Document Title	**Building Decarbonisation Study**
Site	The Spotlight
Client	Borough of Broxbourne Council
Issue	1.0
Date	21/12/2023

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Revision	Date	Details of changes	Author	Approver
0.1	01/12/2023	First draft	HLK	JG
0.2	19/12/2023	Second draft	HLK	
0.3	21/12/2023	Third draft	HLK	AK
1.0	21/12/2023	First issue	HLK	

Glossary

Abbreviation	Meaning
A/C	Air Conditioning
AHU	Air Handling Unit
ASHP	Air Source Heat Pump
AWHP	Air-Water Heat Pump
BMS	Building Management System
CAPEX	Capital Expenditure
CDD	Cooling Degree Day
CHW	Chilled Water
DHW	Domestic Hot Water
ECM	Energy Conservation Measure
EnPI	Energy Performance Indicator
FCU	Fan Coil Unit
GSHP	Ground Source Heat Pump
HH	Half Hourly
HDD	Heating Degree Day
LCCA	Life Cycle Cost Analysis
LED	Light Emitting Diode
LTHW	Low Temperature Hot Water
M&E	Mechanical & Electrical
OPEX	Operational Expenditure
PIR	Passive Infrared
PV	Photovoltaic
VSD	Variable Speed Drive

Executive Summary

Figure 1: Site Photo

This report contains the results of a decarbonisation study for the Spotlight, which has been commissioned by Borough of Broxbourne Council. It documents the findings of a site audit undertaken by Concept Energy Solutions and contains details of the building fabric, building services equipment and plant as of November 2023.

Space heating and DHW to the site are provided by new gas boilers and a gas fired water heater respectively. Lighting is from LED fittings.

The gas and electricity consumption of the site in the 2022/23 financial year were 435,005 kWh and 191,118 kWh respectively, with associated total emissions of 116.4 tCO_2e.

Information collected during the site audit was used to create a bulk energy simulation model of the building using the industry standard "RETScreen" software package. output from the model has been compared with historic consumption data, to check its accuracy.

A number of different decarbonisation measures have then been applied to the model to assess likely carbon reduction impact. We have applied a carbon reduction hierarchy (see section 7.1) to the measures considered in this report. This hierarchy applies a zero cost and some costed efficiency measures before the use of low carbon heating technologies and on-site generation.

The zero cost measure identified is to adjust the BMS occupied space temperature setpoint for the theatre hall AHU, which appears to be too high. However, it is noted from the BMS head end that the AHU control is deemed to be unfit for purpose and that sensors may give false readings.

We have identified a number of costed energy efficiency and low carbon heating measures, which we believe are technically feasible for the site. We have estimated the costs and savings for these projects and calculated the Net Present Value for each investment, as shown in Table 1.

The low carbon heating options include air source heat pumps (ASHP), direct electric heating and biomass boiler. However, it is noted that the existing gas boilers are very new and with an expected life of 20 years it is unlikely that these will be replaced for some time.

The ASHP option has the highest annual carbon saving of ca. 43.7 tCO_2e, but a lower Net Present Value (NPV) than the direct electric heating option due to higher capital and running costs.

Measure	Persistence Factor	Guideline Cost, £	NPV, £	Annual Carbon Saving, tCO_2e
Energy Efficiency				
Plant room valve insulation	23	2,000	14,087	0.9
Replacement of AHU	24	181,000	317,962	7.5
Variable speed pumping	10	10,000	11,330	0.9
Replacement of gas catering equipment	10	4,000	-12,761	1.1
Wall insulation	30	39,000	172,804	8.0
Low Carbon Heating				
Air to water heat pump	20	1,477,000	-1,506,055	43.7
Air to air heat pump	20	1,417,000	-1,446,055	43.7
Direct electric heating	10	273,000	-1,155,894	8.6
Biomass boiler	20	403,000	-1,114,694	33.6
Solar thermal (with ASHPs)	25	44,000	9,916	0.8
Solar thermal (with direct electric heating or biomass boiler)	25	44,000	117,748	2.3
Renewable Energy Generation				
12kWp solar PV system	23	25,000	129,133	2.5

Table 1: Summary of NPV of saving measures

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1 Introduction

1.1 Background

Broxbourne Borough Council has commissioned Concept to provide building decarbonisation study at the Spotlight. The primary purpose of these reports is to identify suitable heating decarbonisation options that could form the basis of an application for funding under the Public Sector Decarbonisation Scheme (PSDS). This scheme requires a 'whole building approach' to heat decarbonisation and in addition to low carbon heating will fund eligible energy efficiency and on-site renewable energy measures.

This is the decarbonisation study report for the Spotlight, completed following surveys of the site in June 2019 and November 2023.

1.2 Site Details

The site is located in High Street, Hoddesdon, EN11 8BE and comprises of a two-storey building with one small basement corridor. It consists of a central theatre hall, public bar, kitchen, entrance foyer, several small offices and a functions room. The building was constructed in the mid-late 70s.

The total useful floor area is ca. 2,550m^2 according to the most recent Display Energy Certificate, which has a rating of B.

Occupancy hours for the site vary depending on the time of year and the event schedule. The core opening hours are Monday to Friday from 07:00hrs to 17:30hrs. Additionally, the site opens in the evenings and on weekends for events, with extended hours until midnight. The occupancy ranges from ca. 20 to 550, depending on the nature of the events.

1.3 Timing of Audit

An inspection of the building was originally carried out by Jamie Green of Concept Energy Solutions on 18th June 2019, focusing on heating options. The site was re-surveyed on the 15th November 2023 to capture any changes since the original survey.

2 Objectives Priorities and Methodologies

2.1 Survey Objectives

As our 2019 survey had captured the expected measures, the main purpose of this report is to:

- update current building services equipment and operation descriptions;
- check validity of previously identified energy savings opportunities, including capital works and operational changes;
- identify improvements that can reasonably be made to building fabric;
- check validity of previously identified options for low carbon heating and on-site renewable energy generation;
- model the savings from identified options sequentially, accounting for any interdependency and present in terms of kWh, CO_2 equivalent and cost;
- recommend potential decarbonisation pathways, and
- quantify any residual emissions after implementation of all recommended measures.

2.2 Survey Methodology

A site survey was conducted in 2019 in which all major energy consuming plant was identified and non-intrusively inspected. Details of changes to building services were collected on site on 15th November 2023.

Baseline energy consumption was calculated for electricity and gas based on available consumption data provided by the client, in order to quantify Scope 1 and Scope 2 emissions. Where consumption data has not been provided, baseline emissions could not be confirmed.

The information gathered has been used to produce a Bulk Energy Model of each of the buildings using industry standard software package, RETScreen. Where actual heating fuel consumption data has been provided, the model was compared with the calculated baseline consumption.

A number of energy saving opportunities were identified during the site visit and savings from these have been estimated using a combination of RETScreen modelling and bespoke calculations. Measures have been grouped in under the following energy hierarchy:

1. Low and zero cost behavioural or control measures
2. Energy efficiency measures
3. Low carbon heating options
4. On-site renewable energy generation

The modelled savings were used to produce a number of decarbonisation pathways.

3 Site Energy Consumption & Cost

3.1 Summary

The table below shows the total site energy consumption for the financial year 2022/23 from April 2022 to March 2023 and is taken from actual site consumption provided by the Council.

Electricity cost data is based on actual invoiced costs, inclusive of CCL and exclusive of VAT.

Gas cost data is based on average rates inferred from total annual charges. No breakdown of these charges has been provided and the annual figures are assumed to be inclusive of CCL and standing charges but exclusive of VAT.

Utility	Energy		Cost		CO_2e emissions	
	kWh	%	£	%	Tonnes	%
Electricity	191,118	30.5	70,562	58.2	37.0	31.8
Gas	435,005	69.5	50,625	41.8	79.4	68.2
Total	**626,123**	**100.0**	**121,187**	**100.0**	**116.4**	**100.0**

Table 2: Energy Consumption during financial year 2022/23

CO_2e emissions have been calculated from conversion factors of 0.19338 kg CO_2e per kWh for electricity and 0.18254 kg CO_2e per kWh for gas, which were obtained from the 2022 government DESNZ (formally BEIS) dataset of conversion factors for greenhouse gas reporting.[1]

3.2 Electricity supply

3.2.1 Supply description and metering

The site has a single three phase electricity supply

One revenue meter record half hourly (HH) site consumption.

Utility	MPAN
Electricity	1014572931795

Table 3: Electricity meter details

The supplier has not been confirmed but charging detail has been provided as of June 2023, which confirms the following average rates:

Average rate (p/kWh)	CCL (p/kWh)
43.55	0.775

*Applied to day and night energy

Table 4: Electricity cost details

[1] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022

3.2.2 Monthly consumption profile

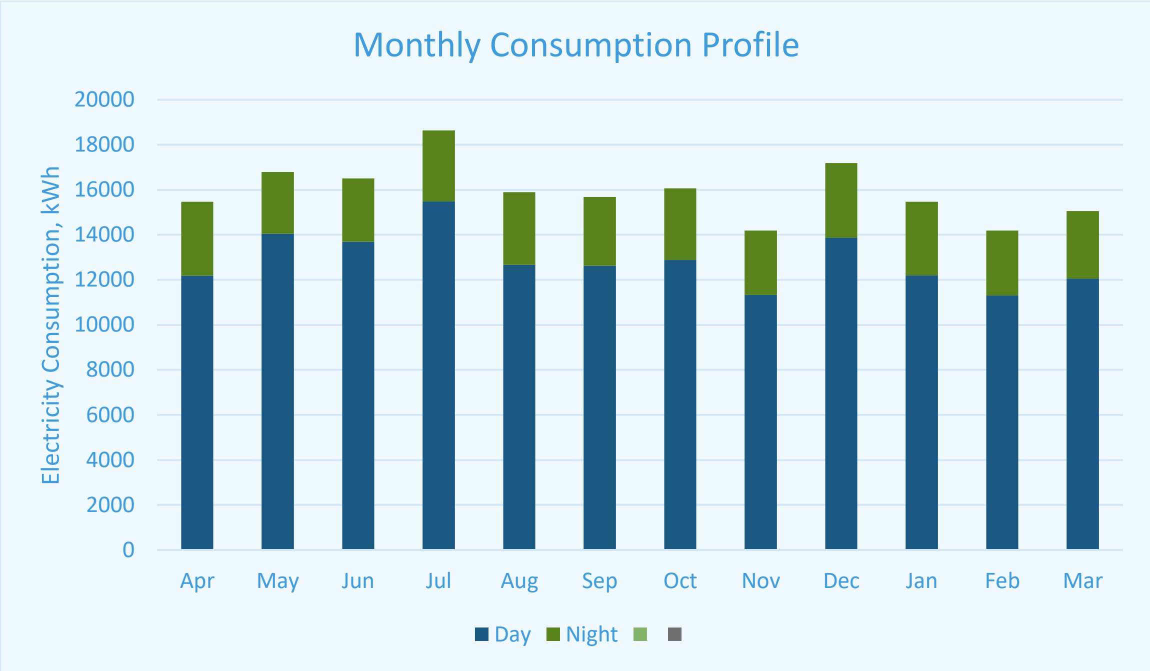

Figure 2: Monthly Electricity Consumption

The monthly profile shows some variability throughout the year, but it is noted that the consumption is subject to the number of events, such as musicals and drama performances.

In the graph above, night is defined as occurring between 00:00hrs and 07:00hrs. Consumption at night was consistently around 19% of the monthly consumption throughout the year.

3.2.3 Weekly consumption profile

Where half-hourly data is available this has been analysed to identify usage patterns and potential energy wastage. Analysis has been undertaken for a typical winter and summer.

Data for the week commencing 23rd January 2023 has been take as representative of a typical winter week. Likewise, data covering the week commencing 8th August 2022 represents a typical summer week.

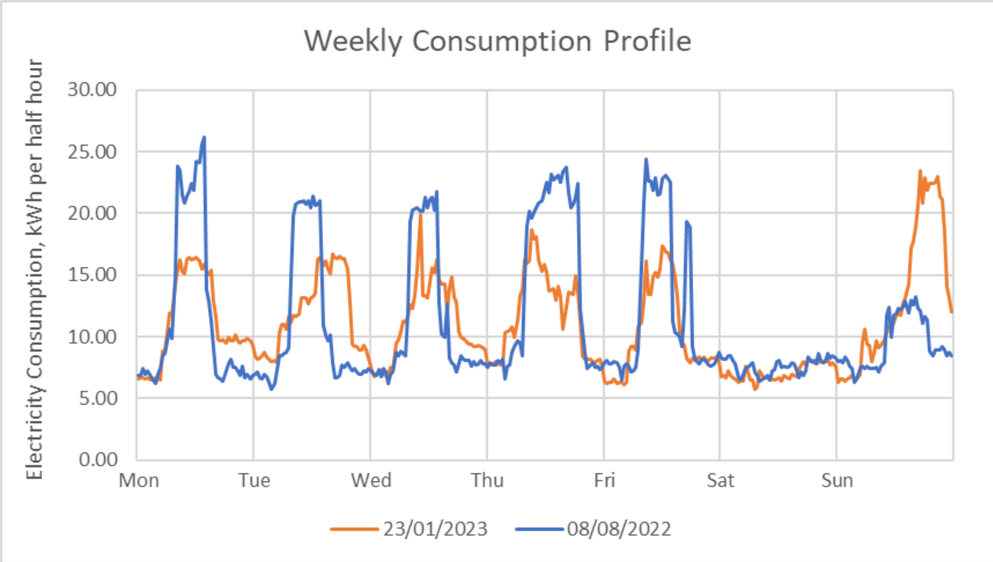

Figure 3: Summer / Winter typical week analysis

The baseload appears to be ca. 14kW in both summer and winter. The slightly higher baseload on the Winter Monday in the graph may be due to some equipment being left on overnight and/or frost protection on pumps. The profile shows highly variable daytime load in both weeks which may be due to variable usage of the building.

The peak demand is ca. 46kW in the winter week and ca. 52kW in the summer week. The peak load in the winter week is recorded on Sunday which is likely due to an evening performance or event.

Additionally, the Christmas week of 2022, commencing 26th December has been analysed and is shown on Figure 4. A consistent pattern is observed throughout the week, with additional afternoon loads noted from Thursday to Saturday.. The consumption during the Christmas week exceeds that of the subsequent weeks which is likely to be due to the Christmas Pantomine performances which ran until 31st December 2022.

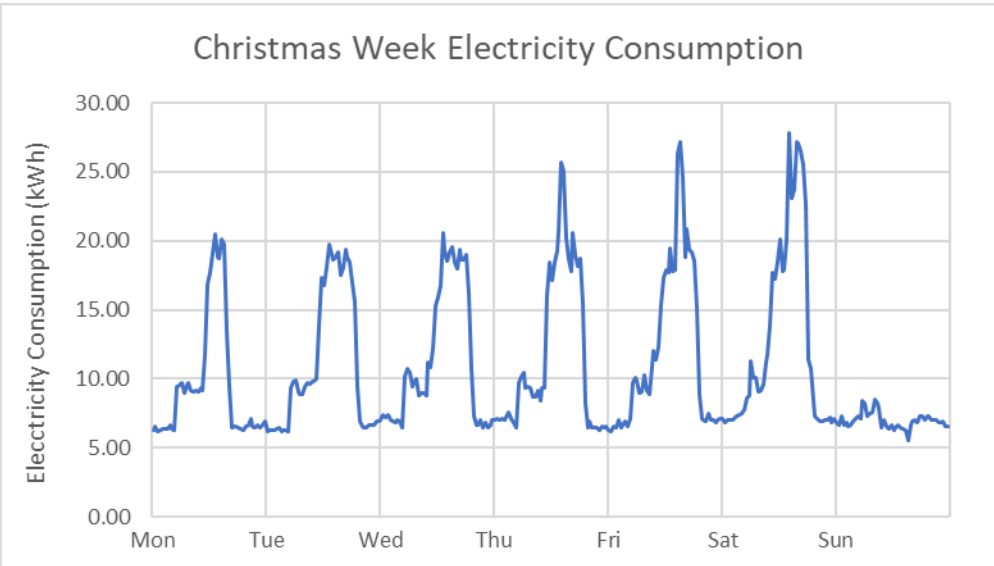

Figure 4: Christmas week electrical consumption profile analysis

3.3 Gas supply

3.3.1 Supply description and metering

The site has a single MPRN and fiscal meter for gas supplies. Details of the main revenue meter are as follows.

Utility	MPRN	Meter Serial Number
Gas	18481909	M100A0043513A6

Table 5: Gas meter details

The current gas supplier has not been confirmed but based on total charges provided for the financial year 2022/23, we have inferred the following average rates, which are assumed to include standing charges and Climate Change Levy.

Unit rate p/kWh
11.6

Table 6: Gas cost details

3.3.2 Monthly consumption profile

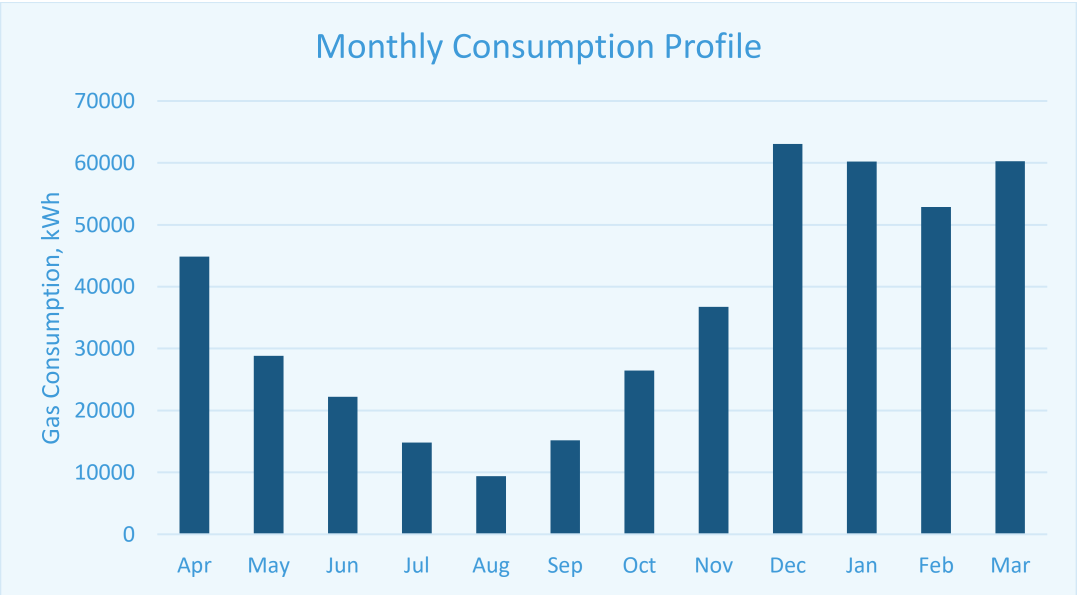

Figure 5: Monthly Gas Consumption

The profile displays an expected seasonal trend for the Spotlight. Gas is used by boilers and water heater to provided space heating and DHW to the site.

3.3.3 Half Hourly (HH) Data

There is no half hourly gas consumption data available for this site.

3.3.4 Gas regression analysis

Concept have access to total historical gas consumption data for a contiguous period of 12 months, with which we have undertaken a regression analysis, whereby gas consumption is compared with Heating Degree Days (HDD).

HDD are a measure of both the severity and duration of cold periods of weather. One degree day represents a temperature of 1°C below the base temperature, sustained for a period of 24 hours. An HDD data set for Stansted Airport and a default base temperature of 15.5°C has been selected. It is noted that the actual building base temperatures may vary.

Plotting the gas consumption directly against the heating degree days gives an indication of the dependence of gas use on weather. The slope of the regression line gives an indication of impact of weather on the rate of gas use. The spread of the points about the line (and the Coefficient of Determination, known as the R^2 value) give an indication of dependence of gas use on weather. An R^2 value of one would indicate that the gas use is strongly dependent on the number of heating degree days, a value of zero would suggest that the two variables are independent. This analysis is presented in Figure 6.

The R^2 value of approximately 0.95 indicates a strong relationship with degree days with no significant outliers. This is significantly better than the regression analysis undertaken in 2019 and suggests that the controls may have been repaired or upgraded when the boiler plant was replaced, and that the gas consumption is now fully dependent on the prevailing weather conditions.

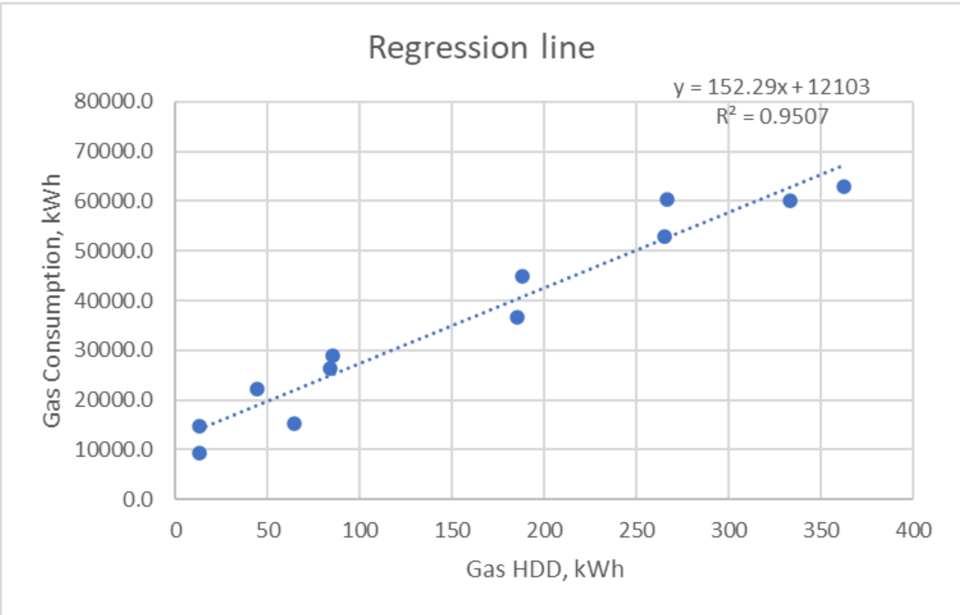

Figure 6: Gas regression analysis in 2022/23

3.4 Energy consumption comparison with benchmark

The purpose of benchmarking is to sense-check the quality of the energy data provided for the audit reference year in terms of energy performance indicator. Benchmarking also gives an indication of the performance of the building compared with other similar properties.

This energy audit uses a benchmark based on the specific energy consumption per square metre (m^2) of the total internal floor area of the site.

The benchmarks selected for this site are taken from CIBSE TM46 benchmarks for 'Entertainment halls' and have been normalised for occupancy hours and heating degree days in accordance with TM46 guidance. Actual occupancy hours are ca. 2,886 hours per annum, compared with the benchmark of 2,856 hours per annum. Heating degree days in the consumption year assessed were 1,903, compared with the benchmark reference value of 1,709.

ELECTRICAL BENCHMARK PERFORMANCE		
Benchmark (kWh/m^2)	**Actual Consumption per floor area (kWh/m^2)**	**Comments**
150.6	181.7	Electricity consumption is higher than the benchmark value. Lighting is mostly from LED fittings, however there is a large AHU serving the main hall which uses electricity. It is also noted that consumption is highly subject to the number of events, performances and occupants.

Table 7: Electrical benchmark performance

GAS BENCHMARK PERFORMANCE		
Benchmark (kWh/m^2)	**Actual Consumption per floor area (kWh/m^2)**	**Comments**
447.1	264.3	Fossil fuel consumption is lower than the benchmark. It is noted that the boilers have recently been upgraded to new condensing units. Again, site heating and DHW use is highly subject to the number of events and occupants.

Table 8: Fossil fuel benchmark performance

4 Building Fabric

4.1 Overview

The building was constructed in the mid to late 70s. It has uninsulated cavity walls and a mix of pitched roof and flat roofs.

The observed windows are double glazed throughout.

The floors are assumed to comprise uninsulated concrete slabs.

4.2 Walls

The external walls of the Spotlight are mostly brick and block cavity walls. The cavity is not insulated.

Building regulations at the time of construction required a maximum wall U-value of 1.7 $W/m^2.K$, Based on the BR443 U-value calculation methodology, we have assumed the wall construction consists of 105mm of brick, 50mm of cavity, 100mm of dense concrete block and 13mm of plaster, and calculated a U-value of 1.55 $W/m^2.K$ for these walls.

Figure 7: External wall

4.3 Floor

The floor is believed to be an uninsulated concrete slab.

Based on the exposed perimeter and ground floor area, we have calculated an average U-value of 0.26 W/m^2K.

4.4 Roof

The roof of theatre hall is pitched roof while the other roofs are flat roofs.

Based on the construction year, we have assumed an average U-value of 1.42 W/m^{2}K according to the maximum U-value of roofs suggested in Building Regulations 1972.

4.5 Glazing

The double glazing observed at the site was found to comprise 6mm glass with ca. 12mm spacers. The windows are believed to be a mix of metal and uPVC frames.

Based on the BR443 calculation methodology we have estimated a U-value of 2.9 W/m^2.K for this glazing.

Figure 8: Typical window

5 Building services

5.1 Overview

Space heating is provided by gas fired boilers, via radiators and an AHU.

DHW is provided by a gas fired water heater.

The main hall is mechanically ventilated by an AHU installed in the main roof void.

Lighting is mostly provided by LED fittings.

5.2 Space heating

The site has 5no. new Potterton 'Sirius Three WH 110' gas fired boilers located in the plant room on the ground floor level. Each boiler has a nominal heat output of 110kW. The boilers are wall mounted, condensing models and manufactured in ca. 2021.

The boiler plant supplies 3no. secondary circuits via a Plate Heat Exchanger (PHE). There are 2no. Constant Temperature (CT) circuits for AHU and fan convector units and one Variable Temperature (VT) circuit for radiators.

Pump ratings within the plant room are as follows:

- Hall CT circuit pumps – 2no. 1.1kW motors, twin head, fixed speed controlled
- Second CT circuit pumps – 2no. 769W motors, twin head, fixed speed controlled
- VT circuit pump – 1no. 356W motor, variable speed controlled
- DHW pump – 1no. 78W motor, fixed speed controlled

Plant room pipework insulation is generally in good condition, while none of the valves and flanges have insulation jackets installed.

Figure 9: Gas fired boilers

PRIMARY HEAT SOURCE					
Type	**Make**	**Model**	**Rated Input**	**Rated Thermal Output**	**Comments**
5no. gas boilers	Potterton	Sirius Three WH 110	116.4kW	110.2kW	Wall mounted, condensing model Manufactured in ca. 2021

Table 9: Primary Boiler Plant

The theatre hall is heated by the main AHU equipped with a LTHW coil and fan convector units.

Most of the offices, toilets, function room and parts of the public bar are heated by radiators with Thermostatic Radiator Valves (TRV).

Parts of the public bar and main hall are also heated by several fan convector units fed by the main LTHW system.

The entrance foyer has over-door heaters connected to the main LTHW system.

Figure 10: Typical radiator

5.3 Domestic Hot Water

DHW is provided by new gas fired calorifier with a storage capacity of 360 litres. The rated output of the calorifier is 71kW. The calorifier was manufactured in 2021.

Figure 11: Gas fired calorifier

DOMESTIC HOT WATER					
Type	**Make**	**Model**	**Rated Input**	**Rated Thermal Output**	**Comments**
1no. gas fired water heater	Andrews	ECOflo EC380/1220	73.2kW	71kW	359.6 litres water storage capacity

Table 10: Domestic Hot Water Plant

5.4 Ventilation

The main hall is mechanically ventilated by an AHU installed in the main roof void. The AHU is equipped with an LTHW coil for space heating and a direct expansion (DX) coil for space cooling. The supply and extract fans belt-driven and operate at fixed speed. The AHU is ca. 37 years old which is considered beyond end-of-life.

There is also a Nuaire ESBHS2H-E extract unit serving the Kitchen, the age of which is not known.

AIR HANDLING UNITS					
REFERENCE	**Type**	**Nominal Power (kW)**	**Serving**	**Control**	**Comments**
AHU	Supply	14.9	Main hall	Fixed Speed	
	Extract	6.72			
Kitchen extract	Extract	1.6	Kitchen	Fixed Speed	

Table 11: Air Handling and Ventilation plant

5.5 Space Cooling

The main AHU is equipped with a DX coil for space cooling. The heat pump outdoor unit was not accessed to obtain the details during the survey.

SPACE COOLING					
REFERENCE	**Type**	**Nominal Electrical Power (kW)**	**Make**	**Model**	**Serving**
Heat pump	Outdoor Unit	Unknown	Unknown	Unknown	Main AHU DX coil

Table 12: Cooling plant

5.6 Lighting

5.6.1 Internal Lighting

Internal lighting for this site is mostly provided by LED fittings, except for house lights. Lighting in toilets is controlled by passive infrared (PIR) sensors, while in other areas, it is controlled manually.

Figure 12: Typical LED panels

5.6.2 External Lighting

External lighting is mostly building-mounted fluorescent wall pack fittings. While numbers of fittings were not counted, these appeared to be controlled by photocells, which will minimise lighting hours.

Figure 13: Building mounted fitting

5.7 Building Management System

The site has a Trend BMS, which is networked and remotely accessible. The BMS graphics were viewed from a head end computer located off site (at Laura Trott Leisure Centre).

The head end software contains graphics for most of the HVAC plant within the building, detailing operating schedules and setpoints, which were reviewed by Concept.

Figure 14: BMS interface

The heating and ventilation plant are operated with a standard daytime schedule and additional time based on events. The observed BMS standard daytime schedules during the site visit are as follows:

Plant	BMS schedule
Main heating	08:00hrs to 17:00hrs Monday to Friday Off Saturday and Sunday
AHU	08:00hrs to 17:00hrs Monday to Friday Off Saturday and Sunday

Table 13: Summary of BMS schedules

BMS setpoints observed in the main BMS are as follows:

Setpoint	Setting
Boiler water temperature setpoint	70°C
VT circuit flow temperature setpoint	57.5°C
AHU area occupied temperature setpoint	26°C
AHU area unoccupied temperature setpoint	10°C
AHU minimum fresh air damper	10%

Table 14: Summary of BMS setpoints

The DHW temperature setpoint is controlled by the water heater built-in controller, which is set to 65°C.

5.8 Small Power

Small power loads are relatively limited and include a small number of computers in the office, microwave, kettle and fridge.

5.9 Catering

There is a kitchen and a bar at the site. The catering appliances include:

- Commercial dishwasher
- Walk-in chiller unit
- Some commercial fridge and freezer units
- Commercial gas hob

Figure 15: Commercial dishwasher

5.10 IT loads

There were no observed significant IT loads at the Spotlight.

5.11 On-site generation and renewable energy sources

There is no on-site generation and renewable energy sources at the Spotlight.

6 Energy Modelling and Usage analysis

We have used RETScreen software to create a 'bulk' energy model of the building.

RETScreen is a software package developed by the Canadian government for project feasibility analysis of energy efficiency and renewable energy technologies. The software calculates annual average energy flows for a range of HVAC systems and specific load types.

A baseline model has been created using drawings and site details collected during our site visits. This provides a reasonable estimate of the building operation from which to calculate potential savings from a range of decarbonisation measures.

6.1 Details of assumptions used in the base model

All building fabric elements have been modelled as per Section 4 of this report.

6.1.1 Air permeability

Air permeability testing records have not been provided or located on site and air permeability has therefore been estimated within RETScreen for each treated space based on building age.

Based on the age of the building, we have applied a default 'medium' setting for walls and windows for air permeability within the software. This gives a result of 1.12 $m^3/h/m^2$. This equates to approximately 14.6$m^3/h/m^2$ at the standard test pressure of 50Pa, which is appropriate for a building of this age.

The unknown air permeability is a large source of uncertainty within the energy model as it is a significant constituent of the space heating load. In order to improve the accuracy of the energy model, air permeability testing could be undertaken to assess any degradation in performance of elements such as door and window seals; however, it is understood that this may be impractical due to the building use.

It should be noted that air permeability refers to uncontrolled and undesired infiltration. Mechanical ventilation is modelled separately.

6.1.2 Building services systems

Building services systems have been modelled as per the plant descriptions given in Section 5 of this report. We have assumed that a flow rate of specific fan power of 2W per L/s based on CIBSE Guide B 2002.

6.1.3 Weather data

The RETScreen model uses inbuilt climate database files selected by the user based on the site location. We have selected the nearest weather file location, in Stansted Airport, which incorporates a mix of ground data and NASA global satellite climate data.

6.1.4 Energy cost

We have assumed a rate of 11.6p/kWh for gas and 44.3p/kWh for electricity based on the current unit rates with CCL, and assumed a rate of wood pellets of £350/tonne (7.3p/kWh).

6.2 Modelled Baseline Carbon Footprint

Concept have used the output from the RETScreen energy model (electricity and gas import) to derive the baseline carbon footprint of the site.

The footprint is based on the 2022 Greenhouse Gas reporting emissions factors as published by HM Government [2].

Emissions Source	Emissions Scope	Baseline Consumption (kWh)	Emissions Factor (CO_2e/kWh)	Baseline Emissions (tCO_2e)
Grid Gas	Scope 1	435,133	0.18254	79.4
Grid Electricity	Scope 2	191,254	0.19338	37.0
Total Emissions				**116.4**

Table 15: Baseline carbon emission from RETScreen model

Electricity consumption in the baseline model (75.1 kWh/m^2 per annum) is very similar to actual metered consumption (74.9 kWh/m^2 per annum).

The consumption of gas in the baseline model (170.6 kWh/m^2 per annum) is also similar to actual metered consumption (170.6 kWh/m^2 per annum).

For the purposes of this report the emissions scopes are as follows:

- Scope 1 emissions relate to emissions from the combustion of fuels on site. Scope 1 would ordinarily include other fuel use, such as vehicle fuel emissions by owned assets. However, the scope of this study has been limited primarily to building services.
- Scope 2 emissions presently relate to the production of electricity, however in future these could include emissions from district heating.

Note that we have not included any scope 3 emissions associated with transmission and distribution of these energy supplies.

6.3 Peak Heat Loss

We have calculated approximate 'steady state' peak heat losses using the Salix Peak Building Heat Loss Calculation Tool, based on a design outside air temperature of -3°C and internal setpoint temperatures of 19°C to 21°C, the calculated peak heat losses are shown as follows:

[2] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022

Area	Internal Setpoint Temperature	Calculated Peak Heat Loss
Theatre hall	21°C	330kW
Circulation space	19°C	320kW

Table 16: Calculated peak heat losses

The calculated total peak heat losses of the building is ca. 650kW, which is higher than the rated output of the existing boilers of ca. 550kW. However, our calculation does not account for occupant heat gains, which are significant during shows.

The calculated peak heat loss does not include DHW demands. The rated output of the existing DHW plant is 71kW.

7 Site Decarbonisation Options

7.1 Carbon Reduction Hierarchy

Concept believe that any pathway to carbon reduction should follow the hierarchy of:

- Energy saving (through behaviours and controls)
- Energy efficiency (through improvements to the building and equipment)
- Low carbon heat sources
- Renewable generation
- Carbon offsetting

For the Spotlight we have identified the measures as shown below.

7.2 Energy Saving

7.2.1 BMS setpoint adjustment

We observed that the temperature setpoint of the hall was set to 26°C, which is higher than the recommended temperature by CIBSE Guide A for a concert hall of 21°C to 23°C. Reducing this temperature setpoint would lead to energy savings.

We have modelled a carbon reduction of ca. tonnes of 7.6 CO_2e per year for reducing the hall temperature setpoint by 4°C.

7.2.2 Summary of savings for energy saving measures

Table 17 shows the summary of savings for energy saving measures.

Measure	Saving, kWh/yr	Saving, £/yr	Saving, tCO_2e/yr
BMS setpoint adjustment	41,534	4,818	7.6

Table 17: Summary of savings for energy saving measures

7.3 Energy Efficiency

7.3.1 Plant room valve insulation

We observed that some valves and flanges are uninsulated.

We estimate that there were ca. 40no. valves uninsulated or with insulation damaged. The below saving is estimated based on a heat loss saving of 68W per equivalent linear metre of pipework.

We have modelled a carbon reduction of ca. 0.9 tonnes of CO_2e per year for this measure.

7.3.2 Replacement of AHU

The existing main AHU is ca. 37 years old, exceeding the economic life for internally located AHUs of 20 years suggested by CIBSE Guide M. This AHU could be replaced to include direct-driven variable-speed fans. The existing belt driven fans introduce additional losses and require additional maintenance. Utilizing direct drive fans with variable speed control would significantly reduce fan energy usage.

We have modelled a carbon reduction of ca. 7.5 tonnes of CO_2e per year for this measure.

7.3.3 Variable speed pumping

The pumps of 2no. CT circuits are controlled at a fixed speed. Variable speed control could be introduced for these pumps to automatically vary pumps speed. There is a non-linear relationship between pump speed and pump power, and small reductions in speed would result in large energy savings.

We have modelled a carbon reduction of ca. 0.9 tonnes of CO_2e per year for this measure.

7.3.4 Replacement of gas catering equipment

The kitchen is currently equipped with gas hobs, which could be replaced with electric hobs. Shifting from ca. 30% efficient gas hobs to more energy-efficient alternatives such as electric induction hobs with an assumed efficiency of ca. 70% would reduce carbon emissions and improve the overall energy efficiency of the catering equipment.

We have modelled a carbon reduction of ca. 1.1 tonnes of CO_2e per year for this measure.

7.3.5 Wall insulation

The building has cavity walls which are believed to have no insulation within the cavities. This is expected to be well below current standards. Improving the wall insulation could reduce the building heat loss.

Solid wall insulation of either External Wall Insulation (EWI) or Internal Wall Insulation (IWI) is likely required as the building is probably hard to treat.

EWI would minimise disruption to building use but would change the look of the building. The external finish could be designed to match the existing brickwork or be rendered like the existing extension sections.

IWI would slightly reduce internal floor area. It would also require all wall mounted fittings such as radiators, lights, switches and sockets to be extended out to the new internal surface at significant expense.

Alternatively, retrofit cavity wall insulation would be possible at this site. However, this is subject to detailed design by a specialist insulation contractor.

Insulating the building fabric may reduce uncontrolled air infiltration and additional mechanical ventilation may be required to maintain indoor air quality.

We have modelled a carbon reduction of ca. 8.0 tonnes of CO_2e per year for this measure.

7.3.6 Summary of savings for energy efficiency measures

Table 18 shows the summary of savings for energy efficiency measures.

Measure	Saving, kWh/yr	Saving, £/yr	Saving, tCO_2e/yr
Plant room valve insulation	5,051	586	0.9
Replacement of AHU	39,011	17,282	7.5
Variable speed pumping	4,667	2,068	0.9
Replacement of gas catering equipment	6,257	-809	1.1
Wall insulation	43,944	5,605	8.0

Table 18: Summary of savings for energy efficiency measures

7.4 Low Carbon Heat Sources

The boilers have recently been upgraded and it is acknowledged that it is highly unlikely that these will be replaced for some time. By the time these boilers are considered end of life, the heating options and accompanying economic cases are likely to be significantly different.

However, decarbonisation of the site typically requires direct combustion of fossil fuels on site to be removed or minimised. Therefore, heat decarbonisation is likely to involve electrification of heating, with heat pumps typically providing the most efficient solution.

7.4.1 Air Source Heat Pumps

Air Source Heat Pumps (ASHPs) would typically provide higher efficiency and lower carbon emissions compared to gas fired boilers but the running costs would be slightly higher than a gas boiler system. ASHPs could be installed to provide space heating and DHW to the site.

In the 2019 report, the option of using Air Source Heat Pumps (ASHPs) was excluded due to a poorly insulated building. However, considering the recommended wall insulation measure in section 7.3.5, this option is now reinstated.

Using ASHPs would increase the grid electricity demand significantly. The historic peak electricity demand is ca. 80kW, and we estimate that the site may require up to ca. 720kW of additional available supply capacity with heat pumps, based on the calculated peak heat loss. This is subject to further feasibility discussion with the District Network Operator (DNO).

ASHPs could be in the form of either:

- Air to Water Heat Pumps (AWHP) serving low flow temperature wet heating systems with a larger LTHW coils in the Air Handling Unit and larger radiators, or
- Air to Air Heat Pumps (AAHP) serving indoor Fan Coil Units to replace radiators and a new refrigerant coil in the Air Handing Unit.

It is noted that the optimal solution may involve using a combination of AWHP and AAHPs to serve specific loads in different parts of the building (e.g. radiators and the AHU).

The ASHP outdoor units could be installed on the flat roof of the building if the building structure could support the weight of ASHPs.

7.4.1.1 Air to Water Heat Pumps

AWHPs transfer heat to water in a conventional Low Temperature Hot Water (LTHW) heating distribution system. The system would be controlled centrally via the BMS as per the existing boilers. An AWHP system could be installed to replace the gas fired boilers and gas fired water heater; DHW would require a high temperature unit to achieve the required storage temperatures, while radiator loads could be met with reduced flow temperatures, typically 45-50°C, to increase heat pump efficiency.

It is likely that a full replacement of the distribution pipework, pumps, AHU coils and heat exchangers (including radiators) would be required to facilitate reduced flow temperatures for this option.

7.4.1.2 Air to Air Heat Pumps

There is potential to use AAHP for the main AHU instead of air to water, to avoid long pipe runs and increase system efficiency. AAHPs deliver heat energy directly from the refrigerant coil to the loading, this case an additional DX coil would be required in AHU to replace the existing LTHW coil.

Radiators could be replaced by Fan Coil Units connected to AAHPs, with the LTHW distribution pipework removed.

The gas fired water heater could be replaced by a AWHP.

We have assumed a Seasonal Coefficient of Performance of all ASHPs to be 3. We have modelled a carbon reduction of ca. 43.7 tonnes of CO_2e per year for this measure.

7.4.2 Direct electric heating

The existing AHU LTHW coil and distribution could be replaced by electric heater batteries, radiators could be replaced by wall mounted electric heaters, and the gas fired water heater could be replaced by an electric water heater.

Direct electric heating has a higher efficiency than a gas boiler system and as the emissions factor for grid electricity is steadily decreasing, the site’s heating would still continue to decarbonise over time.

Using direct electric heating would require an additional available grid supply capacity of up to ca. 720kW as mentioned before. This is subject to further feasibility with the DNO.

The running cost of direct electric heating would be higher than the existing boiler systems and any of the heat pump systems modelled, as electricity cost per unit is higher than for gas and electric heaters have lower efficiency than a heat pump system.

We have modelled a carbon reduction of ca. 8.6 tonnes of CO_2e per year for this measure.

7.4.3 Air Source Gas Absorption Heat Pumps

Air Source Gas Absorption Heat Pumps (GAHPs) are heat pumps utilizing gas combustion, rather than electricity, to drive a refrigerant cycle with ammonia. In the 2019 report, this option was not recommended due to inadequate insulation in the building.

Additionally, considering the emphasis on decarbonization, this option is still unlikely to be considered, as it typically involves reducing or eliminating gas consumption. Although a wall insulation measure is now recommended in section 7.3.5, it may not significantly impact the feasibility of this particular heat pump option.

It should be noted that funding for gas fired heat pumps is not permitted under the Public Sector Decarbonisation Scheme (PSDS).

7.4.4 Biomass Boilers

As recommended in the 2019 report, replacing gas-fired boilers with a biomass boiler would result in lower CO_2 emissions, given that the fuel is renewable. Wood pellets are most commonly used as biomass fuel. Biomass boilers provide the same flow temperature as gas boilers therefore no change is required to existing distribution systems.

Biomass boilers are most efficient when operating at a consistent full load, minimizing frequent on/off cycling. We have assumed that half of the site's heating load would be covered by the biomass boiler, with electric boilers topping up as needed. This would need to be designed carefully to ensure efficiency of the biomass system, which may incorporate significant thermal storage capacity.

The Building would require a ca. 360kW biomass boiler with ca. 360kW top up electric boilers.

We have assumed the efficiency of the boiler to be 85%. We have modelled a carbon reduction of ca. 33.6 tonnes of CO_2e per year for this measure.

7.4.5 Solar Thermal

Solar thermal comprises roof mounted panels through which a working fluid is pumped to collect free heat from the sun. It is typically sized to deliver no more than the peak summer demand to avoid over-heating and as a result will typically only provide a proportion of demand in the winter.

As solar thermal panels are slightly less susceptible to shading impacts than solar PV panels, it may be possible to utilise the flat roof of the public bar to mount these panels, although winter generation could still be significantly impacted by shading from the trees to the South.

It is estimated that 1,000 litres of DHW demand is required for the maximum capacity of 1,000 people based on the Plumbing Engineering Services Design Guide for daily hot water demand for theatre buildings. A 17.5m^2 solar thermal would meet this daily DHW demand, and a ca. 1,300 litres thermal storage cylinder would be required.

As solar thermal cannot provide 100% of the heat load, top up is required from the primary heat source. As the primary system options have different efficiencies, the avoided emissions from solar thermal will vary depending on the primary system installed.

7.4.6 Summary of savings for low carbon heating measures

Three main low carbon heating options have been identified, namely ASHP, direct electric heating and biomass boiler. Solar thermal savings would be different with each of these options as the efficiency of the main systems are different. We have therefore additionally presented savings from solar thermal alongside each main option.

Measure	Saving, kWh/yr	Saving, £/yr	Saving, tCO_2e/yr
Air source heat pumps	244,622	-1,245	43.7
Direct electric heating	63,455	81,502	8.6
Biomass boiler	43,380	-32,014	33.6
17.5m^2 Solar thermal (with ASHPs)	4,016	1,779	0.8
17.5m^2 Solar thermal (with direct electric heating or biomass boiler)	12,048	5,337	2.3

Table 19: Summary of savings for low carbon heating measures

7.5 Renewable Energy Generation

7.5.1 Solar PV

Solar photovoltaics (PV) generate electricity when exposed to sunlight and would offset grid electricity demands at this site.

The roof of the main hall offers an unshaded roof area which could support the installation of solar PV.

We estimate that a 12kW system could be accommodated on the south facing roof of the main hall and this would require 92m^2 of roof area. This is subject to structural loading assessment.

Based on electricity consumption data for 2022/23, we estimate that the system would generate around 7% of current site electricity demand. It is normally recommended to size a solar PV system to maximise on-site use of the solar generation as this provides the best return on investment.

Any installed system should be sized appropriately by a qualified installer.

We have modelled a carbon reduction of ca. 2.5 tonnes of CO_2e per year for this measure.

7.5.2 Summary of savings for renewable generation measures

Table 20 shows the savings for renewable generation measures.

Measure	Saving, kWh/yr	Saving, £/yr	Saving, tCO_2e/yr
12kWp solar PV system	12,671	5,613	2.5

Table 20: Summary of savings for renewable generation measures

8 Decarbonisation Pathways

All of the measures discussed in Sections 7.2 to 7.5 above form a decarbonisation pathway.

In order to provide a fair comparison of each of the measures, the carbon impact shown is based on the 2022 emissions factors for the UK, regardless of planned implementation timescale of each measure.

Three main heat decarbonisation options are shown for the Spotlight – ASHP, direct electric heating and biomass boiler. This results in three different waterfall diagrams. The diagrams show the cumulative effect of the measure in all heating scenarios. The x-axis shows each of the steps and the y-axis shows the carbon emissions at each stage.

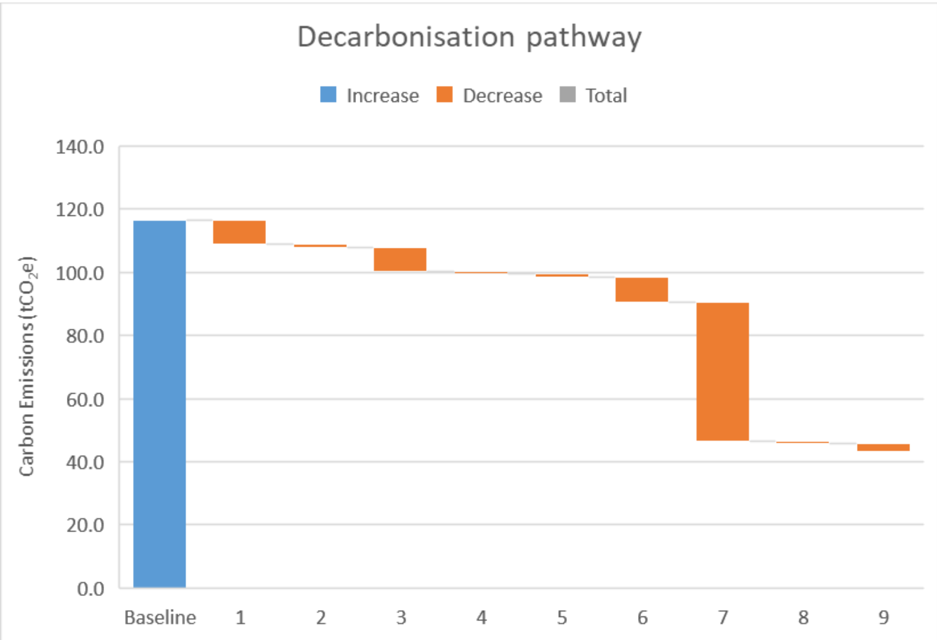

Figure 16: Water fall diagram of cumulative reductions – ASHP scenario

	Stage	Benefit (tCO_2e)	Total emissions (tCO_2e)
Baseline	Baseline	-	116.4
BMS setpoint adjustment	1	-7.6	108.8
Plant room valve insulation	2	-0.9	107.9
Replacement of AHU	3	-7.5	100.4
Variable speed pumping	4	-0.9	99.5
Replacement of gas catering equipment	5	-1.1	98.4
Wall insulation	6	-8.0	90.3
ASHP	7	-43.7	46.7
Solar thermal	8	-0.8	45.9
Solar PV	9	-2.5	43.4

Table 21: Cumulative carbon reductions – ASHP scenario

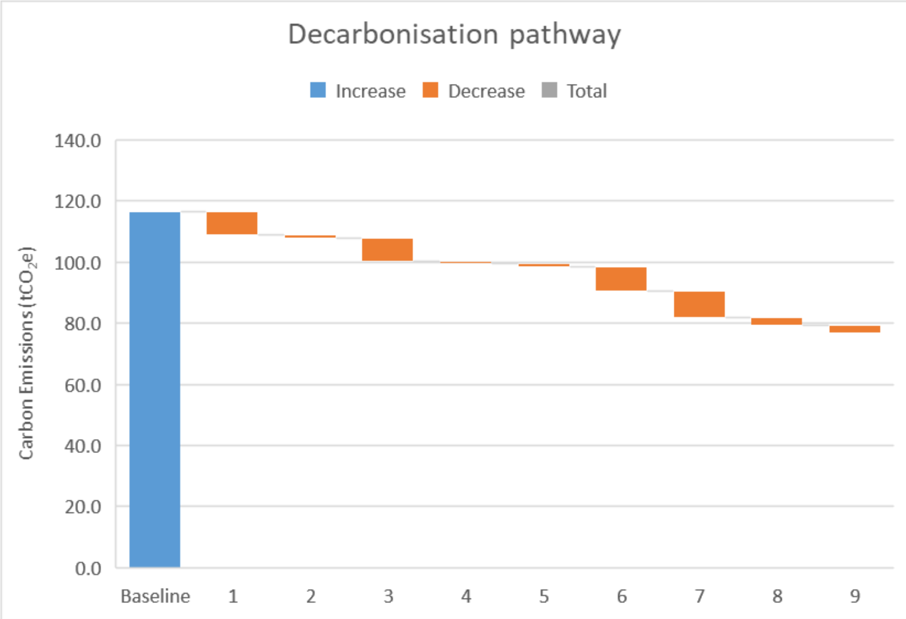

Figure 17: Water fall diagram of cumulative reductions – direct electric heating scenario

	Stage	Benefit (tCO_2e)	Total emissions (tCO_2e)
Baseline	Baseline	-	116.4
BMS setpoint adjustment	1	-7.6	108.8
Plant room valve insulation	2	-0.9	107.9
Replacement of AHU	3	-7.5	100.4
Variable speed pumping	4	-0.9	99.5
Replacement of gas catering equipment	5	-1.1	98.4
Wall insulation	6	-8.0	90.3
Direct Electric Heating	7	-8.6	81.7
Solar thermal	8	-2.3	79.4
Solar PV	9	-2.5	79.2

Table 22: Cumulative carbon reductions – direct electric heating scenario

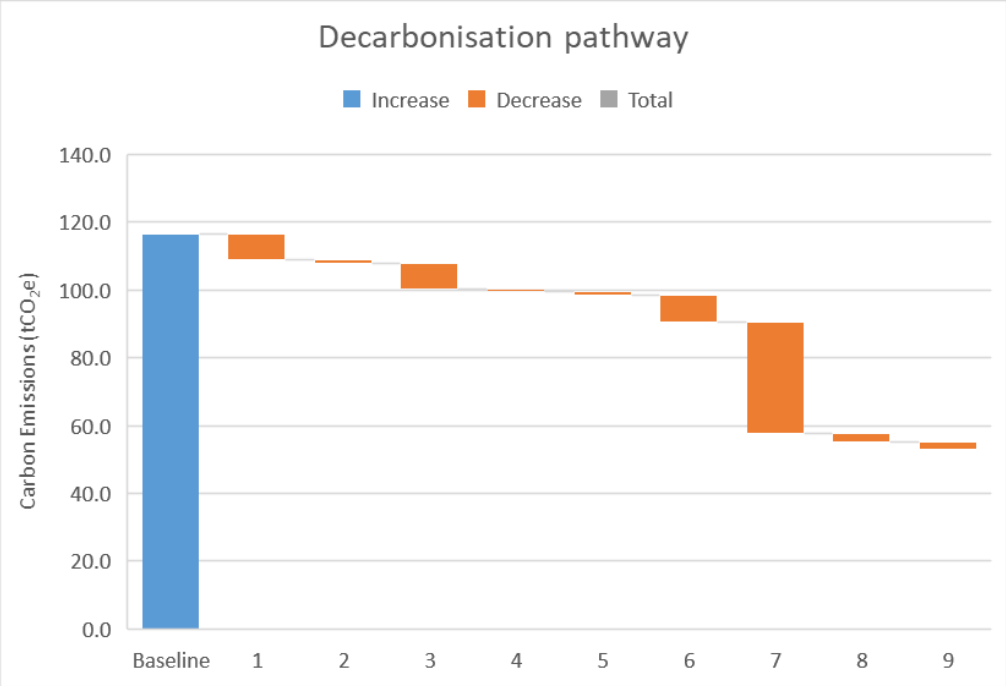

Figure 18: Water fall diagram of cumulative reductions – biomass boiler scenario

	Stage	Benefit (tCO_2e)	Total emissions (tCO_2e)
Baseline	Baseline	-	116.4
BMS setpoint adjustment	1	-7.6	108.8
Plant room valve insulation	2	-0.9	107.9
Replacement of AHU	3	-7.5	100.4
Variable speed pumping	4	-0.9	99.5
Replacement of gas catering equipment	5	-1.1	98.4
Wall insulation	6	-8.0	90.3
Biomass boiler	7	-32.7	57.6
Solar thermal	8	-2.3	55.3
Solar PV	9	-2.5	52.9

Table 23: Cumulative carbon reductions – biomass boiler scenario

8.1.1 Impact of grid decarbonisation

Both the UK gas and electricity grid supplies are decarbonising as a result of changes in the energy supply mix, including injection of biogas into the gas grid and a large increase in wind generation capacity.

Emissions factors are only published annually (in arrears) by UK and we are not aware of any published future predictions.

The table below shows the historic emission factors (to three decimal places) taken from DESNZ (formally BEIS) Government Conversion Factors for Company Reporting of Greenhouse Gas Emissions.

Year	Emissions Factor (kgCO_2e/kWh)								Average Annual Variance
	2016	2017	2018	2019	2020	2021	2022	2023	
Electricity (Scope2)	0.412	0.351	0.283	0.256	0.233	0.212	0.193	0.207	-9.1%
Gas (Scope1)	0.183	0.184	0.183	0.183	0.183	0.183	0.183	0.183	-0.005%

Table 24: Historic Emissions Factors

We have predicted emission factors for 2024 onwards, based on the average annual percentage variance over the last eight years.

It should be noted that the historic emission factor trends may not be representative of future changes in emission factors.

Year	Emissions Factor (kgCO_2e/kWh)					
	2022	2023	2024	2025	2026	2027
Electricity (Scope2)	0.193	0.207	0.188	0.171	0.156	0.142
Gas (Scope1)	0.183	0.183	0.183	0.183	0.183	0.183

Table 25: Predicted Emissions Factors

The impact of changing emissions factors for the Spotlight is shown in the table below. This assumes that all measures were implemented by the end of 2022 and that the ASHP option is adopted.

This data is presented solely to allow the impact of future grid decarbonisation to be assessed.

Year	Site Emissions (tCO_2e) Assuming all measures have been completed					
	2022	**2023**	**2024**	**2025**	**2026**	**2027**
Gas (Scope 1)	0.0	0.0	0.0	0.0	0.0	0.0
Electricity (Scope 2)	43.4	46.5	42.3	38.5	35.0	31.8
Total	**43.4**	**46.5**	**42.3**	**38.5**	**35.0**	**31.8**

Table 26: Impact of changing carbon factors

The impact of the decarbonisation of the national grid means that the footprint could reduce by a further 11.6 tCO_2e over five years without any further action required by the site.

9 Financial Analysis

9.1 Project costs

Concept have made estimates of the likely project costs using published pricing books[3] and historic cost estimates that we hold for similar projects. We have not engaged a quantity surveyor and it should be noted that these estimated costs are solely for the purposes of comparing the individual measures.

Only projects with tangible or quantified energy benefits have been costed.

9.1.1 Plant room valve insulation

Installation of valve insulation does not typically require specialist contractors and can normally be completed by site maintenance personnel. We have allowed for approximate valve numbers observed on site, with a small allowance for installation time cost.

Item	Qty	Cost ea.	Sub-total
Supply and Installation of valve insulation bags	40	£50	£2,000
TOTAL			**£2,000**

Table 27: Valve insulation cost estimate

9.1.2 Replacement of AHUs

We have estimated the cost of replacing AHUs based on SPONs price book rates for supply and installation of AHU which are provided on a cost per m^3/s basis.

Based on the existing fan motor ratings and an assumed a specific fan power of 2W per l/s (CIBSE Guide B 2002) we estimate that the total air volume for supply and extract rates are ca. 10.8 m^3/s.

We have also added a provisional sum for control integration and additional costs for design and making good at 30% of the base cost.

Item	Qty	Cost ea.	Sub-total
Supply and installation of packaged AHUs per m^3/s	10.8	£12,000	£129,600
Control integrations	Provisional sum	£10,000	£10,000
Design and making good	30%	-	£41,880
TOTAL			**£181,000**

Table 28: Replacement of AHU cost estimate

[3] SPON's Mechanical and Electrical Services Price Book

9.1.3 Variable speed pumping

We have estimated the cost of variable speed pumping based on SPONs price book rates for frequency inverters.

We have also added a provisional sum for control integration and additional costs for design and making good at 30% of the base cost.

Item	Qty	Cost ea.	Sub-total
Supply and installation of inverter, 2.2kW	4	£1,200	£4,800
Control integrations	Provisional sum	£3,000	£3,000
Design and making good	30%	-	£2,340
TOTAL			**£10,000**

Table 29: Variable speed pumping cost estimate

9.1.4 Replacement of gas catering equipment

We have estimated the cost of installing of electric hobs based on market rates.

We have added additional costs for design and making good at 30% of the base cost.

Item	Qty	Cost ea.	Sub-total
Supply and installation of electric hobs	1	£3,000	£3,000
Design and making good	30%	-	£900
TOTAL			**£4,000**

Table 30: Replacement of gas catering equipment cost estimate

9.1.5 Wall insulation

We have estimated the cost of installing retrofit cavity wall insulation at base rate of £20 per m^2.

We have added additional costs for design and making good at 30% of the base cost.

Item	Qty	Cost ea.	Sub-total
Supply and install of retrofit cavity wall insulation per m^2	1500	£20	£30,000
Design and making good	30%	-	£9,000
TOTAL			**£39,000**

Table 31: Wall insulation cost estimate

9.1.6 Air source heat pump

Pricing for ASHPs is subject to detailed design to determine the capacity of plant items, which is beyond the scope of this study. However, we have estimated a total required heating capacity of ca. 720kW (section 6.3). The cost to supply and install ASHPs has been estimated based on past manufacturer estimates.

Table 32 shows the cost estimate for AWHP including replacement components required to facilitate reduced flow temperatures. We have added a provisional sum for complete replacement of distribution pipework, control integrations and upgrades to the grid electricity supply. We have also included additional costs for design and making good at 30% of the base cost.

Table 33 shows the cost estimate for AAHP including replacement of AHU coil. We have added a provisional sum for removal of distribution pipework, control integrations and upgrades to the grid electricity supply. We have also included additional costs for design and making good at 30% of the base cost.

Item	**Qty**	**Cost ea.**	**Sub-total**
Supply and installation of ASHP per kW	720	£1,300	£936,000
Plant compound	1	£10,000	£10,000
New hot water storage cylinder	1	£5,000	£5,000
Replacement of distribution system	Provisional sum	£50,000	£50,000
Replacement of AHU coil	1	£500	£500
New pump	6	£2,500	£15,000
Control integrations	Provisional sum	£20,000	£20,000
Grid electricity supply upgrades	Provisional sum	£100,000	£100,000
Design and making good	30%	-	£340,950
TOTAL			**£1,477,000**

Table 32: AWHP cost estimate

Item	**Qty**	**Cost ea.**	**Sub-total**
Supply and installation of ASHP per kW	720	£1,300	£936,000
Removal of water distribution system	Provisional sum	£20,000	£20,000
New hot water storage cylinder	1	£5,000	£5,000
Replacement of AHU coil	1	£500	£500
New fan coil unit	3	£2,000	£6,000
Removal of radiators	5	£500	£2,500
Control integrations	Provisional sum	£20,000	£20,000
Grid electricity supply upgrades	Provisional sum	£100,000	£100,000
Design and making good	30%	-	£327,000
TOTAL			**£1,417,000**

Table 33: AAHP cost estimate

9.1.7 Direct electric heating

We have estimated the cost of electric heater batteries to replace AHU heating coils and the cost of electric wall mounted heaters based on typical market rates.

We have also added a provisional sum for removal of water distribution system, control integration and grid electricity supply upgrades, and additional costs for design and making good at 30% of the base cost.

Item	**Qty**	**Cost ea.**	**Sub-total**
Supply and installation of AHUs electric heater battery per kW	330	£50	£16,500
Replacement of radiators to 3kW electric wall mounted heaters	107	£500	£53,500
Removal of water distribution system	Provisional sum	£20,000	£20,000
Control integration	Provisional sum	£20,000	£20,000
Grid electricity supply upgrades	Provisional sum	£100,000	£100,000
Design and making good	30%	-	£63,000
TOTAL			**£273,000**

Table 34: Direct electric heating cost estimate

9.1.8 Biomass boiler

We have estimated the cost of biomass boiler based on the SPONs capital cost for biomass boiler, with additional costs for top up electric boilers.

We have also added a provisional sum for control integration, grid electricity supply upgrades and additional costs for design and making good at 30% of the base cost.

Item	Qty	Cost ea.	Sub-total
Supply and installation of biomass boiler per kW	360	£500	£180,000
Supply and installation of top up electric boiler - 180kW	2	£5,000	£10,000
New pump	4	£2,500	£10,000
Control integration	Provisional sum	£10,000	£10,000
Grid electricity supply upgrades	Provisional sum	£100,000	£100,000
Design and making good	30%	-	£93,000
TOTAL			**£403,000**

Table 35: Biomass boiler cost estimate

9.1.9 Solar thermal

The cost of an 17.5m^2 solar thermal system has been estimated based on approximate SPONs whole system costs per m^2 of collector area and additional allowances for a plate heat exchanger, thermal storage cylinder and access equipment.

We have included additional costs for design and making good at ca. 30% of the base cost.

Item	Qty	Cost ea.	Sub-total
Supply and installation of roof mounted solar thermal system per m2 of aperture area	17.5	£750	£13,125
Supply and installation of additional PHE	1	£8,000	£8,000
Supply and installation of thermal storage cylinder	1	£10,000	£10,000
Allowance for access	1	£3,000	£3,000
Design and making good	30%	-	£10,238
TOTAL			**£44,000**

Table 36: Solar thermal cost estimate

9.1.10 Solar PV

Costs for solar PV installation have been based on published government solar PV costs per kW for 2022/2023 for systems 10 - 50kW.

An allowance has been included for access equipment to ensure panels, frames and ballast can be safely lifted to the roof.

We have added additional costs for design and making good at ca. 30% of the base cost.

Item	**Qty**	**Cost ea.**	**Sub-total**
Supply and installation of roof mounted solar PV per kW	12	£1,350	£16,200
Allowance for access	1	£3,000	£3,000
Design and making good	30%	-	£5,760
TOTAL			**£25,000**

Table 37: Roof solar PV cost estimate

9.2 Summary of NPV results

Table 38 shows the summary of Net Present Value (NPV) of the costed saving measures. It concludes that plant room valve insulation, replacement of AHU, variable speed pumping and solar PV give a positive NPV, while other measures give a negative NPV. The low carbon heating measures would give a significantly higher carbon saving although they give a negative NPV.

Measure	Persistence Factor	Guideline Cost, £	NPV, £	Annual Carbon Saving, tCO_2e
Energy Efficiency				
Plant room valve insulation	23	2,000	14,087	0.9
Replacement of AHU	24	181,000	317,962	7.5
Variable speed pumping	10	10,000	11,330	0.9
Replacement of gas catering equipment	10	4,000	-12,761	1.1
Wall insulation	30	39,000	172,804	8.0
Low Carbon Heating				
Air to water heat pump	20	1,477,000	-1,506,055	43.7
Air to air heat pump	20	1,417,000	-1,446,055	43.7
Direct electric heating	10	273,000	-1,155,894	8.6
Biomass boiler	20	403,000	-1,114,694	33.6
Solar thermal (with ASHPs)	25	44,000	9,916	0.8
Solar thermal (with direct electric heating or biomass boiler)	25	44,000	117,748	2.3
Renewable Energy Generation				
12kWp solar PV system	23	25,000	129,133	2.5

Table 38: Summary of NPV of saving measures

9.3 Sensitivity Analysis

The results indicated in the previous section are dependent on the modelled values, which may be different following detailed feasibility. To provide some indication of how key metrics will affect the investment, the following tables present the results of a basic sensitivity analysis.

This analysis has been carried out for changing input values of Capex and the gas tariff. For analysis of changing Capex, the replacement option Capex is varied by a percentage. Similarly, adjusting the gas tariff changes the relative fuel cost between the current system and the alternative.

Table 39 shows changing values of Net Present Value (NPV) when the replacement option Capex is adjusted up or down by 10% or 20%. All options remain negative with a 20% reduction in Capex.

Table 40 shows changing values of Net Present Value (NPV) when the gas tariff is adjusted up or down by 10% or 20%. All options benefit from a more expensive gas tariff due to the increased savings over the base case but remain negative with a 20% increase in gas tariff.

Option	Capex Adjustment			
	-20%	**-10%**	**10%**	**20%**
Air to water heat pump	-1,210,655	-1,358,355	-1,653,755	-1,801,455
Air to air heat pump	-1,162,655	-1,304,355	-1,587,755	-1,729,455
Direct electric heating	-1,101,294	-1,128,594	-1,183,194	-1,210,494
Biomass boiler	-1,034,094	-1,074,394	-1,154,994	-1,195,294

Table 39: Sensitivity analysis of NPV results with changing Capex

Option	Gas Tariff Adjustment			
	-20%	**-10%**	**10%**	**20%**
Air to water heat pump	-1,989,626	-1,747,840	-1,264,269	-1,022,484
Air to air heat pump	-1,929,626	-1,687,840	-1,204,269	-962,484
Direct electric heating	-1,380,315	-1,268,104	-1,043,684	-931,474
Biomass boiler	-1,287,575	-1,201,135	-1,028,253	-941,813

Table 40: Sensitivity analysis of NPV results with changing gas tariff

10 Marginal Abatement Cost Curves (MACC)

A Marginal Abatement Cost Curve uses the NPV of each project and the total carbon that the project saves in its lifetime to provide a comparative cost of abating each tonne of Carbon Dioxide Equivalent.

The carbon factors have been fixed at the 2022 values and exclude the impact of grid decarbonisation.

Costs of £0.443/kWh for electricity and £0.116/kWh for gas have been assumed, as has a fuel price inflation of 5% per annum.

A discount rate of 3.5% has been used.

Figure 19 to Figure 22 show the MACC for the AWHP, AAHP, direct electric heating and biomass boiler options respectively.

It should be noted that in the current market, contractual rates for all fuel supplies are typically significantly higher than those stated above. This will improve the cost effectiveness of measures in the short term as lifetime financial savings and NPV will increase.

The Y axis of the MACC is shown in £ per tonne of carbon abated based on the NPV. Note that a positive number indicates a cost whilst a negative number indicates a saving.

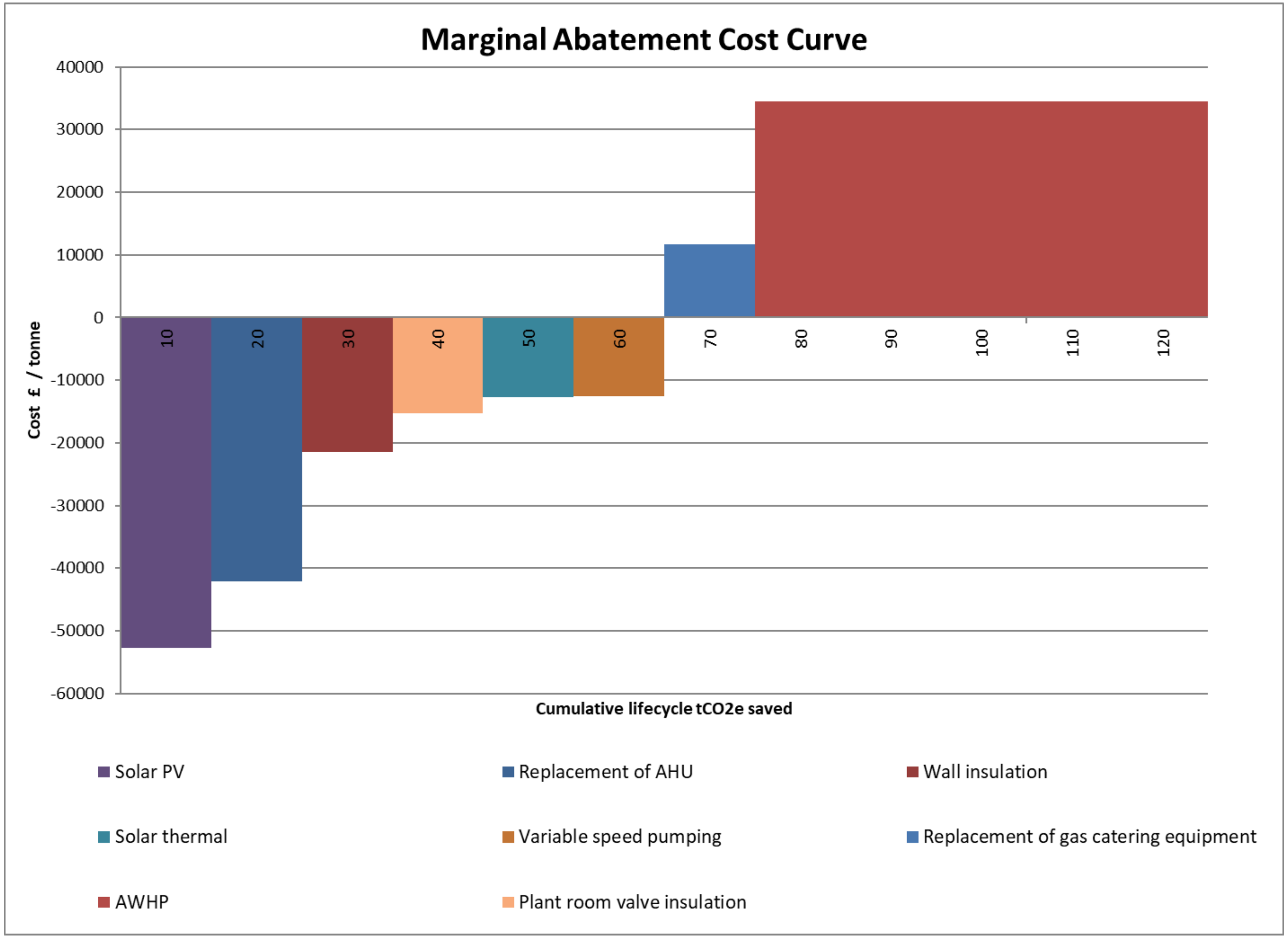

Figure 19: Marginal Abatement Cost Curve – AWHP option

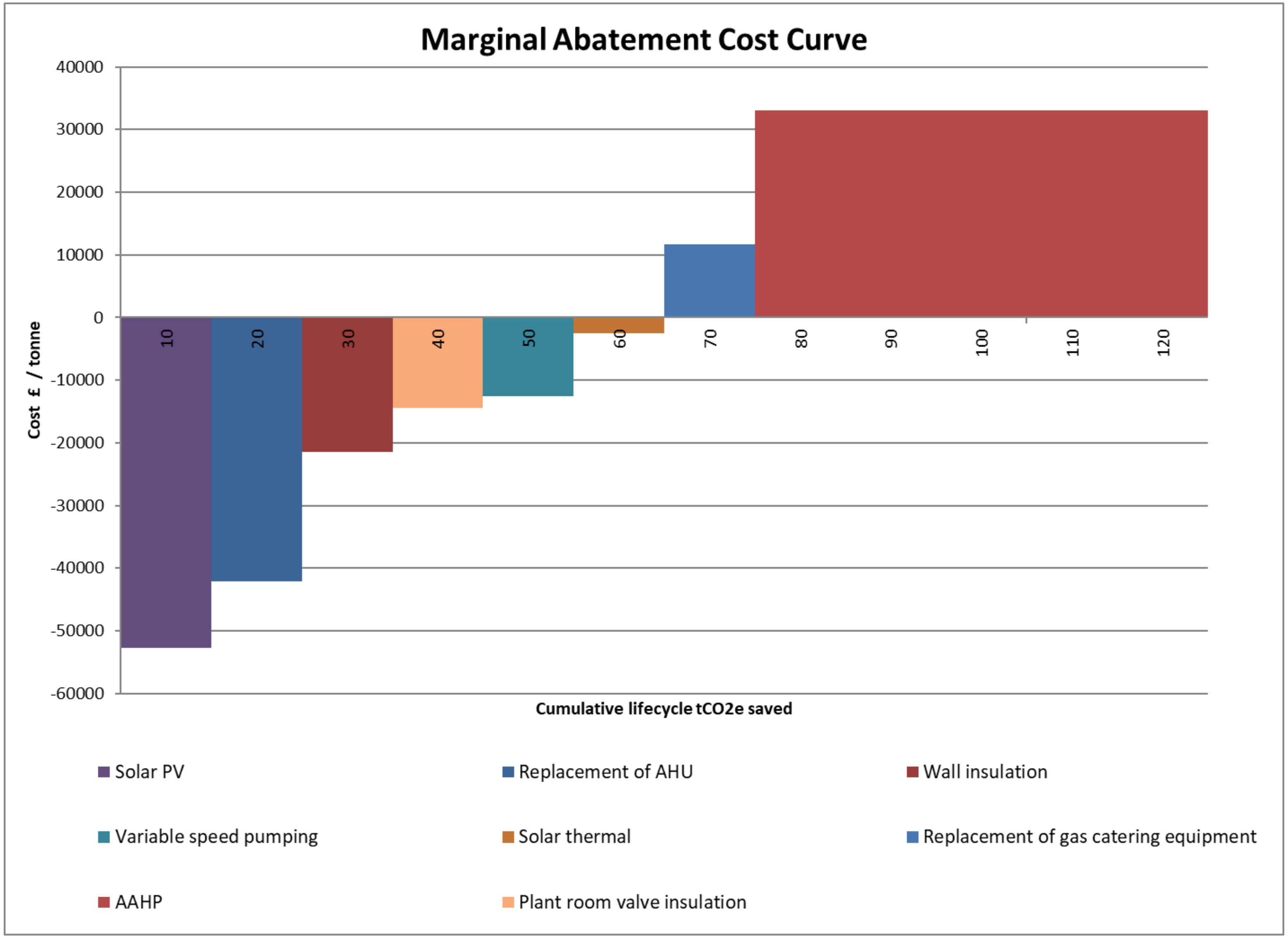

Figure 20: Marginal Abatement Cost Curve – AAHP option

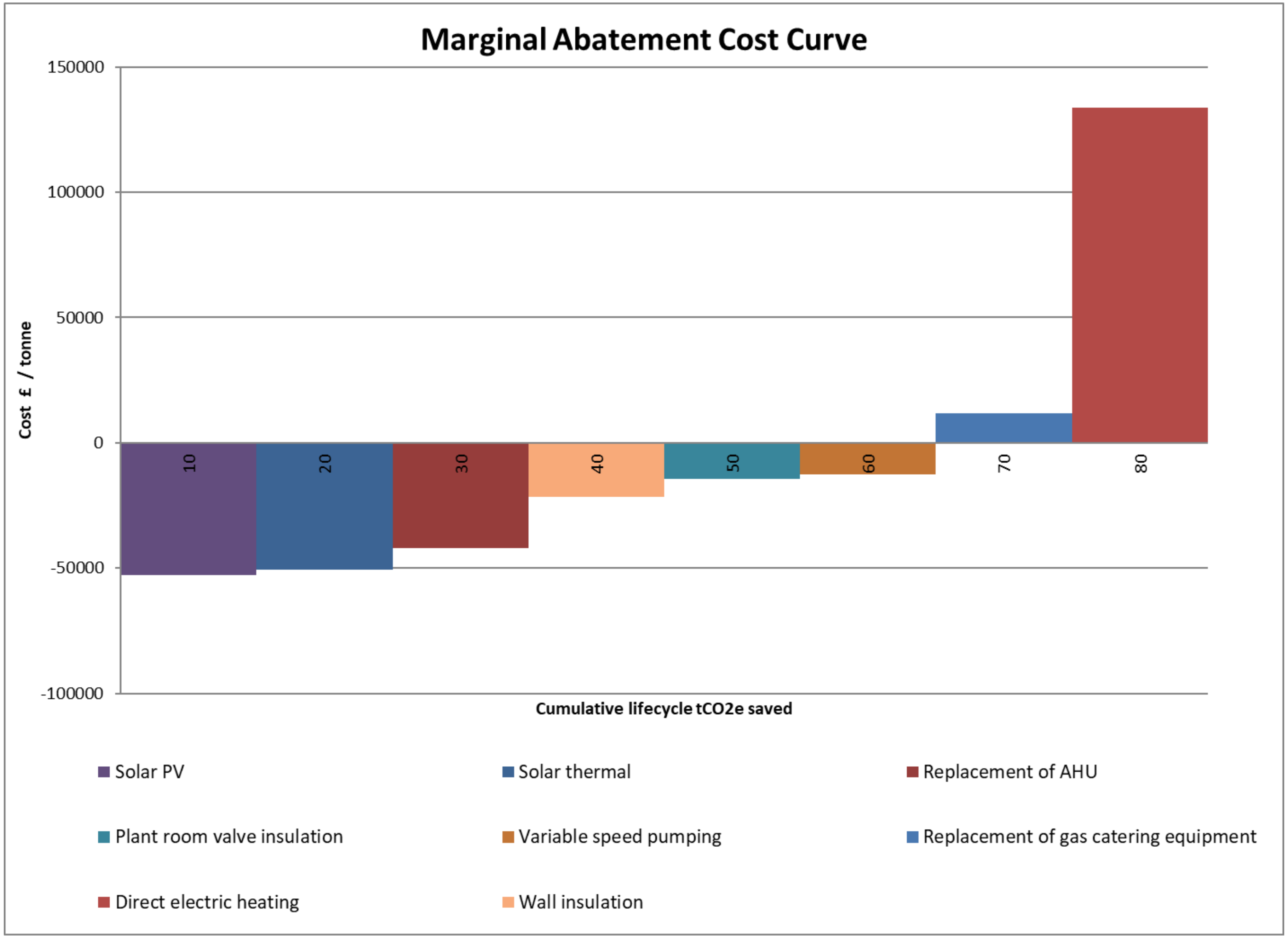

Figure 21: Marginal Abatement Cost Curve – direct electric heating option

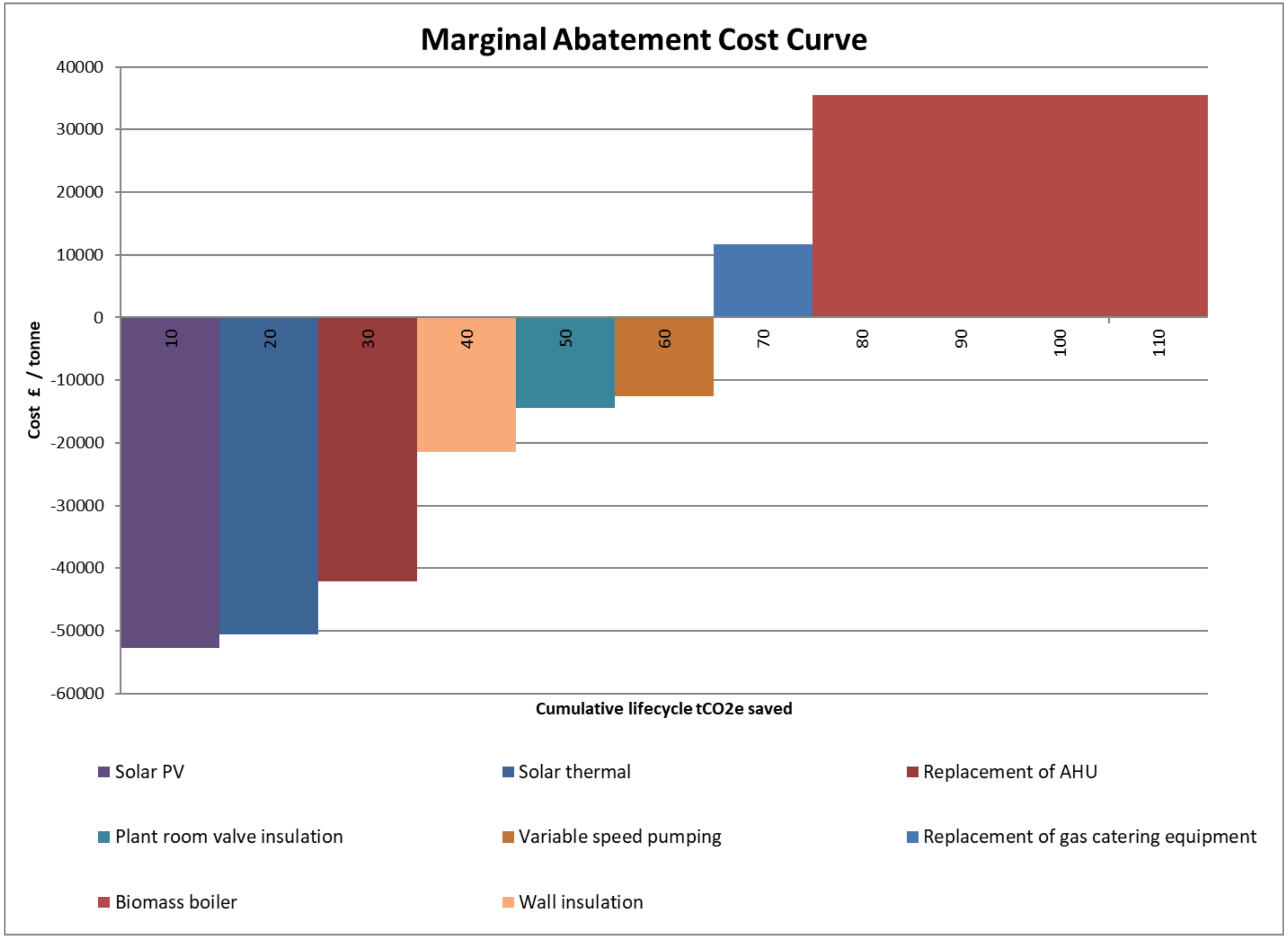

Figure 22: Marginal Abatement Cost Curve – biomass boiler option

11 Summary and Conclusions

The Spotlight comprises of a two-storey theatre hall building. The typical occupancy hours of the buildings are Monday to Friday from 07:00hrs to 17:30hrs. Additionally, the site opens in the evenings and on weekends for events, with extended hours until midnight.

Concept has visited the Spotlight to identify current performance and potential improvements. A number of potential savings measures have been identified including one zero cost measure and some costed measures.

A bulk energy simulation model of the site has been created using RETScreen. The purpose of the baseline model is to attempt to replicate the building in its current condition and model the impact of the identified measures.

Savings were modelled iteratively in order of the energy hierarchy as follows:

- Energy saving (through behaviours and controls)
- Energy efficiency (through improvements to the building and equipment)
- Low carbon heat sources
- Renewable generation

One zero cost measure was identified which is adjusting BMS setpoint for the theatre hall.

A number of energy efficiency measures were identified. These measures include:

- Plant room valve insulation;
- Replacement of AHU;
- Variable speed pumping;
- Replacement of gas catering equipment, and
- Wall insulation

Low carbon heating options include either installing an ASHP, direct electric heating or biomass boiler to replace the existing gas boilers and gas fire water heater to provide space heating and DHW. ASHP would provide a greater emissions reduction but at significantly higher cost than direct electric heating. Solar thermal water heating has been considered alongside both ASHP and direct electric heating or biomass boiler.

The financial analysis suggests that plant room valve insulation, replacement of AHU, variable speed pumping, wall insulation, solar thermal and solar PV measures would give a positive NPV, while all other measures give a negative NPV.

If all of the recommended options were taken up, ASHP was adopted for the low carbon heat source, the site would still have a residual carbon footprint of around 43.4 tCO_2e even after a considerable investment. However, this would be entirely from purchased electricity; grid electricity supplies are expected to decarbonise further over time without intervention as more renewables are introduced to the supplies. Based on historical trends, we have estimated that this could reduce emissions by a further 11.6 tCO_2e within a 5-year period.

Appendix A – Financial Analysis Assumptions

Assumption	Value
Discount rate	3.5%
Gas fuel inflation	5%
Elec fuel inflation	5%
Consumer Price Index (CPI) Inflation	5%
Gas unit rate, £/kWh	0.116
Electricity unit rate, £/kWh	0.443
Wood pellets unit rate, £/kWh	0.073
ASHP seasonal efficiency	300%
Direct electric heating seasonal efficiency	100%
Biomass boiler seasonal efficiency	85%

Appendix B – Summary of Direct Emissions Savings for PSDS

The following table presents the fossil fuel only savings for each modelled heating option, for the purposes of the PSDS calculation against the Carbon Cost Threshold (CCT). The existing system figure is based on modelling after implementation of all other efficiency measures.

Note that all options displace the same existing gas loads and therefore gas savings are the same. Only indirect emissions from grid electricity consumption are different for these measures.

Option	**Annual Gas Consumption, kWh**	**Annual Gas Saving, kWh**	**Gas only CO_2 saving, $kgCO_2/yr$**
Existing system after energy efficiency measures.	335,206	-	-
Option 1 - ASHP	0	335,206	61,189
Option 2 - Direct electric heating	0	335,206	61,189
Option 3 – Biomass boiler	0	335,206	61,189