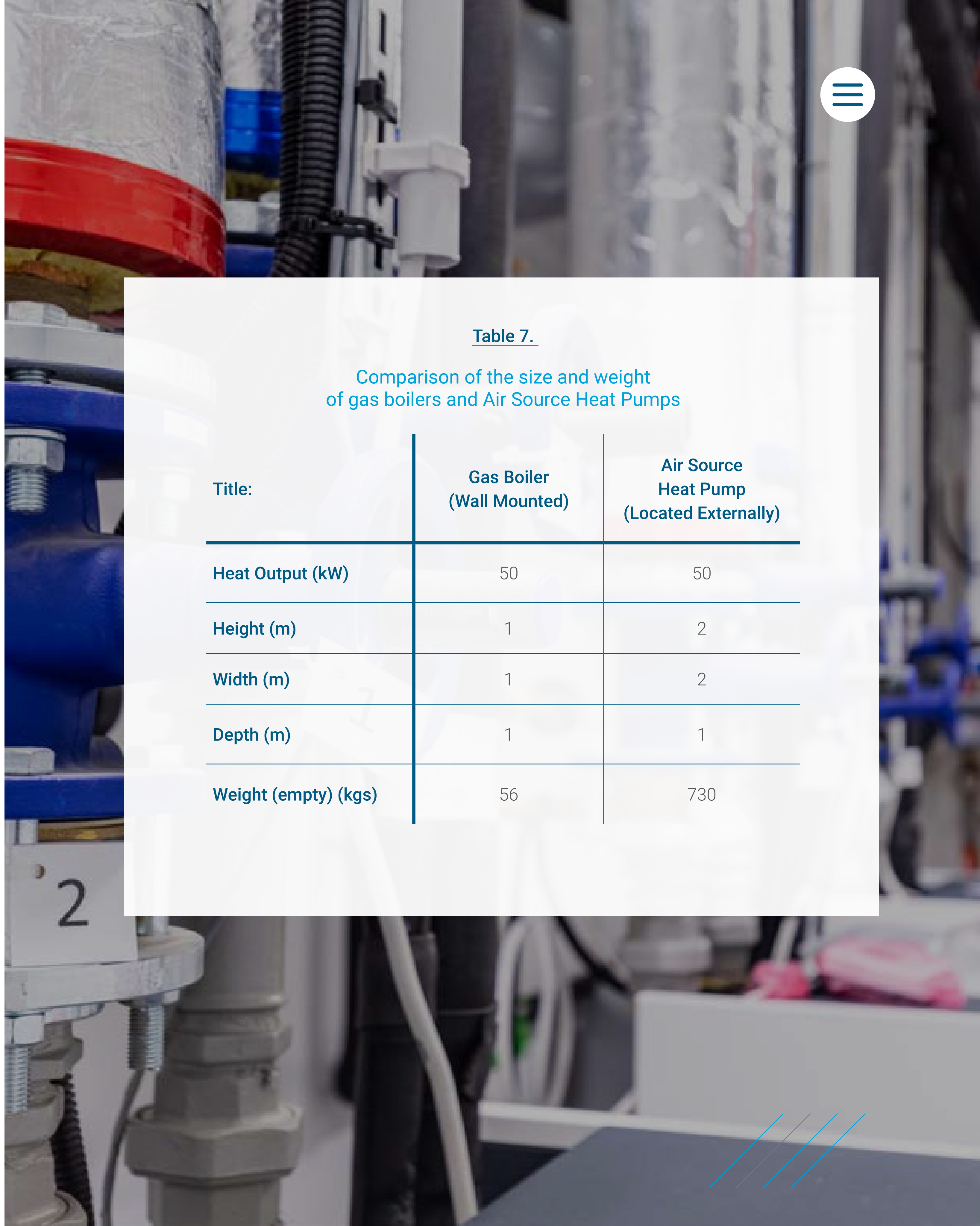


Table 7.

Comparison of the size and weight of gas boilers and Air Source Heat Pumps

Title:	Gas Boiler (Wall Mounted)	Air Source Heat Pump (Located Externally)
Heat Output (kW)	50	50
Height (m)	1	2
Width (m)	1	2
Depth (m)	1	1
Weight (empty) (kgs)	56	730

The following conventions have been adopted when assessing the option for decarbonising the heat source across the estate:

Table 8.

Prioritisation when assessing options of heat source decarbonisation

Item:	Description:
Priority 1:	**For sites with obsolete heating installations** Replace entire heating system (heat source and distribution/emitters) with an ASHP solution using low temperature distribution. Domestic hot water provision to be provided by the ASHP (boosted by electrical immersions) for properties with sufficient demand (determined by Domestic Hot Water System (DHWS) consumption monitoring). Where DHWS demand does not require the provision of centralised storage, point of use electric water heaters are recommended.
Priority 2	**For smaller sites with obsolete boilers/distribution systems** Install ASHP or split DX/VRV replacement installation and electric point of use water heaters.
Priority 3	**Sites with obsolete boilers but fair condition distribution** Retain distribution and emitters and install an ASHP solution to match the existing high temperature distribution. Domestic hot water provision to be provided by the ASHP for properties with sufficient demand (determined by DHWS consumption monitoring). Where DHWS demand does not require the provision of centralised storage, point of use electric water heaters are recommended.
Priority 4	**For sites with new boilers and installations and old DHWS** Retain heating system. Domestic hot water provision to be provided by ASHP for properties with sufficient demand (determined by DHWS consumption monitoring). Where DHWS demand does not require the provision of centralised storage, point of use electric water heaters are recommended.
Priority 5	**For sites with new boilers, installations and DHWS in fair condition** Defer to end of HDP programme and review new technologies available before commencing decarbonisation. If no preferable technology is available, install an ASHP solution to match the existing high temperature distribution. Domestic hot water provision to be provided by the ASHP for properties with sufficient demand (determined by DHWS consumption monitoring). Where DHWS demand does not require the provision of centralised storage, point of use electric water heaters are recommended.

Using the above prioritisation (Table 8), combined with building information gathered from the site audits, the following conventions have been recommended for heating systems across the estate:

Ascot

Ascot is a fire and rescue station which was constructed in 1980 and has a total floor area of 400m^2.

The appliance bay floor area is approximately 84m^2. The building is served by one 30kW gas fired combination boiler which is 5-10 years old and four electric panel heaters. Heating is delivered by radiators in the main building and in the appliance bay. The boiler provides instantaneous domestic hot water to toilets and the kitchen. There are two electric showers.

As the majority of the heating pipework and emitters is 25+ years old, the proposed heating solution is to install an ASHP (air to air) solution throughout the main building. If heating is required for the appliance bay, it is recommended that an electric radiant heating solution is adopted. As the appliance bay doors are often opening and closing, a warm air heating system can prove inefficient with the heated air being continually lost to atmosphere. A radiant solution predominantly heats objects and surfaces rather than the air which will escape when the doors are opened. It is recommended that any heating system within the appliance bay is linked to the operation of the doors and is only enabled when the doors are closed.

It is recommended that DHWS is decentralised for this building, and the combination boiler is replaced with local point of use electric water heaters. The showers are already electric.

Bracknell

Bracknell is a fire and rescue station which was constructed in 1966 and has a total floor area of 503m^2.

The appliance bay floor area is approximately 217m^2. The building is served by two 60kW gas fired condensing boilers which are 1 year old. Heating is delivered by radiators in the main building and LTHW unit heaters in the appliance bay. There is a separate 36kW direct gas fired calorifier (230litres) which provides domestic hot water to toilets, the kitchen and three showers.

The proposed heating solution is to install an ASHP (air to air) solution throughout the main building. If heating is required for the appliance bay, it is recommended that an electric radiant heating solution is adopted. As the appliance bay doors are often opening and closing, a warm air heating system can prove inefficient with the heated air being continually lost to atmosphere. A radiant solution predominantly heats objects and surfaces rather than the air which will escape when the doors are opened. It is recommended that any heating system within the appliance bay is linked to the operation of the doors and is only enabled when the doors are closed.

It is recommended that DHWS is decentralised for this building, and the gas fired calorifier is replaced with local point of use electric water heaters. The showers have already been changed to electric ones.

Using the above prioritisation (Table 8), combined with building information gathered from the site audits, the following conventions have been recommended for heating systems across the estate:

Caversham Road

Caversham road is a fire and rescue station which contains multiple buildings.

The main fire station (583m^2), the training building (340m^2) and workshop/store building (163m^2) were constructed in 1939 and the occupational health building (105m^2) was constructed in 1970. The appliance bay floor area is approximately 262m^2 and is unheated. The main fire station building is served by two 60kW gas fired condensing boilers which are <5 years old. Heating is delivered by radiators in the main building and LTHW unit heaters in the appliance bay. The training building is served by two 42kW gas fired condensing boilers which are over 10 years old. Heating is delivered by radiators. The workshop/store has a minimal amount of electric heaters which appear to provide frost protection only and this building is used for storage. The occupational health building has a mix of electric storage and electric panel heaters which are 5-15 years old. There is a 29kW direct gas fired calorifier which provides domestic hot water to toilets and seven showers in the main station. There is an indirect calorifier (29kW/300litre) fed by the training building boilers which serves the kitchen, toilets and two showers in this building. There are no water services in the store and POU electric water heaters are installed in the occupational health building.

As the majority of the heating pipework and emitters is 25+ years old, the proposed heating solution is to install an ASHP (air to air) solution throughout the main building and training centre. The alternative to this, if DHW would be provided by the system would be an integrated ASHP (Air to water). If heating is required for the appliance bay, it is recommended that an electric radiant heating solution is adopted. As the appliance bay doors are often opening and closing, a warm air heating system can prove inefficient with the heated air being continually lost to atmosphere. A radiant solution predominantly heats objects and surfaces rather than the air which will escape when the doors are opened. It is recommended that any heating system within the appliance bay is linked to the operation of the doors and is only enabled when the doors are closed. The workshop/storage building already has decarbonised heating, with electric heaters providing frost protection. The occupational health building is also electric but operational savings could be gained if an ASHP (air to air) system was installed to replace the existing electric heating.

It is recommended that DHWS is decentralised for the main building and the training centre. The gas fired and indirect calorifiers should be replaced with local point of use electric water heaters and electric showers should be provided (7 in main building and 2 in training building). The kitchen DHW consumption should be monitored to establish the kitchen demand pattern prior to final selection of equipment. The occupational health building already has POU electric water heaters installed.

Lambourne

Lambourne is a fire and rescue station which was constructed in 1974 and has a total floor area of 183m^2.

The appliance bay floor area is approximately 77m^2 and the Client has advised that this area is unheated. The building is served by one 34kW gas fired combination boiler which is <1 year old. Heating is delivered by radiators in the main building and unit heaters in the appliance bay. The boiler provides instantaneous domestic hot water to toilets and the kitchen. There is one electric shower.

As the majority of the heating pipework and emitters is 25+ years old, the proposed heating solution is to install an ASHP (air to air) solution throughout the main building. If heating is required for the appliance bay, it is recommended that an electric radiant heating solution is adopted. As the appliance bay doors are often opening and closing, a warm air heating system can prove inefficient with the heated air being continually lost to atmosphere. A radiant solution predominantly heats objects and surfaces rather than the air which will escape when the doors are opened. It is recommended that any heating system within the appliance bay is linked to the operation of the doors and is only enabled when the doors are closed.

It is recommended that DHWS is decentralised for this building, and the combination boiler is replaced with local point of use electric water heaters. The shower has already been changed to an electric one.

Using the above prioritisation (Table 8), combined with building information gathered from the site audits, the following conventions have been recommended for heating systems across the estate:

Newbury

Newbury is a fire and rescue station which was constructed in 1956 and has a total floor area of 449m^2.

183m^2 of the building is an extension which was added in 1970. The appliance bay floor area is approximately 200m^2 and the Client has advised that this area is unheated. The main building is served by two 50kW gas fired boilers which are 10-15+ years old (one disconnected) and one 69kW gas fired boilers which is 10-15+ years old serves the appliance bay. Heating is delivered by radiators in the main building and unit heaters in the appliance bay. A gas fired calorifier provides domestic hot water to toilets, showers, and the kitchen.

The proposed heating solution is to install an ASHP (air to air) solution throughout the main building, or alternatively an air to water system that would utilise existing pipework with upgrades and replacements where necessary. If heating is required for the appliance bay, it is recommended that an electric radiant heating solution is adopted. As the appliance bay doors are often opening and closing, a warm air heating system can prove inefficient with the heated air being continually lost to atmosphere. A radiant solution predominantly heats objects and surfaces rather than the air which will escape when the doors are opened. It is recommended that any heating system within the appliance bay is linked to the operation of the doors and is only enabled when the doors are closed.

It is recommended that DHWS is decentralised for this building, and the gas fired calorifier is replaced with local point of use electric water heaters and four electric showers. The kitchen DHW consumption should be monitored to establish the kitchen demand pattern prior to final selection of equipment.

Langley

Langley is a fire and rescue station which was constructed in 1963 and has a total floor area of 774m^2.

The appliance bay floor area is approximately 192m^2 and the Client has advised that this area is unheated. The building is served by two 93kW gas fired condensing boilers which are 20+ years old. Heating is delivered by radiators in the main building and LTHW unit heaters in the appliance bay. A 29kW 217litre direct gas fired calorifier provides domestic hot water to toilets, the kitchen and three showers.

As the pipework and emitters do not require replacement, the proposed heating solution is to install a high temperature (up to 80°C) ASHP (air to water) solution to serve the existing heating. Subject to a full feasibility and detail design, a medium temperature ASHP (to operate at 65°C) would offer a lower capital cost and improved operating efficiency solution. If heating is required for the appliance bay, it is recommended that an electric radiant heating solution is adopted. As the appliance bay doors are often opening and closing, a warm air heating system can prove inefficient with the heated air being continually lost to atmosphere. A radiant solution predominantly heats objects and surfaces rather than the air which will escape when the doors are opened. It is recommended that any heating system within the appliance bay is linked to the operation of the doors and is only enabled when the doors are closed.

DHWS could be decentralised for this building, but as a high/medium temperature ASHP is proposed, it makes sense to retain the centralised DHWS system. It is proposed that any remote hot water outlets will have POU electric water heaters installed to reduce continuous heat losses from long runs of DHWS pipework.

Using the above prioritisation (Table 8), combined with building information gathered from the site audits, the following conventions have been recommended for heating systems across the estate:

Windsor

Windsor is a fire and rescue station which was constructed in 1992 and has a total floor area of 223m².

The appliance bay floor area is approximately 91m² and the Client has advised that this area is unheated. The building is served by one 37kW gas fired combination boiler which is 10 years old. Heating is delivered by radiators in the main building and in the appliance bay. The boiler provides instantaneous domestic hot water to toilets, one shower and the kitchen. There is one additional electric shower.

Although the system is not end of life, the proposed heating solution is to install an ASHP (air to air) solution throughout the main building. If heating is required for the appliance bay, it is recommended that an electric radiant heating solution is adopted. As the appliance bay doors are often opening and closing, a warm air heating system can prove inefficient with the heated air being continually lost to atmosphere. A radiant solution predominantly heats objects and surfaces rather than the air which will escape when the doors are opened. It is recommended that any heating system within the appliance bay is linked to the operation of the doors and is only enabled when the doors are closed.

It is recommended that DHWS is decentralised for this building, and the combination boiler is replaced with local point of use electric water heaters and electric showers.

Wokingham Road

Wokingham Road is a fire and rescue station which was constructed in 1970 and has a total floor area of 409m².

The appliance bay floor area is approximately 112m² and the Client has advised that this area is unheated. The building is served by one 45kW gas fired condensing boiler which is 13 years old. Heating is delivered by radiators and fan convectors in the main building and LTHW unit heaters in the appliance bay. A 29kW 217litre direct gas fired calorifier provides domestic hot water to toilets, the kitchen and three showers.

As the majority of the heating pipework and emitters is 25+ years old, the proposed heating solution is to install an ASHP (air to air) solution throughout the main building, or alternatively a high temperature air to water system where existing pipework can be utilised. If heating is required for the appliance bay, it is recommended that an electric radiant heating solution is adopted. As the appliance bay doors are often opening and closing, a warm air heating system can prove inefficient with the heated air being continually lost to atmosphere. A radiant solution predominantly heats objects and surfaces rather than the air which will escape when the doors are opened. It is recommended that any heating system within the appliance bay is linked to the operation of the doors and is only enabled when the doors are closed.

It is recommended that DHWS is decentralised for this building, and the gas fired calorifier is replaced with local point of use electric water heaters and electric showers.

Using the above prioritisation (Table 8), combined with building information gathered from the site audits, the following conventions have been recommended for heating systems across the estate:

Slough

Slough is a fire and rescue station which was constructed in 1956.

There are two buildings on site, the main fire station and a stores building with a total floor area of 1,057m^2. The appliance bay floor area is approximately 245m^2 and the Client has advised that this area is unheated. The stores building is reported as 50% heated. The main building is served by two 40kW gas fired condensing boilers which are 1-5 years old. Heating is delivered by radiators and fan convectors in the main building and in the appliance bay. The boilers also serve a 48kW coil in an 800litre calorifier which provides domestic hot water to toilets, the kitchen and seven showers.

As the majority of the heating pipework and emitters is 25+ years old, the proposed heating solution is to install an ASHP (air to air) solution throughout the main building. If heating is required for the appliance bay, it is recommended that an electric radiant heating solution is adopted. As the appliance bay doors are often opening and closing, a warm air heating system can prove inefficient with the heated air being continually lost to atmosphere. A radiant solution predominantly heats objects and surfaces rather than the air which will escape when the doors are opened. It is recommended that any heating system within the appliance bay is linked to the operation of the doors and is only enabled when the doors are closed. The stores building is currently electrically heated (50% of the building is heated) with halogen and electric heaters that are 15+ years old. Subject to the usage of the building and requirement for heating these could be replaced with a split DX solution for improved efficiency in operation or direct electric heaters. The split DX solution is included within this report.

The staff on site report that there is a large demand for hot water at this site and that more than seven showers are required. The recommendation is for medium temperature (65°C) ASHP (air to water) to provide DHWS to this building with POU electric water heaters and electric showers in remote locations to prevent heat losses from long lengths of pipework. It is recommended that domestic hot water consumption is monitored prior to implementing changes to ensure a centralised system is the most suitable arrangement.

Whitley Wood

Whitley Wood is a fire and rescue station which contains multiple buildings.

The main fire station (675m^2), block 1 (335m^2) and block 2 (227m^2) were constructed in 1992. There are two appliance bay areas in the main block with floor areas of approximately 257m^2 and 218m^2. The Client has advised that appliance bays are unheated. The main fire station building is served by two 60kW gas fired condensing boilers which are 12 years old. Heating is delivered by radiators in the main building and LTHW unit heaters in one of the appliance bays (one appliance bay has no heating installed). Block 1 is served by one 30kW gas fired condensing boiler which is 5-10 years old. This heating system has recently had a major leaking and caused significant building damage. Block 2 is approximately 50% heated by electric heaters which are in fair condition (10-20 years. There is a 22kW/270litre direct gas fired calorifier which provides domestic hot water to toilets, the kitchen and five showers in the main station (31 years old). There is a 59kW/300litre direct gas fired calorifier and a 9kW 250litre electric water heater in block 1 which serves the kitchen, toilets and nine showers. There are electric POU water heaters serving the kitchenette and toilets in block 2.

As the majority of the heating pipework and emitters is 31 years old, the proposed heating solution is to install an ASHP (air to air) solution throughout the main building and block 1, however a high temperature ASHP system with new pipework would also be suitable and achieve high efficiency. If heating is required for the appliance bays, it is recommended that an electric radiant heating solution is adopted. As the appliance bay doors are often opening and closing, a warm air heating system can prove inefficient with the heated air being continually lost to atmosphere. A radiant solution predominantly heats objects and surfaces rather than the air which will escape when the doors are opened. It is recommended that any heating system within the appliance bay is linked to the operation of the doors and is only enabled when the doors are closed. Block 2 already has decarbonised heating, with electric heaters serving 50% of the building (50% unheated). Operational savings could be gained if an ASHP (air to air) system was installed to replace the existing electric heating and a DX split solution has been assumed for this report.

There appears to be a large demand for hot water at this site with large kitchens and numbers of showers. The recommendation is for a medium temperature (65°C) ASHP (air to water) to provide DHWS to the main building and block 1, with POU electric water heaters and electric showers in remote locations to prevent heat losses from long lengths of pipework. It is recommended that domestic hot water consumption is monitored prior to implementing changes to ensure a centralised system is the most suitable arrangement. Block 2 already has POU electric water heaters installed.

Using the above prioritisation (Table 8), combined with building information gathered from the site audits, the following conventions have been recommended for heating systems across the estate:

Maidenhead

Maidenhead is a fire and rescue station which was constructed in 1977 and has a total floor area of 1,144m^2.

The appliance bay floor area is approximately 256m^2 and the Client has advised that this area is unheated. The building is served by two 60kW gas fired condensing boilers which are 1 year old. Heating is delivered by radiators in the main building and LTHW unit heaters in the appliance bay. A 36kW 230litre direct gas fired calorifier provides domestic hot water to toilets, the kitchen and six showers.

As the pipework and emitters do not require replacement, the proposed heating solution is to install a high temperature (up to 80^{o}C) ASHP (air to water) solution to serve the existing heating. Subject to a full feasibility and detail design, a medium temperature ASHP (to operate at 65^{o}C) would offer a lower capital cost and improved operating efficiency solution. If heating is required for the appliance bay, it is recommended that an electric radiant heating solution is adopted. As the appliance bay doors are often opening and closing, a warm air heating system can prove inefficient with the heated air being continually lost to atmosphere. A radiant solution predominantly heats objects and surfaces rather than the air which will escape when the doors are opened. It is recommended that any heating system within the appliance bay is linked to the operation of the doors and is only enabled when the doors are closed.

DHWS could be decentralised for this building, but as a high/medium temperature ASHP is proposed, it makes sense to retain the centralised DHWS system. It is proposed that any remote hot water outlets will have POU electric water heaters installed to reduce continuous heat losses from long runs of DHWS pipework.

Stage 3 - Power

Solar PV

Solar PV is a renewable energy technology which operates by absorbing the sun's energy and converting it into electricity. A solar PV panel is assembled from individual photovoltaic cells grouped together in modules. These modules are mounted together on a panel and the panels can be connected to form an array. The electricity generated by solar PV is Direct Current (DC), whereas building appliances typically operate from an Alternating Current (AC) supply. Therefore, an inverter is installed alongside the system to convert electricity from DC to AC.

As highlighted in the Building Information section, despite being a much lower proportion of the energy mix, the cost for electricity to RBFRS was far higher than gas, without the estate-wide switch to electrical heating. To support the wide-scale electrification of heating outlined in this report, it is recommended that wholly new Solar PV is installed across the estate. Based on our calculations, Langley and Maidenhead stands to benefit the most from a PV installation with a potential 400m^2 of roof available for PV. Bracknell, Slough and Whitley Wood would then be recommended as a prioritisation, however all sites should be investigated further for PV installations to maximise potential.

2,334m^2 of roof has been highlighted for potential Solar PV arrays across the estate, with this being flat or pitched south facing roofs. These installations would produce in the ~402,622kWh of electrical generation per year, at an estimated cost saving of £473,674. The projected carbon emission savings and costs for installation have been provided in further detail in Appendices C and D. A nominal cost of £1000/kWp has been used for the calculations based on previously implemented projects and QS costing, with an assumed 0.21kWp/m^2 for pitched roof, and 0.2kWp/m^2 for flat roof areas.

Table 9.

Solar PV opportunities if installation was to occur without additional storage

Site Name	Area available for additional/new solar PV	Rating of Solar Panels (kWp)	Electrical generation from solar panels (kWh)	Cost of solar panel installation
Ascot Fire Station	60	13	10,710	£12,600
Bracknell Fire Station	250	50	42,500	£50,000
Caversham Road Fire Station	207	42	35,794	£42,110
Lambourne Fire Station	33	7	5,891	£6,930
Langley Fire Station	400	80	68,000	£80,000
Maidenhead Fire Station	400	80	68,000	£80,000
Newbury Fire Station	200	40	34,000	£40,000
Slough Fire Station	324	67	56,978	£67,034
Whitley Wood Fire Station	300	63	53,550	£63,000
Windsor Fire Station	60	12	10,200	£12,000
Wokingham Road Fire Station	100	20	17,000	£20,000
Total	2,334	474	402,622	473,674

Should Solar PV be considered, further investigations by specialist Solar PV consultants and structural engineers must be undertaken to determine the extent of roof suitable for PV arrays, which will ultimately determine the magnitude of electrical generation that can be produced. It must be noted that due to the potential modular system build construction, further structural consideration may be required. Post Solar investigation, we would potentially recommend feasibility of battery storage capacity to deal with excess, however due to the low payback for battery storage it is not recommended within this report.

7. Report Findings

This report outlines the scenarios for achieving Net Zero by 2030, 2040 and 2050. An assumption has been made that funding and expenditure will be equally spaced throughout this period. Also, future utility pricing is based on 6.5% inflation rate and future installation costs based on 20% inflation every 10 years (Table 10).

Tabulated results from the modelling and calculations are included in Appendix B, C, and D. The results are graphically portrayed in the following section. The graphs illustrate that the identified decarbonisation measures discussed in this report will enable the building to reach Net Zero Carbon. There may be new technologies that come to the market or decarbonisation of the National Grid faster than that indicated by the Government. These scenarios would facilitate quicker decarbonisation and a closer approach to Net Zero Carbon. RBFRS could also consider carbon offsetting measures through off-site solar PV. Alternatively, moving to an 100% REGO (Renewable Energy Guarantee Origin) backed electricity contract would support zero carbon energy.

Table 10.

Estimated cost of interventions according to Net Zero scenario

	Cost of Install			
Interventions	2030	2040	2050	tCo_2 Saving without Grid Decarbonisation
Behaviour Change	£1,016	£1,129	£1,233	20.32
Fabric Upgrades	£1,033,828	£1,148,698	£1,255,363	99.93
LED Install	£163,768	£181,965	£198,862	13.44
Htg & DHW Upgrade	£1,790,053	£1,988,947	£2,173,635	94.85
PV Install	£473,674	£526,304	£575,175	77.86
BMS Upgrade	£442,155	£491,283	£536,903	36.64
Chiller Upgrade	£97,500	£108,333	£118,393	0.79
Vent Upgrade	£591,500	£657,222	£718,250	5.32
Total	£4,593,493	£5,103,882	£5,577,813	349.37

Table 10 shows the cost implications of installing each measure to reach Net Zero by 2030, 2040 and 2050, along with the reduction in carbon based on today's factors. Heating for the site will have the highest cost but will provide a significant carbon saving of 94.85 tCO_2 (using todays carbon factors). Fabric upgrades across the site will result in the highest carbon saving, reducing emissions by 99.93 tCO_2, but carries a high cost implication of £1,033,828 if installed by 2030.

PV install is a fraction of the price of the heating upgrade yet is predicted to make over 2/3rds as much saving through intervention at 77.86 tonnes. BMS upgrades across the estate are also highly recommended, for a relatively low cost of £442,155 there is the potential to save 36.64 tonnes of carbon through advanced monitoring and control of heating.

If cost is a prohibitive factor, PV install and BMS upgrade measures are predicted to supply almost as much carbon saving as heating upgrade, for around half of the cost.

Figure 10.

Intervention's scenario Net Zero by 2030

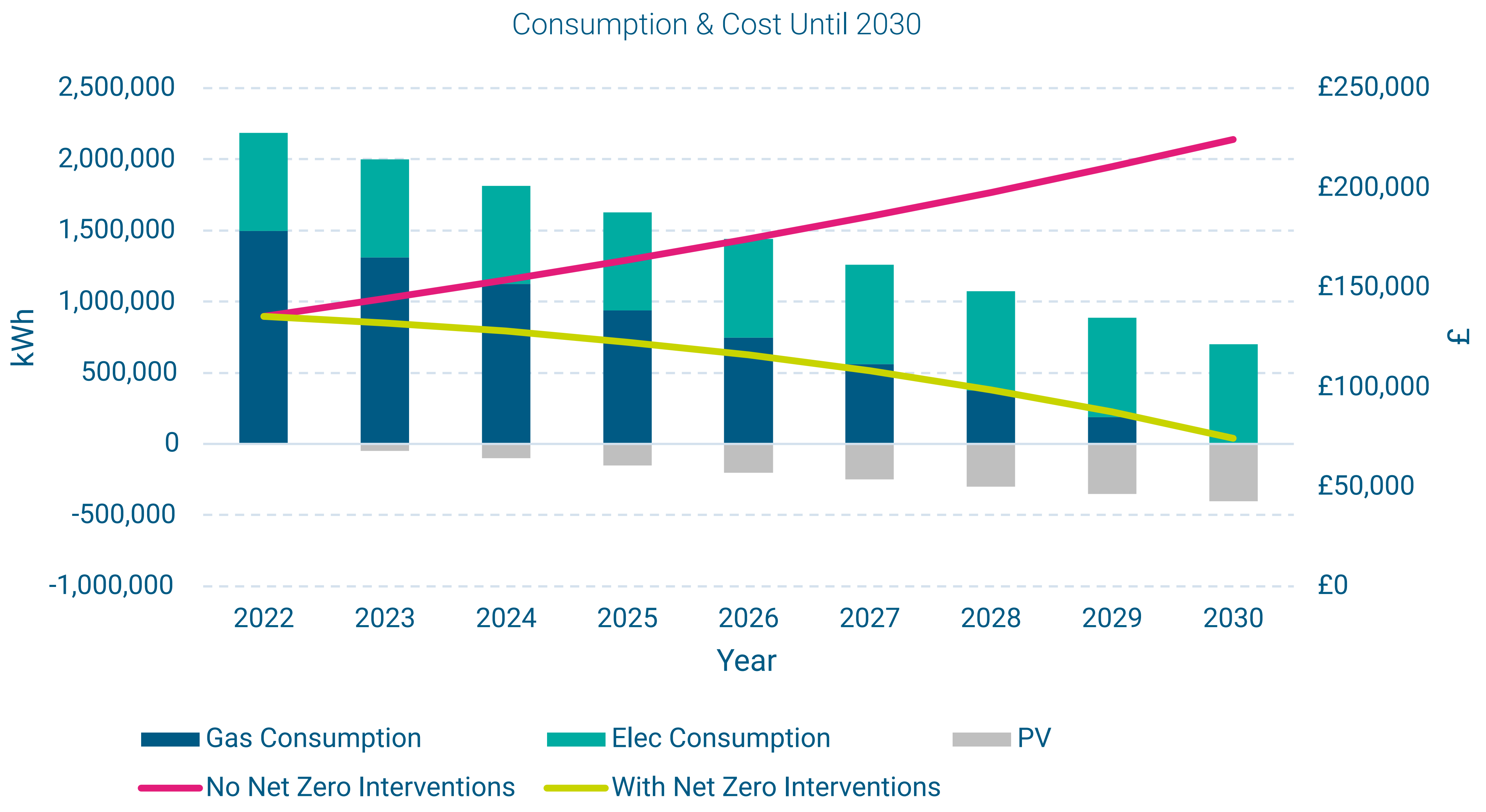


Figure 11.

Intervention's scenario Net Zero by 2040

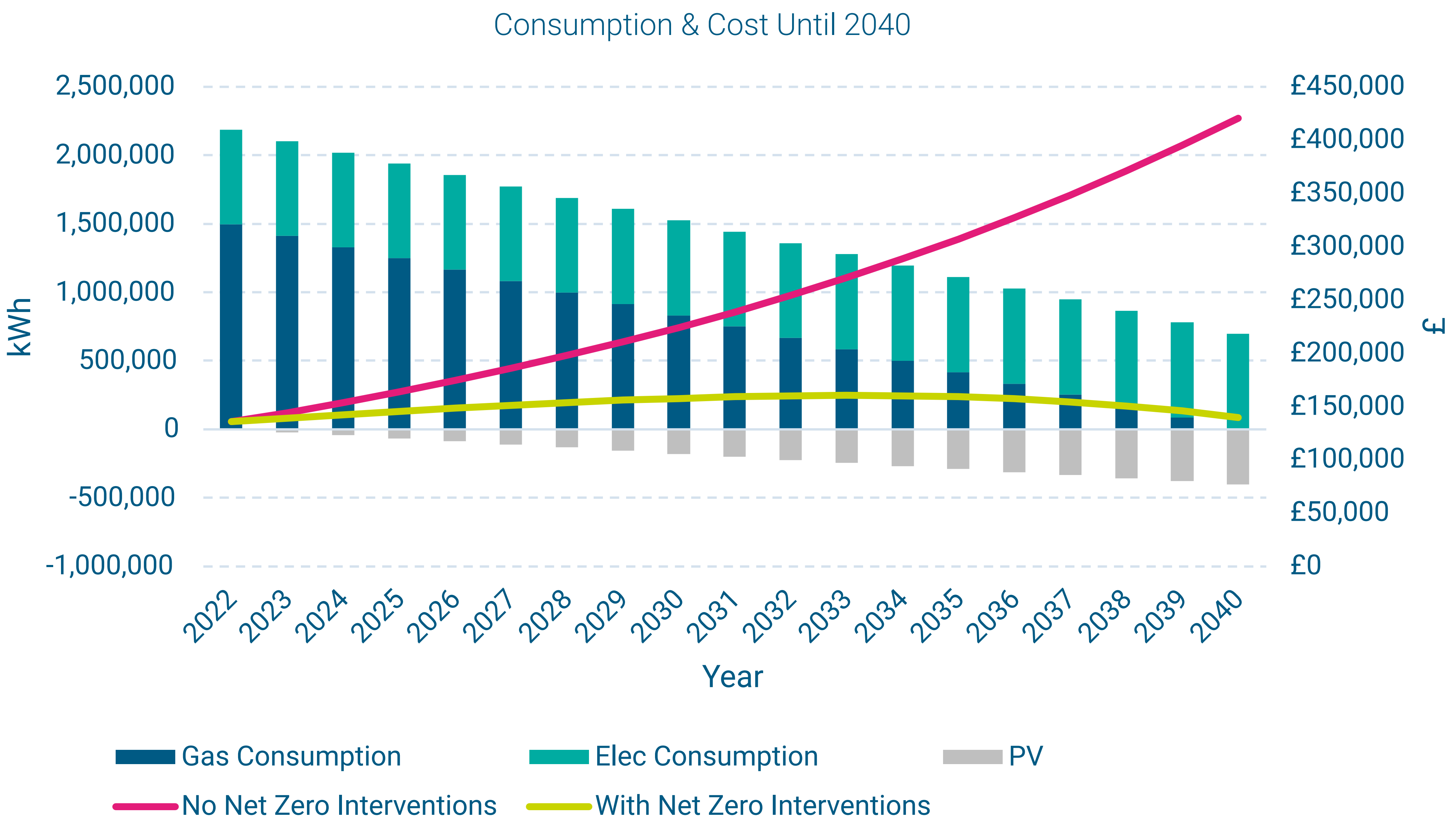
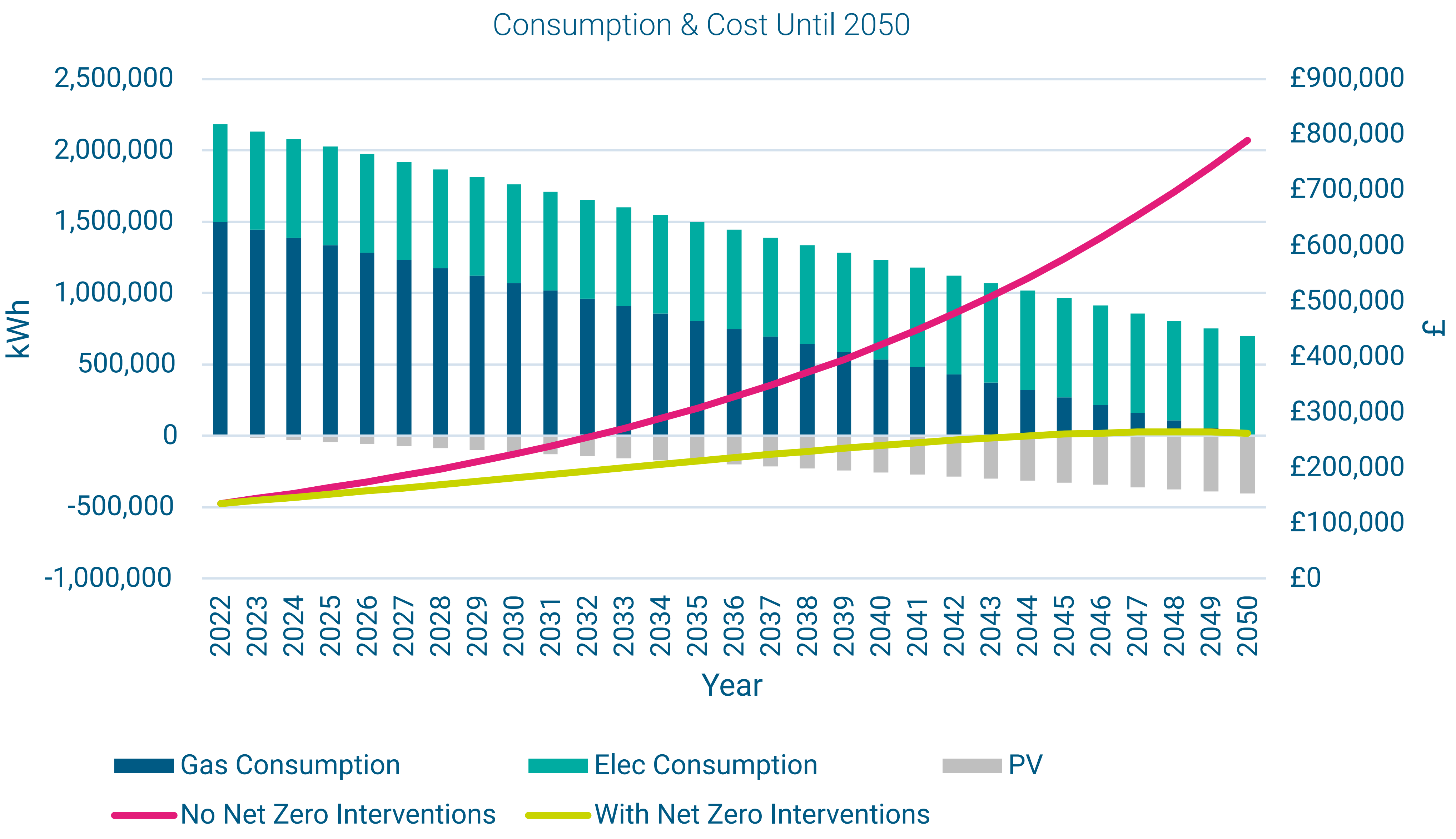


Figure 12.

Intervention's scenario Net Zero by 2050



Figures 10, 11 and 12 show how consumption and energy costs would fall if all interventions were to be installed at an even rate to 2030, 2040 and 2050 respectively. It also highlights how energy costs from 2030 to 2050 would increase when we factor forecast energy price increases based on a 6.5% pa increase.

Figure 13.

Consumption change (kWh)

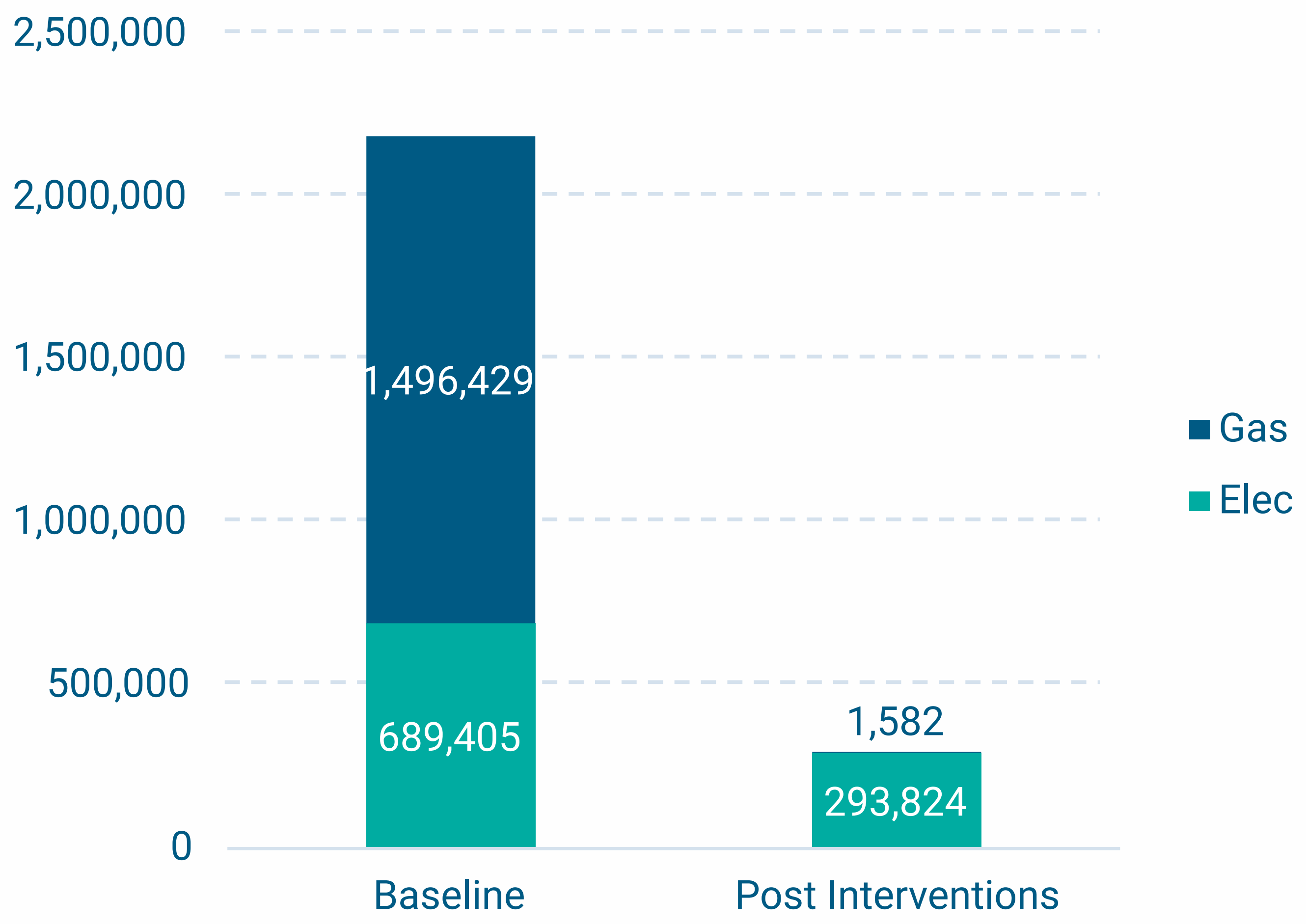


Figure 14.

Annual consumption reduction for interventions (kWh)

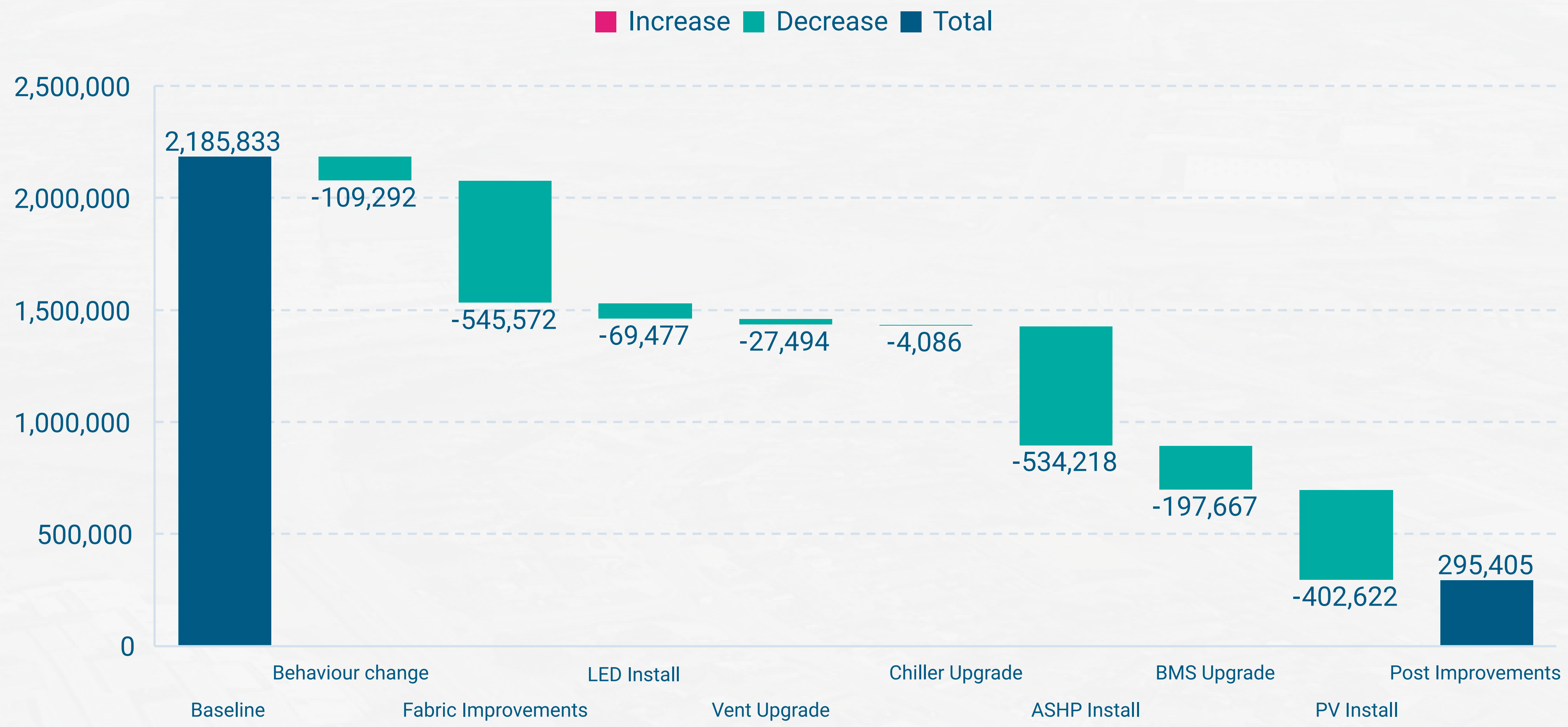


Figure 14 above shows the impact of the interventions on consumption. In total, installation of all measures would see a reduction from 2,185,833kWh to 295,405kWh. The most significant interventions are the fabric improvements, which would see consumption decrease by 545,572kWh, and move to a ASHP heating system, which would see consumption decrease by 534,218kWh. It has been assumed that energy generated from the PV will be fully utilised to provide a consumption reduction of 402,622kWh.

Figure 15.

Carbon emissions change tCO_2e, with grid decarbonisation

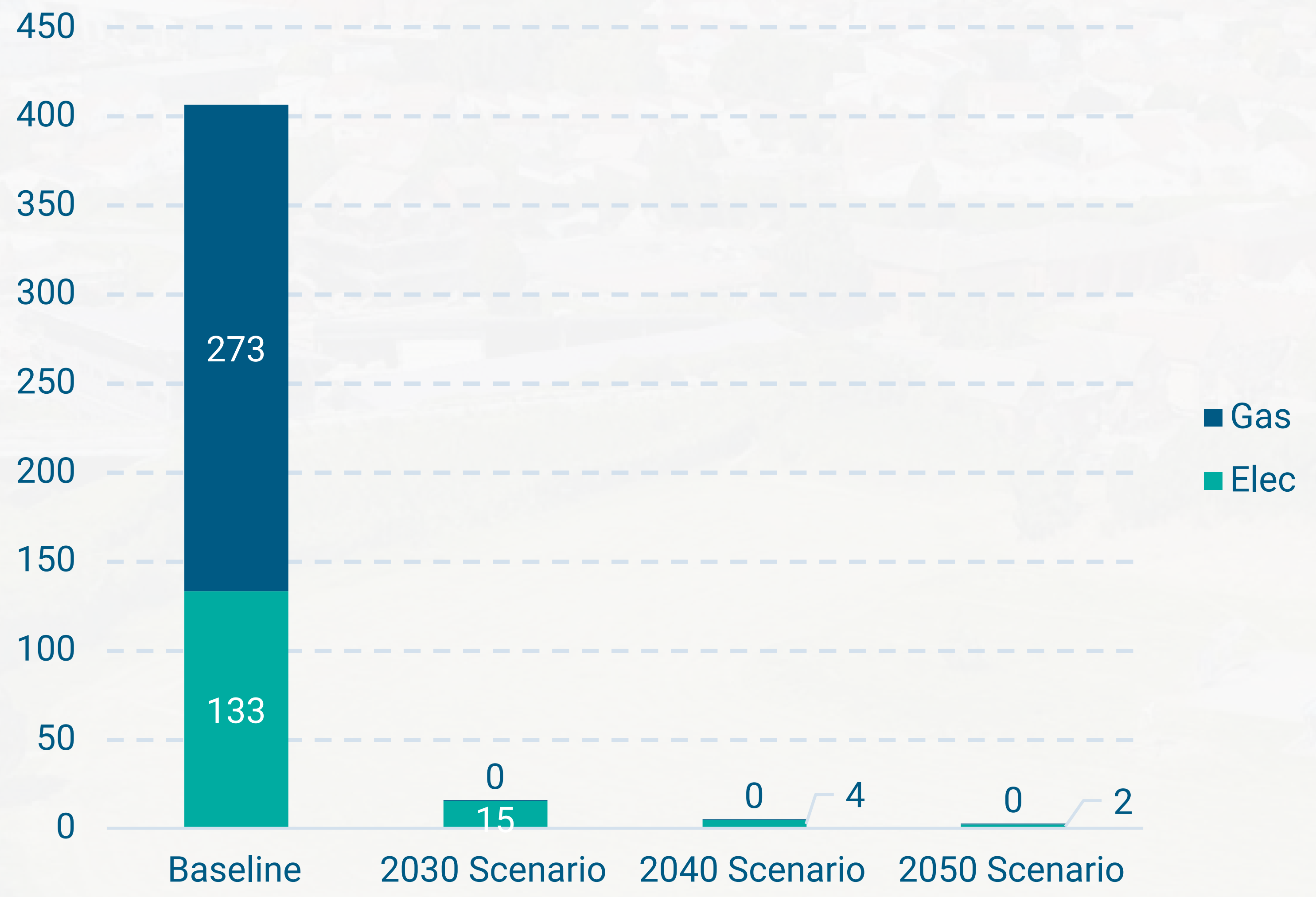


Figure 15 shows the reduction in carbon emissions after implementation of all recommended technologies. Allowing for the decarbonisation of the national grid (by using more renewable technologies to generate our electricity), as outlined in Department for Energy Security and Net Zero tables for valuation of energy in use and greenhouse gas emissions for appraisal, a reduction from 406 tCO_2 to 15 tCO_2 can be seen if all recommended measures are installed by 2030 with decarbonisation of the grid. For the 2040 and 2050 scenarios this will reduce to 4 and 2 tCO_2 respectively as, by this time, the grid will have been sufficiently decarbonised to provide a near zero carbon supply to the site.

Table11.

2030 predicted annual cost savings after implementation of the interventions

Utility	Predicted Annual Spend in 2030 After Install (annual 6.5% inflation)	Predicted Annual Spend in 2030 Without Install (annual 6.5% inflation)	Saving (£)
Electricity	£74,002	£173,632	£99,630
Gas	£53	£50,522	£50,469
		Total Saving	£150,099

Table 12.

2040 predicted annual cost savings after implementation of the interventions

Utility	Predicted Annual Spend in 2040 After Install (annual 6.5% inflation)	Predicted Annual Spend in 2040 Without Install (annual 6.5% inflation)	Saving (£)
Electricity	£138,911	£325,930	£187,019
Gas	£100	£94,837	£94,737
		Total Saving	£281,756

Table 13.

2050 predicted annual cost savings after implementation of the interventions

Utility	Predicted Annual Spend in 2050 After Install (annual 6.5% inflation)	Predicted Annual Spend in 2050 Without Install (annual 6.5% inflation)	Saving (£)
Electricity	£260,755	£611,816	£351,061
Gas	£188	£178,023	£177,834
		Total Saving	£528,895

Tables 11, 12 and 13 indicate the predicted annual cost savings after implementation of the interventions for the 2030, 2040 and 2050 scenario. When predicting the annual spend on utilities for the scenario an allowance has been made for inflationary rises in energy costs at 6.5% inflation each year. If interventions are implemented by 2030, it is predicted that RBFRS will save £150,099 on utility costs for the site in the year 2030. Savings will then increase annually as energy prices continue to inflate, with the saving being £528,895 in 2050.

Table 14.

Payback periods for each intervention

Cost of Install					
Interventions	2030	Elec kWh Saving	Gas kWh Saving	Cost of Saving (today's rates)	Payback (yrs)
Behaviour Change	£1,016	34,470	74,821	£6,772	0.2
Fabric Upgrades	£1,033,828	31,295	514,278	£15,254	68
LED Install	£163,768	69,477	0	£10,573	15
Htg & DHWS Upgrade	£1,790,053	-245,616	779,834	-£21,469	-83
PV Install	£473,674	402,622	0	£61,271	8
Controls Upgrade	£442,155	71,753	125,914	£13,488	33
Cooling Upgrade	£97,500	4,086	0	£622	157
Vent Upgrade	£591,500	27,494	0	£4,184	141
Total	£4,593,493	395,581	1,494,847	£90,694	51

Simple Payback means the number of years after which an investment has paid for itself. Table 14 shows the payback periods for each intervention using today's rates, which have been predicted through a Simple Payback calculation. This is calculated by dividing the initial cost of the retrofit by the energy savings per year. Typically, interventions with the shortest paybacks are assumed to be the most cost effective. It must be noted that with inflation of energy prices, shorter payback periods will be seen, due to an increased annual energy spend saving.

Due to increasing annual energy spend, electrification of heating and DHW do not provide a payback, and therefore have been left out of this calculation.

8. Funding

At the time of completing this plan, the Department for Energy Security and Net Zero has recently announced a further funding round, Public Sector Decarbonisation Scheme (PSDS) Phase 3C, with up to £230 million available in 2024/25.

The previous round (Phase 3b) of PSDS was administered by Salix Finance and closed in September 2022, with 3C opening October 10th. An additional year of funding has now also been granted by the Department, allowing for projects to deliver across two financial years.

A summary of the main criteria for the Phase 3c scheme is outlined below:

1. Applicants must have and be using a fossil-fuelled heating system.
2. The heating system in question should be coming to the end of its useful life.
3. Applications must include a measure to decarbonising heating with a low carbon heating source in each building included in the application. This new low carbon heating system, alongside the energy efficiency measures installed, must meet the heat demand of the original end of life fossil fuel heating system.
4. Applicants can include energy efficiency measures and other enabling works where they reduce the heat or electrical demand of the building being heated by the proposed low carbon heating measure. Energy efficiency measures funded through the PSDS will be capped at 58% of the total grant value.
5. The funding provided to save a tonne of direct carbon (tCO_2e) over the lifetime of the project must be no more than £325 (the Carbon Cost Threshold (CCT)), which is automatically calculated by the Support Tool in the Grant Application Form.
6. Phase 3c funding is primarily for capital works, however external consultancy and management fees may be included. Existing employee costs or any costs previously incurred cannot be included.
7. Reasonable enabling and ancillary works may be included in the application, provided they are directly linked to the core technologies being installed, and these will be reviewed to confirm value for money.
8. Individual applications can be to any value and there is not an upper cap. However, Applicants must demonstrate that they can deliver within the funding timescales.
9. Applicants must either own the building that the funding is being used to upgrade or have a long-term lease arrangement, where the tenancy agreement places the responsibility for operation and maintenance of the building services on the Applicant.
10. Applicants must contribute the cost for a like-for-like replacement at a minimum of 12% of the total project costs - like-for-like costs over 12% should still be contributed by the Applicant in full.
11. To sharpen the scheme's focus on heat decarbonisation, there is a maximum proportion of the grant value that can be claimed for energy efficiency. This maximum proportion will be set at 58% of total grant value for each application
12. All projects must be complete by 31 March 2026. Funding is not available for projects that cannot deliver to this timeframe, and projects which do not complete before this completion date will be liable for any project costs incurred after this date.

The funding scheme criteria focuses on 'heat decarbonisation' and future PSDS funding rounds are likely to continue in this way. The three main points to highlight from PSDS phase 3c are:

1. The existing fossil fuel heating plant must be at the end of its working life and the project application must include a low carbon replacement.
2. PSDS grant funding will only cover the costs of decarbonising the heat within a building, over and above the costs of replacing the existing fossil fuel heating system on a like for like basis.
3. The grant will only fund the project to the value of £325/tCO_2 (the Carbon Cost Threshold (CCT) or below. The CCT relates to the carbon saved over the lifetime of the technology. Any costs above this must be met by the Service.

It is also important to note that whilst a project meets the schemes' criteria, it may not be successful due to PSDS funding limits. There has been extremely high interest in the previous rounds of this scheme, and the funding limit may be achieved within days of the scheme opening for applications.

> The PSDS application for the estate has been progressed separately by Faithful+Gould and the details of this are available on request.

9. Electricity Loading Capacity

Low carbon heating solutions will result in a reduction in fossil fuel consumption and an associated increase in electrical consumption for the site. A key consideration in planning for decarbonisation is whether there is available existing electrical capacity on site to support a change from fossil fuel to electric heating or if an increase in supply capacity is required, which will mean contacting the DNO.

The power strategy firstly aims to reduce the site's electrical demand through a range of energy savings measures such as behaviour change, policy change, LED lighting upgrades, HVAC control upgrades and installation of solar PV (electrical generation to offset site electrical consumption). The existing site capacity will then need to be assessed against the final electrical requirement.

The existing site infrastructure will need to be surveyed to assess whether the site capacity will support the new electrical requirements of the site. It must be noted that, at this stage, an allowance has not been made to upgrade the existing electrical infrastructure. Early engagement with the DNO is necessary, making the DNO aware of any planned installations, and ensuring capacity upgrades are achieved within good time to ensure equipment is able to be commissioned once on site.

It should be noted that detailed storage of generated electricity has not been considered as part of this initial assessment, as current pricing indicates storage is not currently commercially viable, without external funding.

> For the purpose of this initial report, the potential for solar PV has been assessed as a high-level exercise by Faithful+Gould, identifying suitable roof areas during the site surveys and using Google Maps to check orientation and to measure available roof space. Industry rules of thumb methods have been used to calculate the potential annual output for possible PV scenarios at each site, which have been included in the calculations.

10. Supporting Information

Details of the building fabric elements for each site have been collected as part of the site audit and any potential for fabric upgrades highlighted.

Energy savings from potential fabric upgrades have been included within the modelling and calculations using a simple steady state heat loss analysis. The U-Value of a surface is the measure of how well or how badly a component (a wall, a roof, a window, the floor) transmits heat from the inside to the outside. The slower or more difficult it is for heat to transfer through the component, the lower the U-value. Typical U values for various ages of buildings are included in Table 15. Where potential improvements in U values have been highlighted by the surveyors, this has been calculated as a percentage improvement for the heat loss through that element. These percentage improvements have been applied to the "heat loss" element of the building's energy consumption. Heat losses through each element have been estimated using floor plans and Google Maps to estimate areas of walls, roofs, and glazing.

Table 15.

Historical U-values from Building Regulations

YEAR	1965	1976	1985	1990	1995	2002	2006	2010	2013
Fabric	U-Value W/m^2.K								
Walls	1.70	1.00	0.60	0.45	0.45	0.35	0.35	0.35	0.35
Floors		1.00	0.60	0.45	0.45	0.25	0.25	0.25	0.25
Pitched Roof	1.40	0.60	0.35	0.25	0.25	0.25	0.25	0.25	0.25
Flat Roof		0.60	0.35	0.25	0.25	0.16	0.25	0.25	0.25
Windows metal						2.20	2.20	2.20	
Windows all other						2.00	2.20	2.20	2.20
Window Area				0.15	0.23	0.25			
Pedestrian Door							2.20		
Entrance Doors							6.00	3.50	
Air Permeability[3]							10.00	10.00	

Notes

1. 2006 values are area-weighted average limiting standards (Part L2A). SBEM calculation required.
2. 2010 values are limiting fabric parameters (Part L2A). SBEM calculation required.
3. Air permeability units $m^3/(h.m^2)$ @ 50Pa.

11. Key challenges

There are number of barriers to a successful deployment of the HDP which are discussed below.

Table 16a. Financial barriers:

Item:	Description:
1	Availability of funding and budgets to undertake feasibility studies, bid for funding, the capital cost elements of work (including design fees). Determining that funding will be available throughout the plan.
2	Price security, risk of overspending, unforeseen costs (particularly when working in existing buildings), introducing new technologies.
3	Expenditure outside of project for consultancy, securing additional internal resources to deliver the projects.
4	Costs in this report should be regularly reviewed and increased in-line with inflation and up-to-date energy costs.
5	Potential high costs to upgrade electricity supply. A notional cost has been included for the implementation of heat pumps based on a typical ‘new build’. However, as more property owners switch to low carbon technologies increasing electricity demand, it is likely to have an impact on the existing local electricity distribution network and increase the cost of an upgraded supply. This limitation may also delay implementation of the project.
6	Increased operational costs for implementing low carbon technologies (caused by gas and electricity pricing structure and higher servicing & maintenance costs).

Table 16b. Organisational barriers:

Item:	Description:
1	Availability of resource to deliver, manage and monitor the performance of the plan.
2	Complex decision chains and routes to sign off proposals and timings to respond/bid for external funding opportunities.
3	Resistance to change when implementing behavioural change policies (top management support required).
4	Lack of understanding and awareness of the plan and the requirement to decarbonise. The expectation that heat decarbonisation projects capital investment will result in future revenue savings.
5	Training requirements to be identified and supported (time/funding).

Table 16c. Delivery barriers:

Item:	Description:
1	Time to obtain required planning permission for heat decarbonisation works will need to be secured (e.g. the citing of external air source heat pumps, windows replacement, external wall insulation).
2	Possible planning implications for listed buildings.
3	Possible delivery issues for proposed technologies (lack of available equipment due to Covid/Brexit/emerging industry/conflict).
4	Lack of contractor knowledge in delivering low carbon heating projects (emerging technology).
5	Lack of time/funding to facilitate monitoring and metering to provide ongoing feedback to secure the successful implementation of the plan. Feedback is vital to develop successful building solutions.

12. Concluding Remarks

The 11 sites outlined in this report currently have a high dependence on fossil fuels for operational energy use, enhanced by the age of some of the sites i.e. Caversham Road, and the unique energy usage with the split between appliance bays and offices on the sites. As it stands, gas accounts for 68% (1,496,429kWh) of the 2,185,833 kWh total consumption across the estate.

In line with the Government's commitment to be Net Zero by 2050, and RBFRS by 2035, the proposals within this report outline the major undertakings and projects that are required to remove fossil fuel usage across the estate by 2030, shifting to a reliance on renewable electricity, whilst also giving scenarios for 2040 and 2050. As highlighted, Net Zero will not be met by 2030, 2040 and 2050, with the remaining emissions from electrical consumption needing to be offset to reach Net Zero. The Service could consider carbon offsetting measures through off-site solar PV and large-scale wind turbines, as well as other traceable, local offsetting (known as insetting). Alternatively, moving to an 100% REGO (Renewable Energy Guarantee Origin) backed electricity contract would support zero carbon energy.

It is recommended that three key elements are implemented following this report. The Service must firstly seek to increase energy efficiency by reducing demand, before decarbonising the heat source and increasing renewable energy supply. Implementation of all measures would see a reduction in consumption to 295,405kWh, reducing carbon emissions from 406 tCO_2 to 15 tCO_2 by 2030. Fabric improvements and ASHP installation across the estate would have the highest reduction in consumption, reducing consumption by 545,572kWh and 534,218kWh respectively.

Implementing this Heat Decarbonisation Plan will have significant cost implications, estimated at £4.6 million if all measures are proceeded for the 2030 scenario. Despite this, this report has outlined the associated cost savings on utility bills that the Service would see because of increased efficiency and low carbon technologies, £90,694 if all interventions happened immediately with 2023 costs, and an increase to £150,099 per year from 2030, with an estimated quicker payback because of this.

RBFRS should now use this report to put together a priority plan outlining the next steps on their Net Zero journey, with F+G involved in PSDS progression discussions. When looking at potential for carbon reduction, Caversham Road, Slough and Whitley Wood are clearly the most favourable with the highest levels of savings available.

13. Next Steps

This initial plan (and supporting data analysis) has been produced to enable it to be updated over time, as budgets are identified, projects completed and new technological advancement in energy efficient and low carbon heating technologies identified. This plan needs to be communicated widely across the Service.

Prioritisation of sites

One outcome from this plan is that the required investment in existing buildings to decarbonise is prohibitive for the date of the preferred Net Zero scenario (£4.6mil by 2030). As explained above, in addition to the costs identified in this report, RBFRS needs to consider the required organisational, management and staff resources and associated costs.

It is important that future capital new build/major extensions/refurbishment projects and capital repair and maintenance projects are dovetailed into opportunities identified in this Heat Decarbonisation Plan and vice-versa. For example, if a window replacement project is being completed and the building has scaffolding installed, then PV could also be included.

It is highly recommended that the focus for next steps for the service are for the 'worst offenders'; Caversham Road, Slough and Whitley Wood, based on most carbon saved through intervention. In terms of the cheapest projects to undertake, Lambourne should be prioritised as well as Windsor, but there are lower carbon savings here. The lower carbon savings for Ascot, Windsor and Lambourne are due to their much smaller GIA combined with low energy consumption and intensity, thus the fossil fuels being offset start from a much lower baseline.

Table 17.

Carbon Reduction opportunities across the estate

Site	Floor Area (m^2)	Total Carbon Saved (tCO_2e)	Cost of Interventions
Ascot Fire Station	400	6	£185,843
Bracknell Fire Station	720	35	£439,138
Caversham Road Fire Station	1,191	61	£689,948
Lambourne Fire Station	183	10	£67,789
Langley Fire Station	774	43	£523,287
Maidenhead Fire Station	1,144	35	£419,535
Newbury Fire Station	832	38	£399,975
Slough Fire Station	1,103	51	£581,633
Whitley Wood Fire Station	1,864	48	£904,105
Windsor Fire Station	223	6	£115,063
Wokingham Road Fire Station	409	21	£267,177

The following actions are recommended as short-term priorities;

Undertake intrusive surveys of roofs and walls to establish current insulation levels and the suitability and economic viability for thermal improvements. Undertake detailed life cycle costing exercises for the proposed measures, to establish value for money and consider this, alongside the benefits of the improved environment, and future proofing of the asset. When upgrading flat roofs and applying external wall insulation, the high capital cost requires careful consideration and would not be undertaken purely on the benefits of a reduced heat loss/energy saving but may be considered based on extending the life of the asset.

Undertake structural surveys of roofs to establish suitability for the installation of solar PV.

Review domestic hot water use, ways to reduce demand, improve efficiency and options to replace with a low carbon alternative.

Subject to the investigations above and funding availability, the following next steps are recommended:

The cost modelling undertaken in this report identifies budget level costs for decarbonising the buildings. It is recommended that feasibility reports are undertaken, and detailed cost models developed prior to committing expenditure. Whilst this report provides a high-level overview of the site, we suggest the proposed interventions are taken to RIBA Stage 2 in order to de-risk delivery for RBFRS.

Ahead of works being undertaken and whilst feasibilities and programmes of work are put into place, it is recommended that the opportunity is undertaken to measure how energy is being consumed within the buildings. The high level calculations undertaken as part of the decarbonisation programme make industry based assumptions about where the energy is consumed within a particular type of building. However, depending on the type and amount of installed HVAC systems this can vary from building to building. Installing sub metering (permanent and/or temporary will assist with the feasibility work and will make anticipated savings and payback calculation savings far more accurate. Domestic hot water consumption is of particular importance, as this can vary dramatically between buildings, even when they are the same "classification." Logging the times and amounts of consumed hot water for centralised systems will provide the information for a more accurately sized solution which is very important when selecting heat pumps. This will save on capital expenditure as using default design methodologies, based on industry standards is known to produce vastly oversized solutions in most instances.

RBFRS's most important asset in reducing carbon is its people. Raising awareness and skills through a behaviour change programme and training should be prioritised. It is recommended that this measure is undertaken as a site wide initiative.

Replace older lighting with LED fittings to reduce electricity consumption.

Replace single glazing with high standard double glazing and implement other viable building fabric improvements, to reduce heat demand.

Heat pump technology is key to decarbonisation. Early collaboration with RBFRS's supply chain and FM contractors is recommended to understand the current position, future developments and potential risks associated with deployment.

Technology is constantly developing, and other low carbon heating options may become available during RBFRS's journey towards Net Zero Carbon. It is important that this plan is reviewed regularly and adjusted to suit more favourable technologies, as these become available. Hydrogen boilers are being trialled and the technology is being researched and developed. Should these become a viable replacement for gas boilers in the future and gas network infrastructure retained, the cost of decarbonisation could be reduced.

The "embodied" carbon impacts of upgrading the site to Net Zero Carbon has not been assessed in this report. It is recommended that an embodied carbon analysis is factored into procurement decisions.

Appendices

Appendix A – Property List and Details

Appendix B – Existing and Final Fuel Usage and Costs

Appendix C – Cost of Implementation Measures

Appendix D – Carbon Saving of Implementation Measures

Appendix E – Carbon Emissions and Reductions

Appendix F – Energy Prices

(Click title to go to relevant appendix)

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Faithful+Gould

The Hub
500 Park Avenue
Aztec West
Bristol
BS32 4RZ

Tel: **+44 (0)1454 663000**
david.gilbey@fgould.com

Appendix A. Property List

Site	Postcode	Floor Area (m^2)	Lead Heat Source	Lead Heat Source
Ascot Fire Station	SL5 7HF	400	Gas	Gas
Bracknell Fire Station	RG12 7AN	720	Gas	Gas
Caversham Road Fire Station	RG1 8AD	1,191	Gas	Gas
Lambourne Fire Station	RG17 8YT	183	Gas	Gas
Langley Fire Station	SL3 7HS	774	Gas	Gas
Maidenhead Fire Station	SL6 8PG	1,144	Gas	Gas
Newbury Fire Station	RG14 1LD	832	Gas	Gas
Slough Fire Station	SL1 2XA	1,103	Gas	Gas
Whitley Wood Fire Station	RG2 8FT	1,864	Gas	Gas
Windsor Fire Station	SL4 4LS	223	Gas	Gas
Wokingham Road Fire Station	RG6 1LT	409	Gas	Gas

Appendix B. Existing and Final Fuel Use and Cost (Cost using todays energy rates)

Site	Total INITIAL Fossil Fuel consumption (kWh)	INITIAL Cost Of Fossil Fuel (£)	FINAL Annual Fossil Fuel Consumption (kWh)	FINAL Cost of Fossil Fuel (£)	INITIAL Annual Electricity Consumption (kWh)	INITIAL Cost Of Electricity (£)	FINAL Annual Electricity Consumption (kWh)	FINAL Cost of Electricity (£)
RBFRS estate	1,496,429	£30,527	1,582	£32	689,405	£104,914	295,405	£44,714

Appendix C. Cost of Implementation Measures

Site Name	Behaviour Change	Fabric Upgrades	LED Install	Htg & DHW Install	PV In-stall	BMS/Controls Upgrade	Vent Upgrade	Cooling Upgrade	Total
Ascot Fire Station	£23	£14,700	£0	£89,520	£12,600	£24,000	£45,000	£0	£185,843
Bracknell Fire Station	£79	£165,319	£10,080	£145,660	£50,000	£18,000	£50,000	£0	£439,138
Caversham Road Fire Station	£128	£237,470	£20,040	£213,520	£42,110	£61,680	£115,000	£0	£689,948
Lambourne Fire Station	£17	£10,812	£5,856	£38,100	£6,930	£4,575	£1,500	£0	£67,789
Langley Fire Station	£82	£137,613	£26,316	£187,836	£80,000	£46,440	£45,000	£0	£523,287
Maidenhead Fire Station	£125	£68,690	£6,864	£175,256	£80,000	£28,600	£45,000	£15,000	£419,535
Newbury Fire Station	£91	£31,163	£24,760	£179,040	£40,000	£49,920	£60,000	£15,000	£399,975
Slough Fire Station	£120	£118,614	£36,896	£239,790	£67,034	£59,180	£60,000	£0	£581,633
Whitley Wood Fire Station	£278	£175,430	£24,108	£379,450	£63,000	£111,840	£105,000	£45,000	£904,105
Windsor Fire Station	£21	£0	£3,122	£44,040	£12,000	£13,380	£20,000	£22,500	£115,063
Wokingham Road Fire Station	£53	£74,018	£5,726	£97,840	£20,000	£24,540	£45,000	£0	£267,177
Total	£1,016	£1,033,828	£163,768	£1,790,053	£473,674	£442,155	£591,500	£97,500	£4,593,493

Appendix D. Carbon Saving of Implementation Measures

Interventions	tCO_2e Saved (today's factors)
Behaviour Change	20.32
Fabric Upgrades	99.93
LED Install	13.44
Htg & DHW Upgrade	94.86
PV Install	77.86
BMS Upgrade	36.86
Chiller Upgrade	0.79
Vent Upgrade	5.32
Total	349.37

Appendix E. Carbon Emission and Reduction – (Using 2030 Conversion factors that included estimated grid decarbonisation)

Site	Initial Carbon emissions from fossil fuel	Final Carbon emissions from fossil fuel (tCO_2e)	Initial Carbon emissions from electricity (tCO_2e)	Final Carbon emissions from electricity (tCO_2e)	Total Carbon Saved (tCO_2e)
Ascot Fire Station	3	0	3	1	6
Bracknell Fire Station	26	0	10	1	35
Caversham Road Fire Station	57	0.1	14	2	68
Lambourne Fire Station	10	0	1	0	11
Langley Fire Station	34	0	9	0	43
Maidenhead Fire Station	25	0	18	2	41
Newbury Fire Station	33	0	11	2	42
Slough Fire Station	38	0.2	15	0	52
Whitley Wood Fire Station	26	0	43	6	64
Windsor Fire Station	3	0	3	0	6
Wokingham Road Fire Station	18	0	6	1	24
Total	273	0.3	133	15	391

Appendix F. Energy Prices

Fuel Type	p/kWh
Electricity	15.2 April - Sept, 25 Oct - March
Gas	2.0 (8.5 pre levy)