| | |
|---|---|
| **Document Title** | **Building Decarbonisation Study** |
| **Site** | Laura Trott Leisure Centre, Cheshunt |
| **Client** | Borough of Broxbourne Council |
| **Issue** | 1.0 |
| **Date** | 18/12/2023 |


**Concept Energy Solutions Limited**
The Square, Basing View
Basingstoke, Hampshire, RG21 4EB
Tel: 01256 460269

www.conceptenergy.org

# Document Control

| Prepared By | Checked By | Approved By |
| --- | --- | --- |
|  |  |  |
| Hon Lam Kwan<br>Consultant | Jamie Green<br>Head of Consulting | P A Stockwell<br>Director |

| Revision | Date | Details of changes | Author | Approver |
| --- | --- | --- | --- | --- |
| 0.1 | 30/11/2023 | First draft | HLK | JG |
| 0.2 | 06/12/2023 | Second draft | HLK | JG |
| 0.3 | 13/12/2023 | Third draft | HLK | JG |
| 0.4 | 15/12/2023 | Fourth draft | HLK | JG/PS |
| **1.0** | 18/12/2023 | First issue | JG | |

# Glossary

| Abbreviation | Meaning |
|---|---|
| A/C | Air Conditioning |
| AHU | Air Handling Unit |
| ASHP | Air Source Heat Pump |
| AWHP | Air-Water Heat Pump |
| AAHP | Air-Air 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 |
| PHE | Plate heat exchanger |
| 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 Laura Trott Leisure Centre, 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, DHW and pool water to the site is mainly provided by two gas boilers and a biomass boiler, with space heating for a few areas provided by air-to-air heat pumps. Lighting is mostly from LED fittings, with a small number of fluorescent fittings remaining in some areas.

The gas, grid electricity and biomass consumption of the site in the 2022/23 financial year were 1,227,207 kWh, 838,290 kWh and 424,557 kWh respectively. Total emissions associated with these supplies were 390.6 $tCO_2e$.

Information collected during the site audit was used to create a bulk energy simulation model of the building using industry standard software: RETScreen. The 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 energy efficiency measures before the use of low carbon heating technologies and on-site generation.

We have identified one zero cost energy saving measure which is pool hall temperature setpoint adjustment and this could result in annual carbon saving of ca. 15.2 $tCO_2e$.

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), ground source heat pumps (GSHP) and direct electric heating. The GSHP option has the highest annual carbon saving of ca. 134.3 $tCO_2e$, 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 pipe and valve insulation | 23 | 1,100 | 21,126 | 1.3 |
| Replacement of AHUs | 24 | 533,000 | 1,478,651 | 56.9 |
| Variable speed pumping | 10 | 41,000 | 433,822 | 17.5 |
| Control upgrade for A/C in studio | 9 | 800 | 6,822 | 0.4 |
| Replacement of remaining T8 and CFL lighting | 25 | 4,400 | 84,316 | 1.2 |
| Low Carbon Heating | | | | |
| Air to water heat pump | 20 | 1,990,000 | -2,119,546 | 121.9 |
| Air to air heat pump | 20 | 1,925,000 | -2,054,546 | 121.9 |
| Ground source heat pump | 25 | 3,512,000 | -2,866,570 | 134.3 |
| Direct electric heating | 10 | 249,000 | -2,635,817 | 23.4 |
| On Site Renewable Energy | | | | |
| 53kWp Solar PV | 23 | 145,000 | 488,642 | 10.1 |

*Table 1: Summary of NPV of saving measures*

# Contents

concept

# 1 Introduction

## 1.1 Background

Broxbourne Borough Council has commissioned Concept to provide a building decarbonisation study at the Laura Trott Leisure Centre. The primary purpose of this report 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 was completed following a survey of the site in November 2023.

## 1.2 Site Details

The site is located in Cheshunt, Waltham Cross, EN8 9AJ and is a two-storey sports centre with swimming pool. The building was constructed in 1984.

The main building consists of a pool hall, sports hall, squash court, dance studios, bar area, offices and some general common areas.

The total useful floor area of the site is approximately 5,046m$^2$ according to the most recent Display Energy Certificate, which shows a rating of C.

Floor plans are included as Appendix A.

The typical occupancy hours of the site at the time of the survey are from 06:00hrs to 22:00hrs on Monday to Thursday, from 06:00hrs to 21:00hrs on Friday, and from 07:00hrs to 18:00hrs on Saturday and Sunday.

## 1.3 Timing of Audit

An inspection of the building was carried out by Jamie Green of Concept Energy Solutions on 15th November 2023. We gratefully acknowledge the assistance of Pete Hurley during the survey process.

# 2 Objectives Priorities and Methodologies

## 2.1 Survey Objectives

The purpose of the survey and audit was to:

- identify current building services equipment and operation;
- identify energy savings opportunities, including capital works and operational changes;
- identify improvements that can reasonably be made to building fabric;
- identify options for low carbon heating and on-site renewable energy generation;
- estimate the savings from any recommendations 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 which all major energy consuming plant was identified and non-intrusively inspected.

Details of building services were collected on site on 15$^{th}$ November 2023, supported by information provided by Broxbourne Borough Council.

The building fabric was also visually inspected; scaled site plans were obtained, wherever available, for off-site measurement of building heat loss areas. A dimensional survey of a representative sample of openings and elevations was conducted during the site survey for comparison with scaled floor plans provided.

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 the building using industry standard software, 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 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. Gas and electricity consumption is taken from actual site consumption provided by the Council.

Electricity cost data is based on actual invoiced costs, excluding 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.

The cost data for biomass wood pellets is based on the total delivery cost in the financial year 2022/23, and exclusive of VAT and ca. £26,000 of Renewable Heat Incentive (RHI) payments made in this financial year.

PV monthly generation data has been provided for the financial year 2022/23.

| Utility | Energy | | Cost | | $CO_2$e emissions | |
|---|---|---|---|---|---|---|
| | kWh | % | £ | % | Tonnes | % |
| **Electricity** | 838,290 | 33.0 | 306,522 | 62.4 | 162.1 | 57.6 |
| **PV Generation** | 46,990 | 1.9 | - | - | - | - |
| **Gas** | 1,227,207 | 48.4 | 139,729 | 28.5 | 224.0 | 41.7 |
| **Biomass (wood pellet)** | 424,557 | 16.7 | 44,698 | 9.1 | 2.8 | 0.7 |
| **Total** | **2,537,044** | **100.0** | **490,949** | **100.0** | **389.0** | **100.0** |

*Table 2: Energy Consumption during financial year 2022/23*

$CO_2$e Emissions have been calculated from conversion factors of 0.19338 kg $CO_2$e per kWh for electricity, 0.18254 kg $CO_2$e per kWh for gas and 0.01053 kg $CO_2$e per kWh for wood pellets, 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 is served by a single 3-phase incoming electricity supply. The current available supply capacity for the main meter is 350kVA.

There is a single revenue meter recording half hourly (HH) site consumption, which is located in an external cupboard outside the main boiler plant room.

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

| Utility | MPAN | Meter Serial Number |
|---|---|---|
| **Electricity** | 1014573186400 | NG14K01306 |

*Table 3: Electricity meter details*

The current electricity supply agreement is with Npower and the charging detail has been provided as of March 2023, which confirms the following contractual rates:

| Supplier | Rate (p/kWh) | Standing Charge (p/day) | CCL (p/kWh) |
|---|---|---|---|
| NPower | 43.47386 | 48.385 | 0.775 |

*Applied to day and night energy

*Table 4: Electricity cost details*

### 3.2.2 Monthly consumption profile

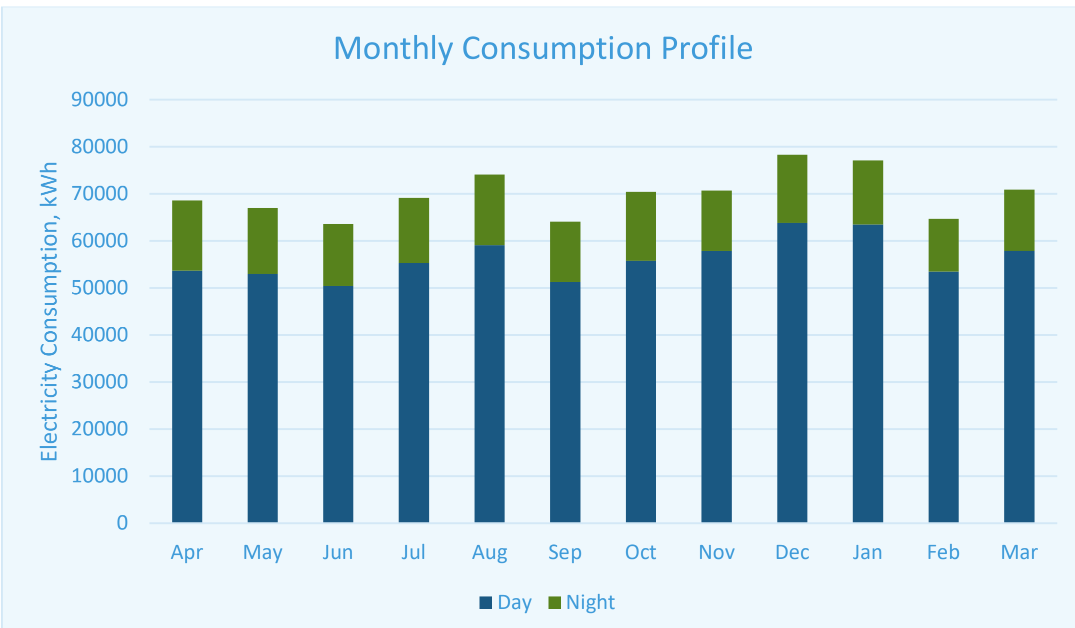



*Figure 2: Monthly Electricity Consumption*

The monthly profile shows reasonably consistent consumption throughout the year, with a slight increase in August, December and January in particular. As space heating and cooling in some areas, such as the gym, are provided by heat pumps, electricity consumption would be expected to rise slightly during the peak of winter and summer.

The overnight electricity consumption from 00:00hrs to 07:00hrs is recorded and averaged 20% of the overall electricity 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 16th January 2023 has been take as representative of a typical winter week. Likewise, data covering the week commencing 1st August 2022 represents a typical summer week.

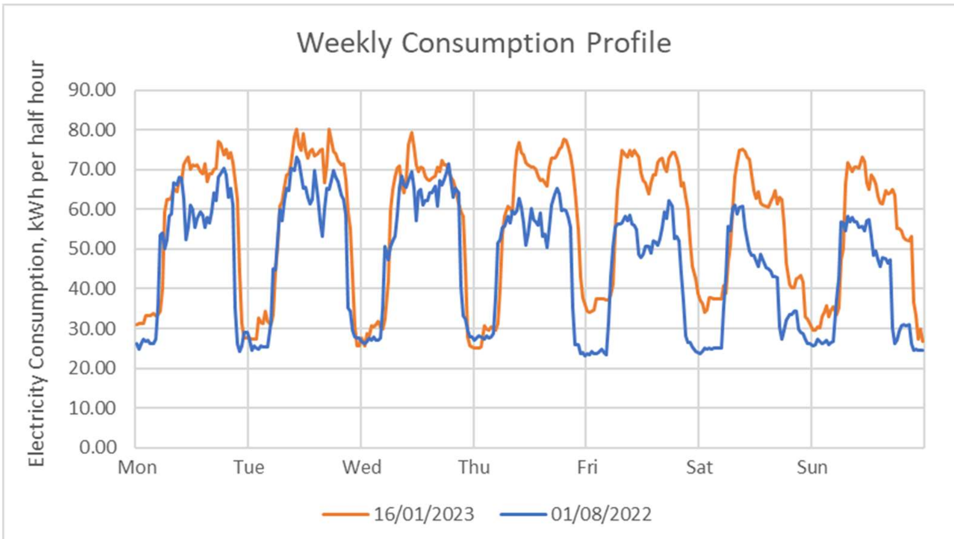



*Figure 3: Summer / Winter typical week analysis*

The baseload appears to be ca. 50kW in both the winter week and the summer week.

The peak demand is ca. 160kW in the winter week and ca. 145kW in the summer week.

Both weeks show a similar pattern with slightly reduced operational hours at weekends as expected. There was a reduction in baseload in the second half of the summer week where both daytime and overnight loads dropped by a similar amount. In the winter week, there were elevated overnight loads from Friday to Sunday, which could possibly be due to frost protection controls bringing pumps on, or simply plant left on, such as one of the local ventilation units or A/C units. Daytime electricity consumption is slightly higher during the winter week, which could indicate use of local ventilation units and electric door curtains in the main entrance area.

Additionally, Christmas week has been analysed and is shown on Figure 4. This profile shows a lower demand on Monday (Boxing Day), followed by a return to regular demand levels starting from Tuesday.

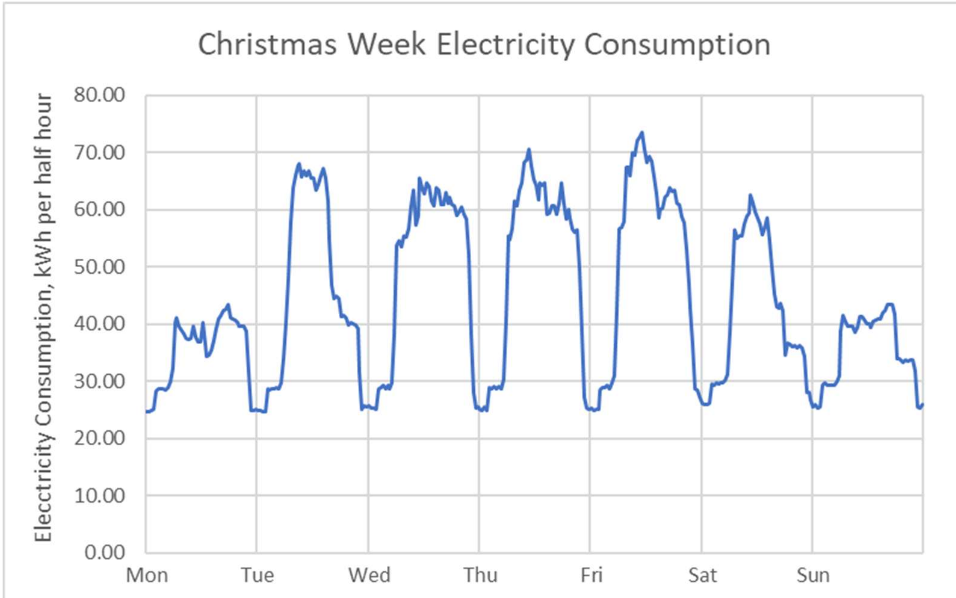



*Figure 4: Christmas week electrical consumption profile analysis*

## 3.3 Gas supply

### 3.3.1 Supply description and metering

There is a single incoming gas supply and one revenue meter records monthly gas consumption. The meter is located to the rear of the site outside the sports hall.

| Utility | MPRN | Meter Serial Number |
|---|---|---|
| **Gas** | 17965107 | M160K0278513D7 |

*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 an average unit rate of 11.4p/kWh, which is assumed to include standing charges and Climate Change Levy but exclude VAT.

### 3.3.2 Monthly consumption profile

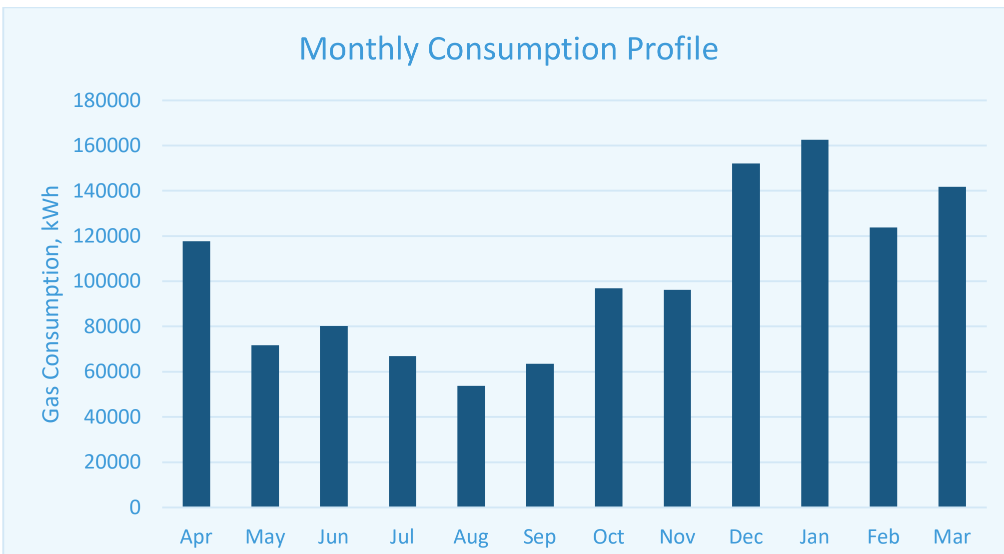



*Figure 5: Monthly Gas Consumption*

The profile displays an expected seasonal trend with higher winter consumption but with lower consumption than expected in May and November. It is noted that a biomass boiler provides the baseload heat demand at this site and therefore this profile does not show the full heat demand of 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 periods of cold 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, although it is recognised 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 $R^2$ 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 ca. 0.92 indicates a strong relationship with degree days with no significant outliers. This may suggest effective control of heating plant in the site, although it is important to note that correlation does not definitively guarantee good control in all cases. Given the variance in Biomass heat generation, this is also perhaps a stronger correlation that might have been expected.

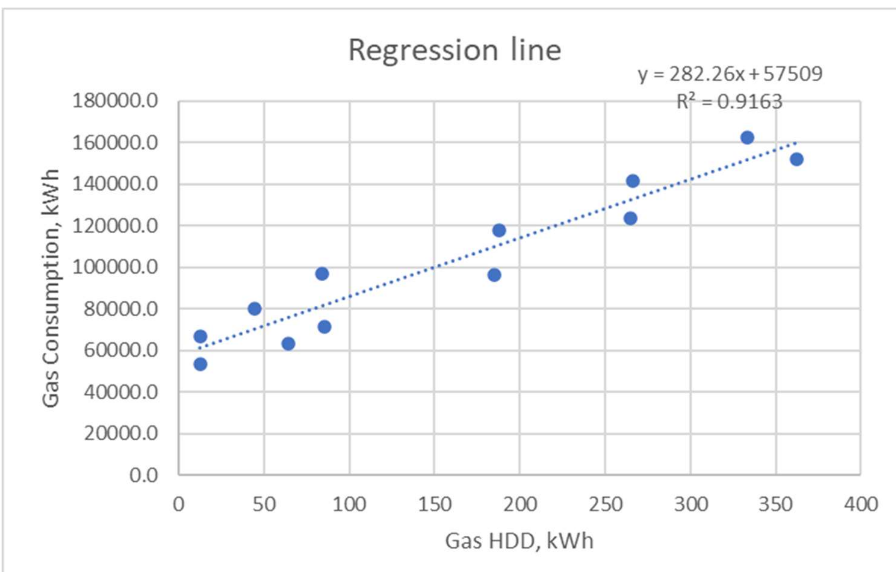



Figure 6: Gas regression analysis

## 3.4 Biomass wood pellets supply

### 3.4.1 Supply description

The supply of biomass wood pellets is delivered upon request, and the quantity is ca. 10–13 tonnes per delivery.

The current biomass wood pellets supply agreement is with AMP and the charging detail has been provided as of October 2023, which confirms the following contractual rates:

| Supplier | Rate (£/tonne) | RHI Tier 1 Tariff Rate (p/kWh) | RHI Tier 2 Tariff Rate (p/kWh) |
|---|---|---|---|
| AMP | 390.62 | 10.82 | 2.84 |

*Table 6: Biomass cost details*

### 3.4.2 Monthly consumption profile

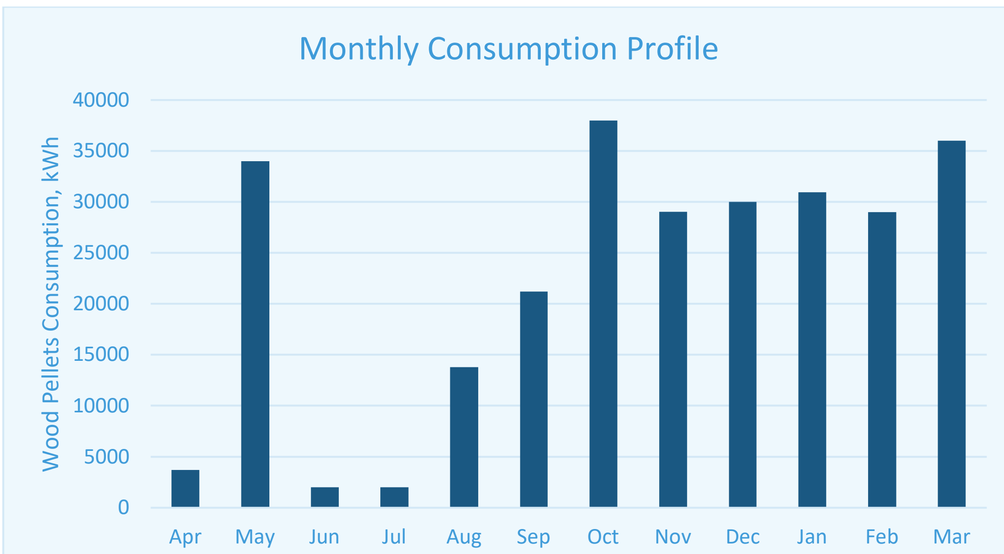



*Figure 7: Monthly Biomass Heat Generation*

The profile shows higher winter consumption but also exhibits high consumption in May. As the biomass boiler is designed to meet baseload demands, a strong seasonal trend would not be expected and it appears that, other than in May, there may have been significant downtime from April to September. Comparison of heat meter readings and biomass fuel deliveries also supports this conclusion, as it indicates a relatively low seasonal efficiency (ca. 64%) for the biomass boiler in this period.

## 3.5 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 'Dry sports and leisure facility' and 'Swimming pool centre' based on floor area weighted average of dry side and wet side and have been normalised for occupancy hours and heating degree days in accordance with TM46 guidance. Actual occupancy hours are ca. 5,252 hours per annum, compared with the benchmark of 2,754 hours per annum for dry sports and leisure facility and 2,856 per annum for swimming pool centre. 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** |
| 164.5 | 166.1 | Electricity consumption is slightly higher than the benchmark value.<br>Lighting in this site is mostly from LED fittings, while in some areas is still fluorescent fittings.<br>Space heating for some areas is provided by heat pumps. |

*Table 7: Electrical benchmark performance*

| GAS BENCHMARK PERFORMANCE | | |
|---|---|---|
| **Benchmark ($kWh/m^2$)** | **Actual Consumption per floor area ($kWh/m^2$)** | **Comments** |
| 577.6 | 327.3 | Combined gas and biomass consumption is significantly lower than the fossil fuel benchmark value.<br>It is noted that some of the heating loads are provided by heat pumps, which will contribute to reduced consumption. |

*Table 8: Fossil fuel benchmark performance*

# 4 Building Fabric

## 4.1 Overview

The Laura Trott Leisure Centre was constructed in 1984; it is of brick and block construction with cavity walls, while the  is an uninsulated, pitched roof with tile external finish.

The centre has double glazed windows throughout.

Floors are assumed to  be uninsulated concrete slabs throughout.

## 4.2 Walls

The external walls of the site are mostly brick and block cavity walls.  No existing wall openings were identified through which a borescope survey could be conducted to confirm insulation.

Based on prevailing building regulations at the time of construction we have assumed a wall U-value of 1.0 W/m$^2$.K. This would be commensurate with an uninsulated cavity wall construction.

*Figure 8: External wall*

## 4.3 Floor

The floor is believed to be an uninsulated concrete slab although full construction details could not be located.

Based on the exposed perimeter and ground floor area, we have calculated an average U-value of 0.2 W/m$^2$K.

## 4.4 Roof

The roofs of the centre are pitched roofs. There is no insulation above the suspended ceilings but we believe there to be insulation at rafter level. However, this could not be verified on site.

Based on the construction year, we have assumed an average U-value of 0.35 W/m²K according to the maximum U-value of roofs suggested in Building Regulations 1981.

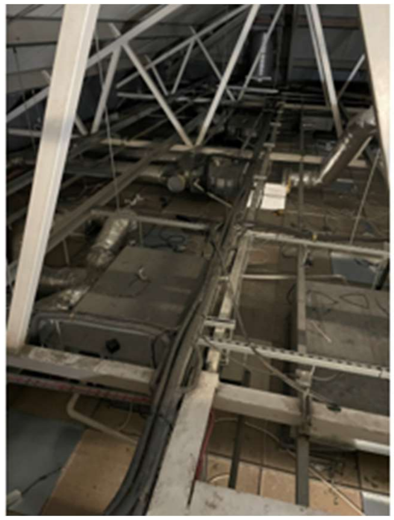


*Figure 9: Ceiling void*

## 4.5 Glazing

Most of the double glazing at the centre was found to comprise 6mm glass with ca. 18mm spacers. The windows are mostly aluminium framed and are believed to have been retrofitted during refurbishment in ca. 2013. Other double glazing types were observed, in particular around the pool hall and in the atrium at high level; these could not be accessed.

Based on the BR443 calculation methodology we have calculated a U-value of 2.5 W/m².K for this glazing.

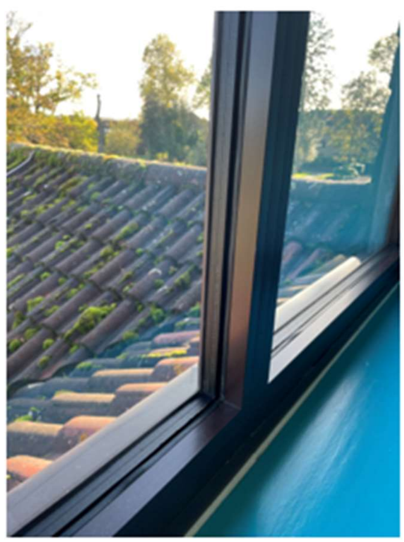


*Figure 10 Typical window*

# 5 Building services

## 5.1 Overview

Space heating is provided by gas fired boilers and biomass boiler via heating coils in AHUs, radiant panels and radiators.

Pool water heating is provide by the gas boilers and biomass boiler.

Domestic hot water is provided the gas boilers and biomass boiler via indirect calorifiers.

Space cooling is provided by A/C units serving various individual rooms.

The building is mechanically ventilated by several air handling units.

Lighting has mostly been upgraded to LED fittings, with a small number of fluorescent fittings remaining.

## 5.2 Space heating

Space heating to the site is provided by 2no. gas fired boilers and one biomass boiler.

The biomass boiler is located in a containerised biomass plant room outside the main plant room. It supplies heat to site via a 2,500 litres thermal storage vessel within the container and a plate heat exchanger (PHE) within the main plant room. It has rated heat output of 199kW and was installed in ca. 2014. This acts as the lead heat source.

2no. gas fired are located in the plant room. One of the gas fired boilers is MHS ‘UltraMax 508’ and another is an Elco ‘Ultramax R606’. These gas fired boilers are floor standing, condensing models. The rated heat output of the Elco boiler is 475.3kW. The Elco boiler was manufactured in 2017. The Ultramax 508 boiler has a nominal heat output of 502kW; the exact age of manufacture has not been confirmed but is known to be at least 12 years old.

*Figure 11: Gas fired boilers*

*Figure 12: Biomass boiler*

There is a main Constant Temperature (CT) circuit for AHUs and radiant panels, from which 2no. CT and 1no. Variable Temperature (VT) circuits are derived. The tertiary CT circuits serve pool water and DHW calorifiers respectively. The VT circuit serves a small number of radiators.

Pump ratings within the plant room are as follows:

- MHS boiler circulation pump – 1no. 720W motor
- Elco boiler circulation pump – 1no. 590W motor
- Biomass boiler primary pump to buffer - 1no. 252 motor, in containerised plant room
- Biomass PHE primary pump – 1no. 252 motor
- Biomass PHE secondary pump – 1no. 252 motor
- Main CT circuit pumps – 2no. 3kW motors and 2no. 4kW motors, two sets of two single head pumps in parallel.
- VT circuit pumps – 2no. 305W motors in parallel as duty and standby
- Pool water circulation pumps – 4no. 7.5kW motors

All pumps are controlled at fixed speed. These operate in duty/standby.

The pool water is heated via 2no. shell and tube heat exchangers fed from the main CT circuit. On the secondary side of these heat exchangers, three of the four pool circulation pumps were running during the survey.

Pipe insulation in the plant room is in poor condition in places and most valves and flanges are uninsulated.

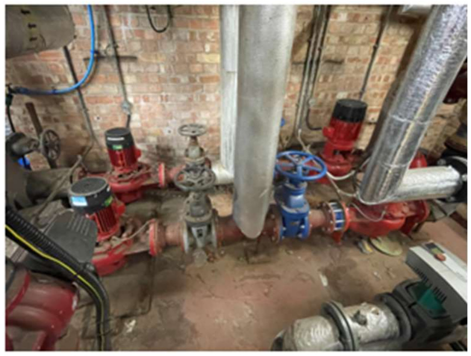


*Figure 13: Main CT pumps*

The AHUs for the pool hall, sports hall and bar area are equipped with LTHW heating coils with 3-port bypass valves as the primary means of control. The AHUs for the dry side and wet side are not equipped with heating coils, but there are LTHW local reheat coils for the supply air. The Gym AHU is equipped with direct expansion (DX) coils for heating and cooling.

There are also local ventilation units serving the café and reception area and first floor holistic room, which are also supplied with heat by LTHW coils.

There are radiant panels to provide space heating to sports hall, activity room and squash court, but it is noted that the radiant panels in the activity room are not used.

The corridors, toilets and external changing rooms are heated by radiators with thermostatic radiator valves (TRV).

Two electric over-door heaters are installed above the door entrance of the centre to provide a warm air curtain to reduce heat loss from the automatic door.


*Figure 14: A/C outdoor unit (left) and indoor unit (right)*

| PRIMARY HEAT SOURCE | | | | | |
|---|---|---|---|---|---|
| **Type** | **Make** | **Model** | **Rated Input** | **Rated Thermal Output** | **Comments** |
| 1no. gas fired boiler | MHS | UltraMax 508 | 532kW | 502kW | Floor standing and condensing model |
| 1no. gas fired boiler | Elco | Ultramax R606 | 538.3 kW | 475.3 kW | Floor standing and condensing model<br><br>Manufactured in 2017 |
| 1no. biomass boiler | D'Alessandro | CS 199 | Unknown | 199kW | Pellet fuel<br><br>Manufactured in 2014 |
| 2no. Air to Air Heat pumps | Daikin | ERQ250A7 W1B | 7.7kW each | 31.5kW each | Serves Gym AHU DX coils. Note also provide space cooling (see section 5.5 |

*Table 9: Primary Boiler Plant*

## 5.3 Domestic Hot Water

There are 3no. indirect calorifiers, each with a capacity of ca. 1,000 litres, to provide DHW to the centre. Each contains 2no. 3kW electric immersions as backup.

There is a DHW secondary circulation pump located at high level above the calorifiers but this could not be accessed.

| DOMESTIC HOT WATER | | | | | |
|---|---|---|---|---|---|
| **Type** | **Make** | **Model** | **Rated Input** | **Rated Thermal Output** | **Comments** |
| 3no. Indirect calorifiers | Flamco | 1000 litres Solar | 2 x 3kW each | 2 x 3kW each | Manufactured in 2012 |

*Table 10: Domestic Hot Water Plant*

*Figure 15: Calorifiers*

## 5.4 Ventilation

The site is mechanically ventilated by a number of Air Handling Units (AHUs).

Most of the main AHUs have supply and extract fans. They are equipped with recirculation dampers to blend return air with supply air for heat recovery; it was noted that these units originally had thermal wheels for heat recovery but these have all been removed.

The gym AHU is a supply only unit, which was original equipped with a gas-fired air heater but has been retrofitted with a DX coil.

The pool hall AHU has been recently replaced and now incorporates direct driven fans, an LTHW reheat coil and a recirculation damper. It is controlled by a dedicated controller in the plant room next to the calorifiers and main control panel, whereas other AHUs are controlled via the main BMS. The fans of the AHUs for the pool, dry side and sports hall are variable speed controlled by VSD inverters. The dry side and wet side AHUs are equipped with inverters but operate at a fixed speed.

Other than the new pool hall AHU, all of the AHUs fans are belt driven and the AHUs are considered end-of life. The recirculation damper of the wet side AHU had developed a fault on the day of the survey and was awaiting maintenance.

*Figure 16: Pool AHU*

There are some ceiling mounted ventilation units serving the café, reception and the first floor holistic room. These are controlled by local 'Nuaire' touchscreen controllers and contain LTHW heating coils.

There are 3no. through wall supply and extract ventilation units serving the first floor Dance studio.

There are some extract fans for the toilets.


*Figure 17: Local vent unit (left) and Nuaire controller (right)*

*Table 11: the dry side AHU (left) and bar AHU (right)*

| AIR HANDLING UNITS | | | | | |
|---|---|---|---|---|---|
| **REFERENCE** | **Type** | **Nominal Power (kW)** | **Serving** | **Control** | **Comments** |
| AHU1 | Supply | 11 | Sports Hall | VSD | Equipped with LTHW heating coil |
| | Extract | 11 | | VSD | |
| AHU2 | Supply | Unknown | Bar Area | Fixed speed | Equipped with LTHW heating coil |
| | Extract | Unknown | | Fixed speed | |
| AHU3 | Supply | 7.5 | Dry Side | VSD | |
| | Extract | 11 | | VSD | |
| Wet side AHU | Supply | 8.5 | Wet Side | Fixed speed | With inverters, but running in fixed speed |
| | Extract | 8.5 | | Fixed speed | |
| Kitchen AHU | Supply | Unknown | Kitchen | Fixed speed | Equipped with LTHW heating coil |
| | Extract | Unknown | | Fixed speed | |
| Pool hall AHU | Supply | Unknown | Pool Hall | VSD | Equipped with LTHW heating coil Max flow rate: 22,500 $m^3/h$ |
| | Extract | Unknown | | VSD | |
| Gym AHU | Supply | Unknown | Gym | Fixed speed | Equipped with DX coils |
| | Extract | Unknown | | Fixed speed | |
| 3no. Through wall ventilation units | Supply | Unknown | Dance studio | Unknown | |
| | Extract | Unknown | | Unknown | |
| Changing inline supply and extract | Supply | Unknown | External changing rooms | Fixed speed | Equipped with LTHW heating coil |
| | Extract | Unknown | | Fixed speed | |

| AIR HANDLING UNITS | | | | | |
|---|---|---|---|---|---|
| **REFERENCE** | **Type** | **Nominal Power (kW)** | **Serving** | **Control** | **Comments** |
| Local ventilation units | Extract | Unknown | Toilets, Café, reception and holistic room | Fixed speed | |

*Table 12: Air Handling and Ventilation plant*

## 5.5 Space Cooling

There is no centralised cooling system at this site.

As noted in the previous section, parts of the site are served by split A/C units via internal ceiling or wall cassettes. These are provided for the gym, dance studio, spin studio, studio, salons, preschool health suite and holistic room.

The gym AHU has recently been upgraded with DX coils for both heating and cooling.

The outdoor condenser units were mostly manufactured between 2013 and 2022 and were considered to be in good condition. However, the 'Sanyo' condenser units serving the dance studio were produced in 2003 and considered end-of-life.

*Table 13: A/C outdoor units*

| SPACE COOLING | | | | | | |
|---|---|---|---|---|---|---|
| **REFERENCE** | **Type** | **Nominal Electrical Power (kW)** | **Nominal Capacity (kW)** | **Make** | **Model** | **Serving** |
| 2no. A/C Units | Outdoor Unit | Heating: 5.12 Cooling: 4.18 | Heating: 16 Cooling: 14 | Sanyo | SPW-CR483EHL8 | Dance studio |
| 2no. A/C Units | Outdoor Unit | Heating: 2.94 Cooling: 2.84 | Heating: 10.8 Cooling: 9.5 | Daikin | RZQSG100L8Y1B | Spin studio |
| 1no. A/C Units | Outdoor Unit | Heating: 5.93 Cooling: 5.21 | Heating: 22.4 Cooling: 19 | Mitsubishi | PUZ-M200YKA2 | Gym |
| 1no. A/C Units | Outdoor Unit | Heating: 3.53 Cooling: 3.2 | Heating: 13.5 Cooling: 12 | Daikin | RZQG125L8Y1B | Gym Mezzanine |
| 1no. A/C Units | Outdoor Unit | Heating: 13.45 Cooling: 8.4 | Heating: 56.5 Cooling: 50.4 | Daikin | RYYQ18U7Y1B | Gym |
| 2no. heat pumps | Outdoor Unit | Heating: 7.7 Cooling: 7.42 | Heating: 31.5 Cooling: 28 | Daikin | ERQ250A7W1B | Gym AHU DX coils |
| 1no. A/C Units | Outdoor Unit | Heating: 2.9 Cooling: 3 | Heating: 10 Cooling: 8.5 | Fujitsu | AOY30LMBWL | Salon |
| 1no. A/C Units | Outdoor Unit | Heating: 6.74 Cooling: 6.23 | Heating: 23 Cooling: 20 | Daikin | RZQ200C7Y1B | Health suite |
| 1no. A/C Units | Outdoor Unit | Heating: 2.8 Cooling: 2.75 | Heating: 7.5 Cooling: 6.8 | Samsung | AC071RXADKG | Holistic room |
| 1no. A/C Units | Outdoor Unit | Heating: 6.74 Cooling: 6.23 | Heating: 23 Cooling: 20 | Daikin | RZQ200C7Y1B | Preschool |
| 1no. A/C Units | Outdoor Unit | Heating: 2.28 Cooling: 2.15 | Heating: 8 Cooling: 7.1 | Mitsubishi | SUZ-M71VA | Youth gym |

*Table 14: Space cooling plant*

## 5.6 Lighting

### 5.6.1 Internal Lighting

Internal lighting to this site is mostly from LED fittings. LEDs in changing rooms, spin studio, foyer and the ground floor corridors are controlled by passive infrared (PIR) sensors, while in other areas are controlled manually.

Lighting in only a few areas is provided by fluorescent fittings, including 6ft T8 fluorescent tubes in the squash court and the activity room, 4ft T5 tubes in the sports hall, circular fluorescent tubes in the bar area and compact fluorescent lamp (CFL) downlights on the first floor level of the atrium and corridor.

*Table 15: T8 fluorescent tubes in squash court (left) and LED panels in the ground floor corridor*

### 5.6.2 External Lighting

There are external LED lighting columns at the front of the building and LED building mounted floodlights. These lights are controlled by a time clock, turning on from 15:30hrs to 08:00hrs, but has 1 hour ahead BST.

The carpark lighting is a mix of fluorescent and LED. There is a timeclock in the main plant room for car park lighting but this is no longer used. These light fittings are being replaced with LED on failure with PIRs added.

*Table 16: LED floodlight*

## 5.7 Building Management System

The site has a Trend BMS with IQ4 controllers in the main control panels. The head end computer is located in the site manager's office near the plant room.

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 on site.

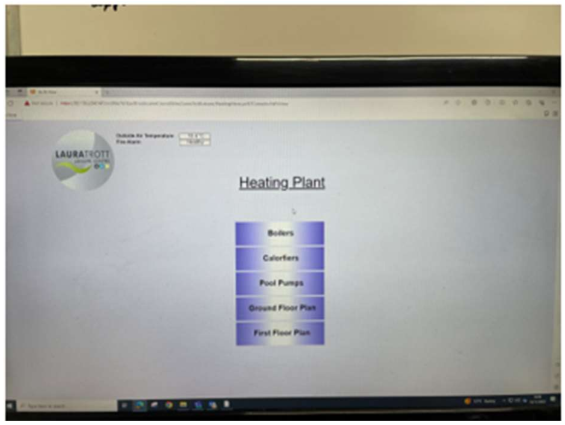



*Table 17: BMS interface*

The BMS schedules observed during the site visit are as follows:

| Plant | BMS schedule |
|---|---|
| Main heating | 05:00hrs to 22:00hrs Monday to Sunday |
| AHU1 | 06:00hrs to 21:00hrs Monday to Sunday |
| AHU2 | 10:00hrs to 18:00hrs Sunday and Monday<br>11:00hrs to 18:00hrs Tuesday<br>09:30hrs to 18:00hrs Wednesday and Thursday<br>18:30hrs to 23:45hrs Friday and Saturday |
| AHU3 | 05:45hrs to 22:00hrs Monday, Thursday and Friday<br>06:00hrs to 22:00hrs Tuesday and Wednesday<br>06:30hrs to 18:00hrs Saturday and Sunday |
| Wet Side AHU | 05:00hrs to 22:30hrs Monday to Sunday |
| Kitchen AHU | 05:00hrs to 19:00hrs Sunday |
| Gym AHU | 06:00hrs to 22:00hrs Monday to Thursday<br>06:00hrs to 21:00hrs Friday<br>06:00hrs to 18:00hrs Saturday and Sunday |
| Dance Studio A/C units | Schedule programmed for individual room bookings only<br>Ca. 29 hours per week |

*Table 18: Summary of BMS schedules*

BMS setpoints observed in the main BMS are as follows:

| Setpoint | Temperature |
|---|---|
| Sports hall supply setpoint | 24°C |
| Dry side male change supply setpoint | 26°C |
| Dry side female change supply setpoint | 26°C |
| Retreat supply setpoint | 27°C |

| | |
|---|---|
| Kitchen supply setpoint | 26°C |
| Wet side male change supply setpoint | 28°C |
| Wet side female change supply setpoint | 28°C |
| Reception supply setpoint | 18°C |
| Office areas supply setpoint | 25°C |
| Gym temperature setpoint | 19°C |
| Studios temperature setpoint | 18°C |

*Table 19: Summary of BMS setpoints*

The temperature setpoints of the boilers and calorifiers were not displayed, but the measured flow temperature of the boilers was 55°C and water temperature setpoints in the calorifiers were from ca. 49°C to 51°C. It is important to note that water stored at temperatures below 60°C may pose a risk of bacterial growth, including Legionella.

The pool AHU has a dedicated Honeywell controller, which gives air flow rates, minimum fresh air volumes, humidity setpoints and temperatures. This AHU operates continuously. The main setpoints for the pool AHU are as follows:

| Setpoint | Setting |
|---|---|
| Pool hall temperature setpoint during pool open | 28°C |
| Pool hall temperature setpoint during pool closed | 30°C |
| Humidity setpoint | 60% |
| Supply fan high air flow rate | 22,500 $m^3/h$ |
| Supply fan low air flow rate | 15,000 $m^3/h$ |
| Return fan high air flow rate | 23,688 $m^3/h$ |
| Return fan low air flow rate | 15,792 $m^3/h$ |
| Minimum fresh air volume | 30% |
| Minimum supply temperature setpoint | 22°C |
| Maximum supply temperature setpoint | 45°C |

*Table 20: Summary of pool AHU setpoints*

The pool water temperature is set to 29°C.

There are individual room controllers for most AC units and local ventilation units. The AC units in the spin studio are programmed to bookings while in the first floor studio AC is manually turned on and off, and may occasionally be left on outside bookings.

The local ventilation unit controllers are 'Nuaire' touchscreen models, and those behind reception and in the holistic suite were not functional; these units are said to break regularly. There were two functional controllers for the Café units

## 5.8 Small Power

Small power loads are relatively limited and include a small number of computers behind reception and in the first-floor office, gym equipment, hand driers and a small number of vending machines.

## 5.9 Catering

There is a café kitchen and a bar at the site. The catering appliances are all electric, including

- 2no. microwaves

- Oven
- Deep fryer
- Some commercial fridge and freezer units
- Chilled drinks cabinets

*Table 21: Kitchen appliances*

## 5.10 On-site generation and renewable energy sources

There is a solar PV array with 50 PV panels on the south-facing pitched roofs and 162 PV panels on the west-facing pitched roofs, providing a maximum rated output of ca. 51 kW. There are 4no. 12kW inverters installed on the exterior of the building outside the main plant room.

There is no other on-site generation.

*Table 22: Solar PV Inverters*

# 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 'leaky' setting for windows for air permeability within the software. This gives a result of 0.74 $m^3/h/m^2$. This equates to approximately 9.7$m^3/h/m^2$ 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, the London Weather Centre, which incorporates a mix of ground data and NASA global satellite climate data.

#### 6.1.4 Energy cost

We have assumed a rate of 11.4p/kWh for gas, 44.25p/kWh for electricity and £390.62/tonne (ca. 13.73p/kWh) for wood pellets.

## 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 | 1,227,373 | 0.18254 | 224.2 |
| Grid Electricity | Scope 2 | 885,321 | 0.19338 | 162.1 |
| Wood pellets | Scope 1 | 424,557 | 0.01053 | 4.5 |
| **Total Emissions** | | | | **390.8** |

*Table 23: Baseline carbon emission from RETScreen model*

Note that this includes 46,994kWh for PV generation and the model therefore assumes that all of this is used directly on site.

Electricity consumption in the baseline model (141.8 kWh/m$^2$ per annum) is very similar to actual metered consumption (141.8 kWh/m$^2$ per annum).

The consumption of gas in the baseline model (207.7 kWh/m$^2$ per annum) is also similar to actual metered consumption (207.5 kWh/m$^2$ per annum).

The consumption of wood pellets in the baseline model (71.8 kWh/m$^2$ per annum) is also similar to actual consumption (71.8 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.

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

## 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 as follows:

| Area | Internal Setpoint Temperature | Calculated Peak Heat Loss | Total Peak Heat Loss |
|---|---|---|---|
| Pool hall | 28°C | 413kW | 1308kW |
| Sports hall | 16°C | 232kW | |
| Gym | 19°C | 111kW | |
| Change rooms | 21°C | 60kW | |
| Squash court | 16°C | 10kW | |
| Studios | 16°C | 110kW | |
| Kitchen | 16°C | 16kW | |
| Other areas | 19°C | 356kW | |

*Table 24: Calculated peak heat losses*

The calculated peak heat loss does not include DHW and pool water demands. The rated output of the existing DHW calorifiers and pool water plate heat exchangers is not known.

We have estimated pool evaporation heat losses based on the commonly used Biasin and Krumme method, which suggests a typical heat load in the region of ca. 75kW for the pool. The calculated peak heat loss plus pool water load is ca. 1383kW with areas heated by air- to-air heat pumps accounting for ca. 281kW and areas heated by boilers accounting for ca. 1,102kW. The latter is slightly lower than the existing boiler capacity of 1,176kW.

It is assumed for the purposes of this report that the additional boiler capacity equates roughly to DHW loads but may also include some 'plant size ratio' to facilitate heating of the swimming pool from cold within a reasonable timeframe.

# 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 Laura Trott Leisure Centre we have identified the measures as shown below.

## 7.2 Energy Saving

### 7.2.1 Pool hall temperature setpoint adjustment

We observed that the current pool hall temperature setpoint is set to 28°C during use, which is lower than the pool water temperature of 29°C. The pool hall temperature should be at least 1°C above the water temperature during use but can be set back overnight. Having the pool hall temperature higher than the water temperature would reduce the pool water load.

We have modelled with a temperature setpoint of 30°C during use and set back to 28°C overnight, resulting in a carbon reduction of ca. 15.2 tonnes of $CO_2e$ per year for this measure.

### 7.2.2 Summary of savings for energy efficiency measures

Table 25 shows the summary of savings for energy efficiency measures.

| Measure | Saving, kWh/yr | Saving, £/yr | Saving, $tCO_2e/yr$ |
|---|---|---|---|
| Pool hall temperature setpoint adjustment | 83,517 | 9,521 | 15.2 |

*Table 25: Summary of savings for energy saving measures*

## 7.3 Energy Efficiency

### 7.3.1 Plant room pipework and valve insulation

We observed that some small sections of pipework insulation are damaged and most valves and flanges are uninsulated.

We estimate that approximately 1m of pipework and 30no. valves are uninsulated or with insulation damaged. The below saving is estimated based on a heat loss saving of 68W per metre of pipework.

We have modelled a carbon reduction of ca. 1.3 tonnes of $CO_2$e per year for this measure.

### 7.3.2 Replacement of AHUs

All main AHUs except the pool hall AHU have belt driven fans and are end-of-life. These could be replaced to include direct driven variable speed fans. The existing belt driven fans introduce additional losses and require additional maintenance. Utilising direct drive fan with variable speed control would significantly reduce fan energy usage.

We have modelled a carbon reduction of ca. 56.9 tonnes of $CO_2$e per year for this measure.

### 7.3.3 Variable speed pumping

All pumps are controlled at fixed speed. Variable speed control could be introduced for the major pumps such as the main CT circuit pumps and pool circulation pumps to automatically vary pumpspeed. There is a non-linear relationship between pump speed and pump power and small reductions in speed result in large energy savings.

While variable speed pumps could be implemented relatively easily, the AHU valves would need to be converted from 3-port to 2-port control to see significant benefit.

We have modelled a carbon reduction of ca. 17.5 tonnes of $CO_2$e per year for this measure.

### 7.3.4 Control upgrade for A/C in studio

The operational schedules of A/C units in the dance studio are manually programmed for individual room bookings. However, human error may lead to inconsistencies between A/C unit operation and room bookings. In some other areas, AC is manually controlled only. Controlling A/C using Photo Infrared (PIR) motion sensors would optimize operational hours and avoid manual adjustment of operational schedules.

The savings are indicative and highly dependent on the existing manual control by occupants. We have estimated that half an hour of operational time for dance studio A/C units could be saved per day and modelled a carbon reduction of ca. 0.4 tonnes of $CO_2$e per year for this measure.

### 7.3.5 Replacement of remaining T8 and CFL lighting

While most lighting has been replaced with LED equivalents, some CFL and T8 fluorescent fittings remain in the corridors, activity room, bar area and squash court. Replacement with modern LED equivalents would yield significant energy savings.

In addition to energy savings, LED lighting typically has a longer service life, up to 50,000 hours compared with 15,000 hours for fluorescent fittings. This would lead to additional lifetime benefits.

We have modelled a carbon reduction of ca. 1.2 tonnes of $CO_2$e per year for this measure.

### 7.3.6 Summary of savings for energy efficiency measures

Table 26 shows the summary of savings for energy efficiency measures.

| Measure | Saving, kWh/yr | Saving, £/yr | Saving, $tCO_2e$/yr |
|---|---|---|---|
| Plant room pipework and valve insulation | 7,100 | 809 | 1.3 |
| Replacement of AHUs | 305,505 | 69,675 | 56.9 |
| Variable speed pumping | 90,502 | 40,047 | 17.5 |
| Control upgrade for A/C in studio | 1,869 | 827 | 0.4 |
| Replace remaining T8 and CFL lighting | 6,288 | 2,782 | 1.2 |

*Table 26: Summary of savings for energy efficiency measures*

## 7.4 Low Carbon Heat Sources

Part of the site's heating load is currently supplied by a biomass boiler, which is approximately halfway through its expected 10-year life cycle. However, the majority of the site's heat demand is still met by gas boilers. While Biomass is already considered a low carbon heating option, decarbonisation of heat typically requires direct combustion of fossil fuels on site to be removed or minimised. Therefore, heat decarbonisation is likely to involve electrification of remaining gas boiler loads, with heat pumps typically providing the most efficient solution.

When implementing the heat pump option, it will be necessary to ensure that the 199kW biomass boiler still has a sufficient load to ensure continuous running as at present. Therefore, it is suggested that the pool water, pool AHU and DHW loads remain connected to the biomass as the primary heat source, and that top up for these, as well as other heating demands, could be addressed using the following low carbon heating options:

### 7.4.1 Air Source Heat Pump

Air Source Heat Pumps (ASHP) 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 to the site.

Using ASHPs would increase the grid electricity demand significantly. The current electricity supply is 350kVA, and we estimate that the site may require up to ca. 980kW of additional available supply capacity with heat pumps, based on the calculated peak heat load and accounting for existing biomass capacity. This is subject to further feasibility discussion with the District Network Operator (DNO).

ASHPs could be in the form of either central air to water heat pumps (AWHP) serving a low flow temperature wet system with larger heat emitters, or air to air heat pumps (AAHP). It may be beneficial to utilise both of these across the building depending for individual heat loads (e.g. AHUs, radiators, pool water etc).

#### *7.4.1.1 Air to Water Heat Pump*

AWHPs transfer heat to water in a conventional heating distribution system but for efficient operation, the flow temperatures would need to be reduced and would therefore be incompatible with the existing distribution system served by the biomass boiler. Therefore an AWHP system could be installed to replace the gas fired boilers but this would likely form a largely separate system to the biomass boiler. Specifically AWHPs would likely serve all AHUs with LTHW coils other than the pool AHU, all local reheater batteries and all radiators. It may also be used as a top up heat source for the swimming pool water.

It is likely that a full replacement of the distribution pipework, pumps, AHU coils and local reheaters, and radiators would be required to facilitate reduced flow temperatures for this option, typically 45-50°C.

It is assumed that in all cases the biomass would continue to serve the pool water, pool AHU and DHW loads but based on modelled heat loads would require a new backup or top-up heat source if gas boilers were removed.

For the pool AHU top up, a separate AAHP system with a new DX coil could be added. For pool water heating, a secondary PHE served by a low temperature AWHP could be added to top up pool water temperature when required. For DHW, top up could be from either a direct electric boiler and/or larger DHW immersion coils. A high temperature AWHP could potentially be used for this purpose but requires careful consideration if used as top up only; this option would be more expensive to install and less efficient than a low temperature heat pump but would be cheaper to run than direct electric boilers.

Based on the recommendations of CIBSE AM15, in all cases, the backup must be configured to only operate when given setpoints, such as biomass return temperature, drop below a given value indicating the biomass is unable to meet the load. This requires very careful design.

The area immediately outside the existing plant room doors is a car park with an electric vehicle charge point, and therefore is potentially unsuitable for installation of the external ASHP units. The containerised biomass plant room occupies most of the remaining space adjacent to the plant room. There is a small grass areas remaining alongside the biomass compound; this compound could potentially be enlarged to accommodate new ASHP units. Due to proximity of residential buildings and increased noise and visual impact, it would not be recommended to locate an ASHP plant compound to the South or East of the building. The available space is therefore likely to be a limiting factor for implementation of AWHPs.

#### *7.4.1.2 Air to Air Heat Pump*

There is potential to use AAHPs for all of the AHUs instead of AWHPs, to avoid replacing long sections of LTHW distribution pipework. AAHPs deliver heat energy directly from the refrigerant coil to the load, in this case DX coils in AHUs, as per the existing gym AHU. This is also more efficient than the equivalent AWHP system.

This option would incorporate multiple heat pump units distributed throughout the site nearer to end loads such as AHUs, similar to the existing DX units serving the Gym AHU. Some could be roof mounted alongside existing DX units. Therefore, there would be less need for external plant space near the existing plant room.

Reheater batteries in ductwork from AHU 3 and the Nuaire local ventilation units could be replaced with split systems serving new ceiling cassettes in the occupied spaces.

There are a few radiators in the atrium, external changing rooms and stairwells. In stairwells, AWHPs would be required if retaining radiators, and one heat pump unit could be fitted to each stairwell with the pipework isolated from the rest of the existing LTHW system. In the atrium, the radiator could be removed and supplemented with a larger reheater battery from AHU 3. In the external changing rooms, the LTHW coil for the supply fan could be replaced with electric heater batteries as these rooms have quite minimal use.

We have assumed a Seasonal Coefficient of Performance of all ASHPs to be 3. We have modelled a carbon reduction of ca. 121.9 tonnes of $CO_2$e per year for this measure.

### 7.4.2 Ground Source Heat Pump

Closed loop Ground Source Heat Pumps (GSHPs) could be utilised to provide space heating, with either multiple borehole collectors installed to a depth of up to ca. 200m or a horizontal loop collector. Alternatively, subject to further detailed study, it may be possible to implement an open loop ground water collector.

This option would use the large grass area to the East of the building, which has an area of ca. 4,500m$^2$ and is understood to be owned by the Council.

The soil type in this area is believed to be clay, silt and sand according to BGS Geology of Britain map viewer, and we believe an output of ca. 40W/m of ground collector would be achievable. With 200m borehole depth, a maximum number of ca. 123 boreholes would be required to meet the non-biomass load of the site and this could be accommodated within the ca. 4,500m$^2$ grass area with appropriate borehole spacing. During detailed design, it will be necessary to undertake thermal response testing, which will establish the actual peak output of the system.

The ground may hold sufficient ground water to implement an open loop collector; this would require a detailed study at significant up front cost in order to confirm sufficient resource. However, if feasible, it would reduce installation costs, disruptions, and timescales considerably.

An electric boiler would be installed as backup for the pool water and larger immersions would be necessary for DHW calorifiers.

As with ASHP, GSHP would require an additional available grid supply capacity of up to ca. 980kW, which is subject to further feasibility with the DNO.

We have assumed the Seasonal Coefficient of Performance of GSHP to be 4. We have modelled a carbon reduction of ca. 134.3 tonnes of $CO_2$e per year for this measure.

### 7.4.3 Direct electric heating

The existing AHUs LTHW coils and distribution could be replaced by electric heater batteries and radiators could be replaced by wall mounted electric heaters.

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. 980kW. This is subject to further feasibility discussion with the DNO.

The running cost of direct electric heating would be significantly 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. 23.4 tonnes of $CO_2$e per year for this measure.

### 7.4.4 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 such it could be typically installed alongside the biomass system.

At the Laura Trott Leisure Centre solar thermal could potentially contribute a proportion of the pool water and DHW demands. The roof spaces shown in Figure 18 offer a total of ca. 70m$^2$ of unshaded roof area for installation of solar arrays within reasonable proximity to the existing DHW calorifiers. It is estimated that solar thermal installed here could generate approximately 6% of the annual pool water and DHW loads.

*Figure 18: Areas for solar thermal array installation*

However, the pool water and DHW loads are currently the baseload demands supplied by the biomass, which is already a low-carbon heating system. Biomass normally needs to run continuously at high output for efficiency and therefore, it is not advised to add solar thermal for these loads unless there is significant additional load that the biomass cannot meet.

On this basis, to avoid potential detrimental impact on biomass performance, we have discounted solar thermal from further consideration at LTLC.

### 7.4.5 Summary of savings for low carbon heating measures

Three main low carbon heating options have been identified, namely ASHP, GSHP and direct electric heating. Table 27 shows the summary of savings for low carbon heating measures.

| Measure | Saving, kWh/yr | Saving, £/yr | Saving, $tCO_2e$/yr |
|---|---|---|---|
| Air source heat pump | 683,187 | -5,827 | 121.9 |
| Ground source heat pump | 746,894 | 22,363 | 134.3 |
| Direct electric heating | 173,533 | -231,349 | 23.4 |

*Table 27: Summary of savings for low carbon heating measures*

## 7.5 On Site Renewable Energy

### 7.5.1 Solar PV

Additional solar photovoltaics (PV) could be installed as there are additional feasible roof areas of ca. 412m$^2$ unshaded roof areas as shown in Figure 19, which could support the installation of solar PV instead of solar thermal.

From the available roof area we estimate that a 53kW system could be accommodated. Based on electricity consumption data for 2022/23, we estimate that the system would generate around 6% of current site electricity demand.

However, the cost effectiveness is reduced with increased export, due to the relative value of export payments (via the Smart Export Guarantee) compared to direct bill savings is reduced.

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

We have modelled a carbon reduction of ca. 10.1 tonnes of $CO_2e$ per year for this measure.

In comparison with Table 27 the figures in Table 28 suggest that both cost and financial savings from solar PV would be greater than from solar thermal. Therefore solar thermal will be excluded from further analysis.

*Figure 19: Areas for solar PV array installation*

| Measure | Saving, kWh/yr | Saving, £/yr | Saving, $tCO_2e$/yr |
|---|---|---|---|
| 53kWp solar PV system | 52,148 | 23,075 | 10.1 |

*Table 28: Summary of savings from renewable energy measures*

# 8 Decarbonisation Pathways

All of the measures discussed in Sections 7.3 to 7.4 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 the planned implementation timescale of each measure.

Three different heat decarbonisation options are shown for the Laura Trott Leisure Centre – ASHP, GSHP and direct electric heating. 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.

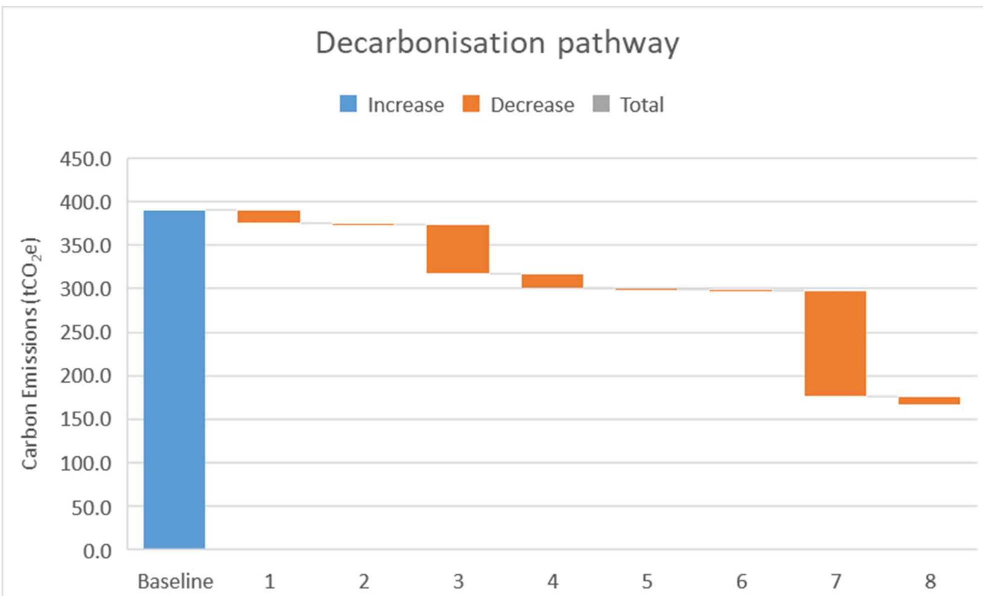



*Figure 20: Water fall diagram of cumulative reductions – ASHP scenario*

| | Stage | Benefit ($tCO_2e$) | Total emissions ($tCO_2e$) |
|---|---|---|---|
| Baseline | Baseline | - | 390.8 |
| Pool hall temperature setpoint adjustment | 1 | -15.2 | 375.5 |
| Plant room pipework and valve insulation | 2 | -1.3 | 374.2 |
| Replacement of AHUs | 3 | -56.9 | 317.3 |
| Variable speed pumping | 4 | -17.5 | 299.8 |
| Control upgrade for A/C in studio | 5 | -0.4 | 299.4 |
| Replace remaining T8 and CFL lighting | 6 | -1.2 | 298.2 |
| ASHP | 7 | -121.9 | 176.3 |
| Solar PV | 8 | -10.1 | 166.2 |

*Table 29: Cumulative carbon reductions – ASHP scenario*

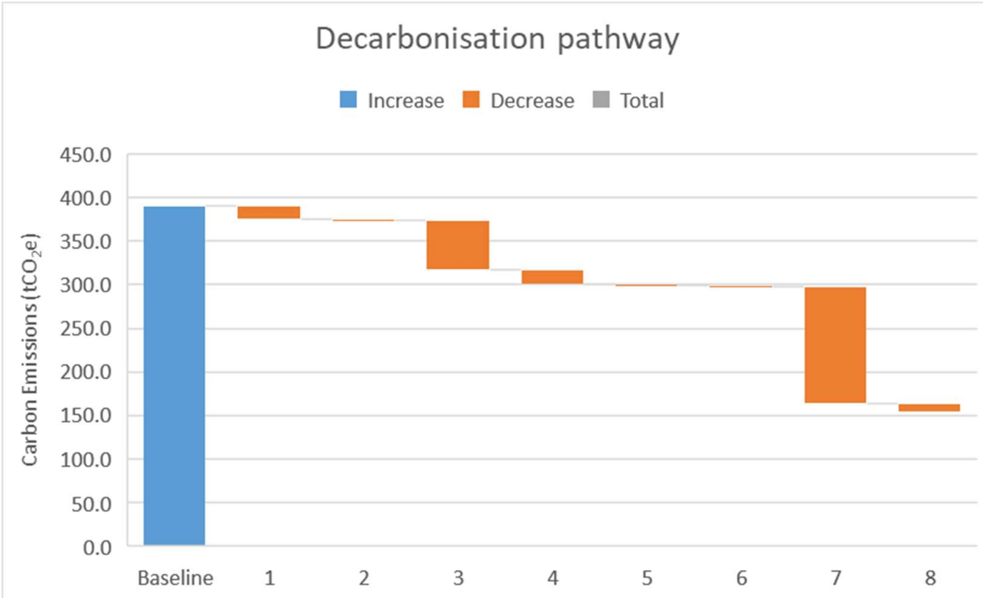



*Figure 21: Water fall diagram of cumulative reductions – GSHP scenario*

| | Stage | Benefit ($tCO_2e$) | Total emissions ($tCO_2e$) |
|---|---|---|---|
| Baseline | Baseline | - | 390.8 |
| Pool hall temperature setpoint adjustment | 1 | -15.2 | 375.5 |
| Plant room pipework and valve insulation | 2 | -1.3 | 374.2 |
| Replacement of AHUs | 3 | -56.9 | 317.3 |
| Variable speed pumping | 4 | -17.5 | 299.8 |
| Control upgrade for A/C in studio | 5 | -0.4 | 299.4 |
| Replace remaining T8 and CFL lighting | 6 | -1.2 | 298.2 |
| GSHP | 7 | -134.3 | 164.0 |
| Solar PV | 8 | -10.1 | 153.9 |

*Table 30: Cumulative carbon reductions – GSHP scenario*

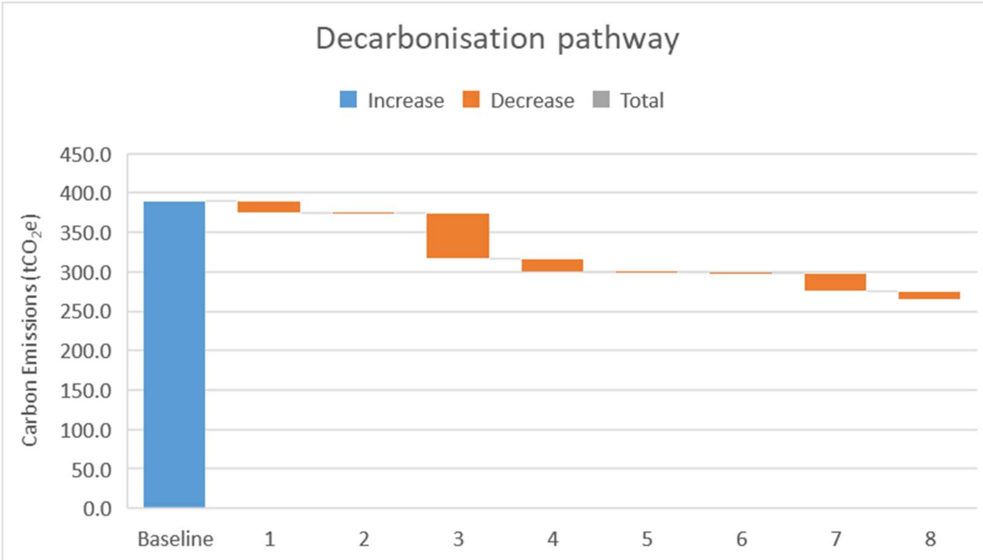



*Figure 22: Water fall diagram of cumulative reductions – direct electric heating scenario*

| | Stage | Benefit ($tCO_2e$) | Total emissions ($tCO_2e$) |
|---|---|---|---|
| Baseline | Baseline | 389.0 | 390.8 |
| Pool hall temperature setpoint adjustment | 1 | -15.2 | 375.5 |
| Plant room pipework and valve insulation | 2 | -1.3 | 374.2 |
| Replacement of AHUs | 3 | -56.9 | 317.3 |
| Variable speed pumping | 4 | -17.5 | 299.8 |
| Control upgrade for A/C in studio | 5 | -0.4 | 299.4 |
| Replace remaining T8 and CFL lighting | 6 | -1.2 | 298.2 |
| Direct electric heating | 7 | -23.4 | 274.8 |
| Solar PV | 8 | -10.1 | 264.7 |

*Table 31: Cumulative carbon reductions – direct electric heating 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) in the 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 32: 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 33: Predicted Emissions Factors*

The impact of changing emissions factors for Laura Trott Leisure Centre 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, and the emissions factor of wood pellets remains unchanged.

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) | 161.7 | 173.2 | 157.5 | 143.2 | 130.2 | 118.4 |
| Wood pellets (Scope 1) | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| **Total** | **166.2** | **177.7** | **162.0** | **147.7** | **134.7** | **122.9** |

*Table 34: Impact of changing carbon factors*

The impact of the decarbonisation of the national grid means that the footprint could reduce by a further 43.3 $tCO_2e$ 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 pipework and valve insulation

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

| Item | Qty | Cost ea. | Sub-total |
|---|---|---|---|
| Installation of pipe insulation, per m | 1 | £30 | £30 |
| Installation of valve insulation, per m | 15 | £50 | £750 |
| Installation | 16 | £20 | £320 |
| **TOTAL** | | | **£1,100** |

*Table 35: Pipe and 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. We have assumed a specific fan power of 1.5W per l/s, which indicates limiting values for different buildings. This indicates a total air volume for supply and extract of ca. 30 $m^3/s$ based on existing fan motor ratings.

We have also added a provisional sum for control integration, allowance for access and installation, 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 m3/s | 30 | £12,000 | £360,000 |
| Control integrations | Provisional sum | £30,000 | £30,000 |
| Allowance for access and installation | Provisional sum | £20,000 | £20,000 |
| Design and making good | 30% | - | £123,000 |
| **TOTAL** | | | **£533,000** |

*Table 36: Replacement of AHUs cost estimate*

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

### 9.1.3 Variable speed pumping

We have estimated the cost of new pumps with integral pressure controlled VSDs based on market prices and 2-port control valves based on SPONs price book rates.

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 new pumps | 8 | £2,500 | £20,000 |
| Supply and install of AHU 2-port valves | 6 | £230 | £1,380 |
| Control integrations | Provisional sum | £10,000 | £10,000 |
| Design and making good | 30% | - | £9,414 |
| **TOTAL** | | | **£41,000** |

*Table 37: Variable speed pumping cost estimate*

### 9.1.4 Control upgrade for A/C in studio

We have estimated the cost of installing PIR motion sensors based on typical market rates from supplier websites.

We have added a provisional sum for control integration.

| Item | Qty | Cost ea. | Sub-total |
|---|---|---|---|
| Supply and installation of PIR sensor for A/C units | 2 | £150 | £300 |
| Control integrations | Provisional sum | £500 | £500 |
| **TOTAL** | | | **£800** |

*Table 38: Control upgrade for A/C in studio cost estimate*

### 9.1.5 Replacement of remaining T8 and CFL lighting

We have estimated the number of fittings based on the number of fittings observed during survey. We have allowed for installation and emergency fitting costs as extra components.

| Item | Qty | Cost ea. | Sub-total |
|---|---|---|---|
| Supply of LED per unit | 50 | £30 | £1,500 |
| Installation standard fittings per unit | 50 | £30 | £1,500 |
| Extra for emergency fittings to 10% | 5 | £70 | £350 |
| Design and making good | 30% | - | £1,005 |
| **TOTAL** | | | **£4,400** |

*Table 39: Replacement of remaining T8 and CFL lighting with LED cost estimate*

### 9.1.6 Air Source Heat Pumps

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. 1,457kW (section 6.3) including pool water and DHW loads, where ca. 281kW is heated by existing heat pumps (Gym AHU) and 199kW is heated by existing biomass boiler. The cost to supply and install ASHPs has been estimated based on past manufacturer estimates.

For the backup or top-up to the biomass loads, a separated DX system has been included for the pool AHU, a secondary PHE served by a low temperature AWHP is included for pool water top up, and a high temperature heat pump system is added for the DHW.

Table 40 shows the cost estimate for a solution using predominantly AWHPs, including replacement components required to facilitate reduced flow temperatures. We have added costs for new thermal storage, upgrade of DHW calorifier immersions and provisional sums for complete replacement of distribution pipework and control integrations.

Table 41 shows the cost estimate for a solution using predominantly AAHP including replacement of all AHU coils and local reheat coils. We have added costs for upgrade of DHW calorifier immersions and provisional sums for removal of distribution pipework and control integrations.

We have also included the cost of upgrading the grid electricity supply and additional costs for design and making good at 30% of the base cost. While AWHP and AAHP options are presented as separate costs, the site may utilise a mix of AWHP and AAHP suited to specific end loads.

| Item | Qty | Cost ea. | Sub-total |
|---|---|---|---|
| Supply and installation of ASHP per kW | 977 | £1,300 | £1,270,100 |
| Plant compound | 1 | £10,000 | £10,000 |
| Replacement of distribution system | Provisional sum | £50,000 | £50,000 |
| Replacement of AHU coils and local reheat coils | 10 | £5,000 | £50,000 |
| New PHE to top up pool water | 1 | £5,000 | £5,000 |
| New DX coil to top up pool AHU | 1 | £5,000 | £5,000 |
| New thermal storage cylinder | 1 | £5,000 | £5,000 |
| Replacement of DHW calorifiers immersions | 3 | £2,000 | £6,000 |
| New pump | 4 | £2,500 | £10,000 |
| Control integrations | Provisional sum | £20,000 | £20,000 |
| Grid electricity supply upgrades | Provisional sum | £100,000 | £100,000 |
| Design and making good | 30% | - | £459,330 |
| **TOTAL** | | | **£1,990,000** |

*Table 40: AWHP cost estimate*

| Item | Qty | Cost ea. | Sub-total |
| --- | --- | --- | --- |
| Supply and installation of ASHP per kW | 977 | £1,300 | £1,270,100 |
| Removal of LTHW distribution system | Provisional sum | £20,000 | £20,000 |
| Replacement of AHU coils and local reheat coils | 10 | £5,000 | £50,000 |
| New PHE to top up pool water | 1 | £5,000 | £5,000 |
| New DX coil to top up pool AHU | 1 | £5,000 | £5,000 |
| New thermal storage cylinder | 1 | £5,000 | £5,000 |
| Replacement of DHW calorifiers immersions | 3 | £2,000 | £6,000 |
| Control integrations | Provisional sum | £20,000 | £20,000 |
| Grid electricity supply upgrades | Provisional sum | £100,000 | £100,000 |
| Design and making good | 30% | - | £444,330 |
| **TOTAL** | | | **£1,925,000** |

*Table 41: AAHP cost estimate*

### 9.1.7 Ground source heat pump

Pricing for GSHPs is subject to detailed design to determine the capacity of plant items, which is beyond the scope of this study. However, as with the ASHP options an estimated capacity of ca. 903 kW was assumed. The cost to supply and install the GSHP was based on past manufacturer estimates.

We have added costs for new thermal storage, electric boiler for pool water, upgrade of DHW calorifiers immersions, a provisional sum for complete replacement of internal 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 GSHP per kW | 977 | £2,500 | £2,442,500 |
| External pipework per meter | 20 | £150 | £3,000 |
| Replacement of distribution system | Provisional sum | £50,000 | £50,000 |
| Replacement of AHU coils and local reheat coils | 10 | £5,000 | £50,000 |
| New thermal storage cylinder | 1 | £5,000 | £5,000 |
| New electric boiler | 1 | £5,000 | £5,000 |
| Replacement of DHW calorifiers immersions | 3 | £2,000 | £6,000 |
| New pump | 4 | £2,500 | £10,000 |
| Control integration | Provisional sum | £20,000 | £20,000 |
| Grid electricity supply upgrades | Provisional sum | £100,000 | £100,000 |

| | | | |
|---|---|---|---|
| Thermal response testing | Provisional sum | £10,000 | £10,000 |
| Design and making good | 30% | - | £810,450 |
| **TOTAL** | | | **£3,512,000** |

*Table 42: GSHP cost estimate*

### 9.1.8 Direct electric heating

We have estimated the cost of electric heater batteries to replace AHUs heating coils based on typical market rates, with additional costs for replacement of existing radiators to electric wall mounter heaters.

We have also added a provisional sum for 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 | 977 | £50 | £48,850 |
| Replacement of radiators to electric wall mounted heaters | 5 | £500 | £2,500 |
| 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% | - | £57,405 |
| **TOTAL** | | | **£249,000** |

*Table 43: Direct electric heating cost estimate*

### 9.1.9 Solar PV

Costs for solar PV installation have been based on published government solar PV costs per kW for Q1 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 | 53 | £1,350 | £71,550 |
| Allowance for access | Provisional sum | £50,000 | £50,000 |
| Design and making good | 30% | - | £23,900 |
| **TOTAL** | | | **£145,000** |

*Table 44: 53kWp Solar PV cost estimate*

## 9.2 Summary of NPV results

Table 45 shows the summary of Net Present Value (NPV) of the costed saving measures. It concludes that plant room pipe and valve insulation, replacement of AHUs, variable speed pumping and Replacement of T8 and CFL lighting 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 pipe and valve insulation | 23 | 1,100 | 21,126 | 1.3 |
| Replacement of AHUs | 24 | 533,000 | 1,478,651 | 56.9 |
| Variable speed pumping | 10 | 41,000 | 433,822 | 17.5 |
| Control upgrade for A/C in studio | 9 | 800 | 6,822 | 0.4 |
| Replacement of remaining T8 and CFL lighting | 25 | 4,400 | 84,316 | 1.2 |
| Low Carbon Heating | | | | |
| Air to water heat pump | 20 | 1,990,000 | -2,119,546 | 121.9 |
| Air to air heat pump | 20 | 1,925,000 | -2,054,546 | 121.9 |
| Ground source heat pump | 25 | 3,512,000 | -2,866,570 | 134.3 |
| Direct electric heating | 10 | 249,000 | -2,635,817 | 23.4 |
| On Site Renewable Energy | | | | |
| 53kWp Solar PV | 23 | 145,000 | 488,642 | 10.1 |

*Table 45: 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 46 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 47 shows changing values of 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. However, all options remain a negative NPV with a 20% increase in gas tariff.

| Option | Capex Adjustment | | | |
|---|---|---|---|---|
| | -20% | -10% | 10% | 20% |
| Air to water heat pump | -1,721,546 | -1,920,546 | -2,318,546 | -2,517,546 |
| Air to air heat pump | -1,669,546 | -1,862,046 | -2,247,046 | -2,439,546 |
| Ground source heat pump | -2,164,170 | -2,515,370 | -3,217,770 | -3,568,970 |
| Direct electric heating | -2,586,017 | -2,610,917 | -2,660,717 | -2,685,617 |

*Table 46: Sensitivity analysis of NPV results with changing Capex*

| Option | Gas Tariff Adjustment | | | |
|---|---|---|---|---|
| | -20% | -10% | 10% | 20% |
| Air to water heat pump | -2,594,983 | -2,357,264 | -1,881,828 | -1,644,109 |
| Air to air heat pump | -2,529,983 | -2,292,264 | -1,816,828 | -1,579,109 |
| Ground source heat pump | -3,483,827 | -3,175,199 | -2,557,941 | -2,249,312 |
| Direct electric heating | -2,856,463 | -2,746,140 | -2,525,495 | -2,415,172 |

*Table 47: 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 £0.4425kWh for electricity and £0.114/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 23 to Figure 26 show the MACC for the AWHP, AAHP, GSHP and direct electric heating 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.

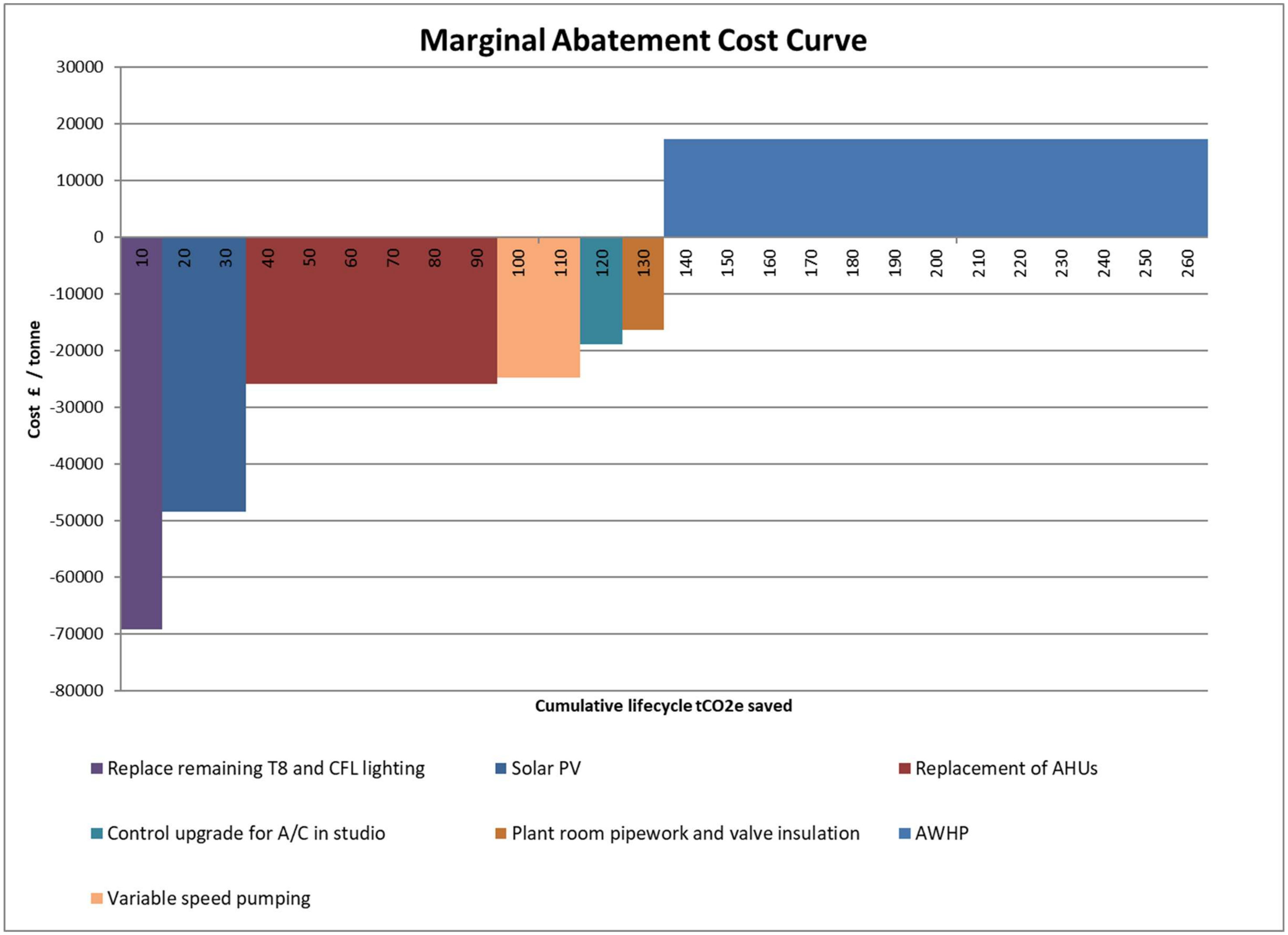



*Figure 23: Marginal Abatement Cost Curve - AWHP*

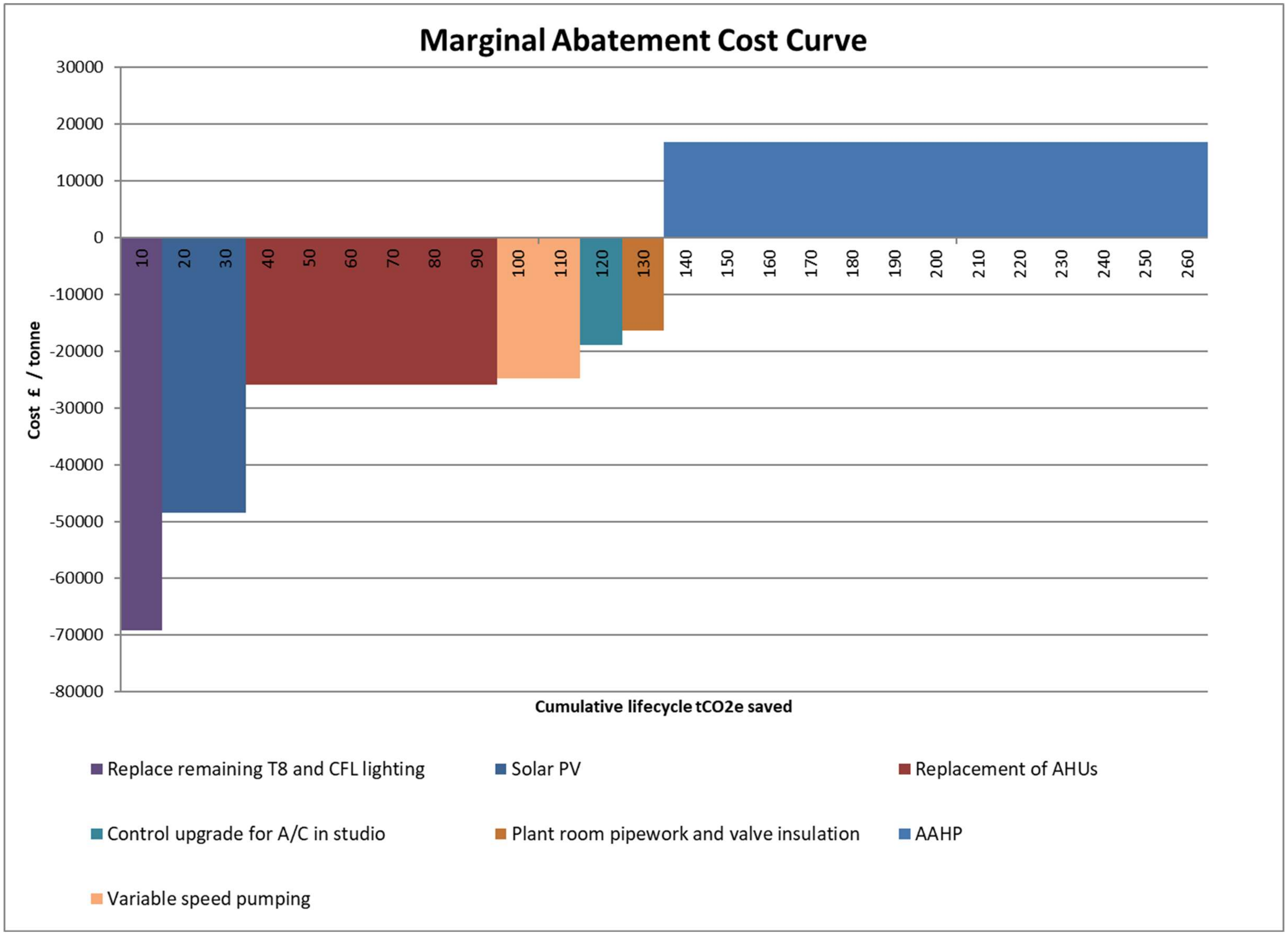



*Figure 24: Marginal Abatement Cost Curve - AAHP*

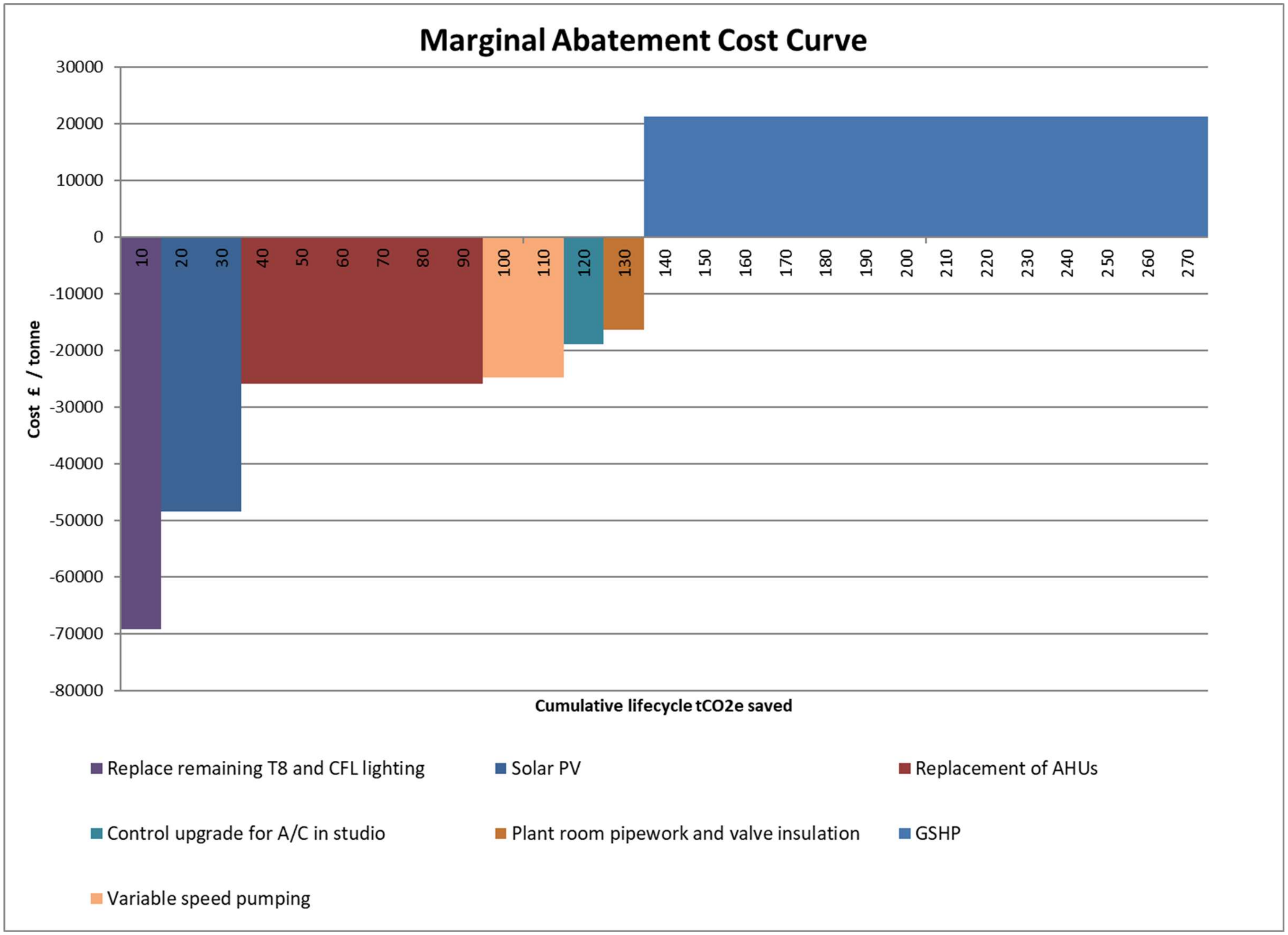



*Figure 25: Marginal Abatement Cost Curve - GSHP*

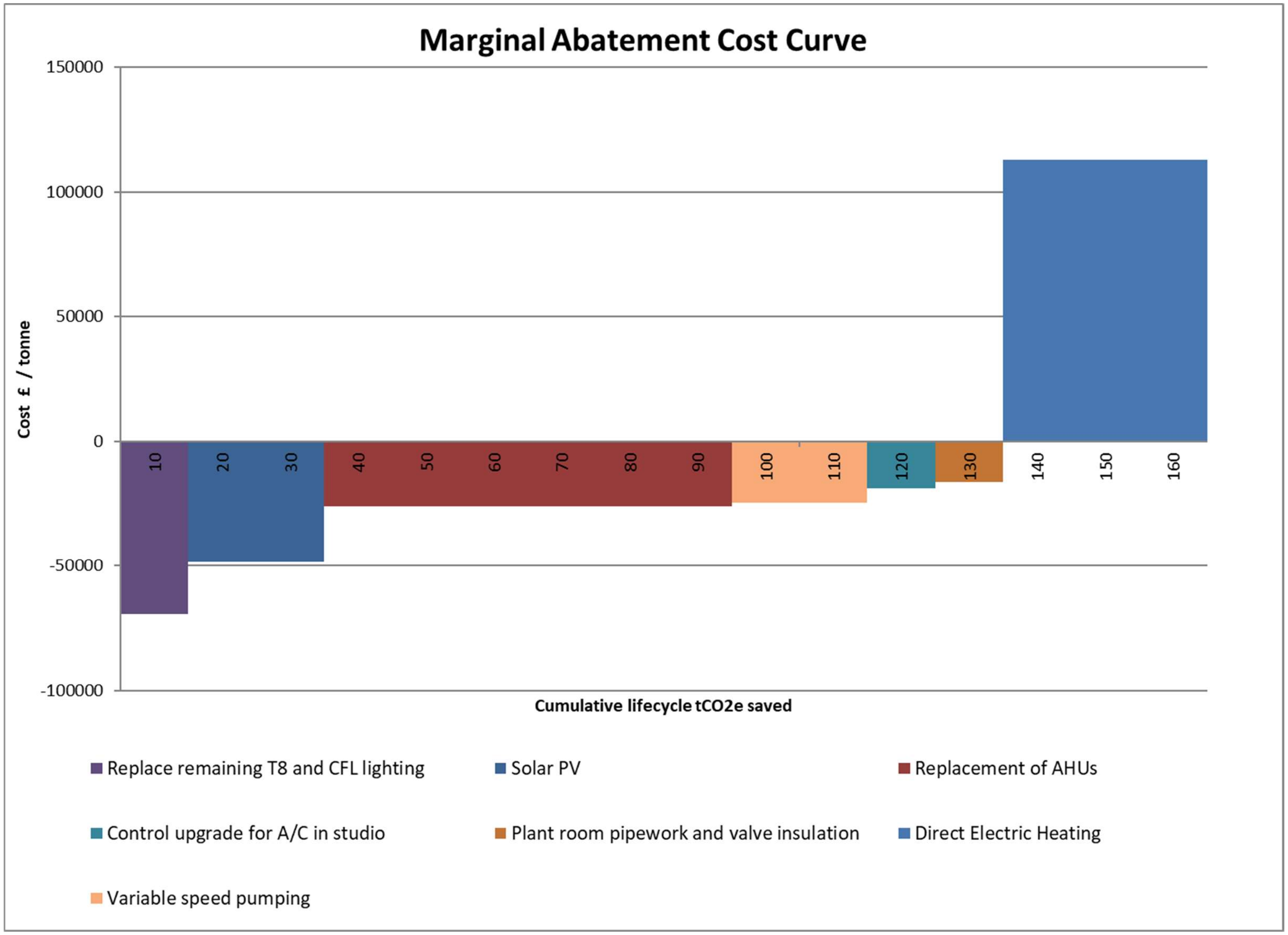



*Figure 26: Marginal Abatement Cost Curve – direct electric heating*

# 11 Summary and Conclusions

Laura Trott Leisure Centre comprises of a two-storey sports centre with swimming pool. The typical occupancy hours of the buildings are from 06:00hrs to 22:00hrs on Monday to Thursday, from 06:00hrs to 21:00hrs on Friday, and from 07:00hrs to 18:00hrs on Saturday and Sunday.

Concept has visited Laura Trott Leisure Centre to identify current performance and potential improvements. A number of potential savings measures have been identified including 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 energy saving measure was identified which is pool hall temperature setpoint adjustment.

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

- Plant room pipe and valve insulation;
- Replacement of AHUs;
- Variable speed pumping;
- Control upgrade for A/C in studio, and
- Replacement of remaining T8 and CFL lighting

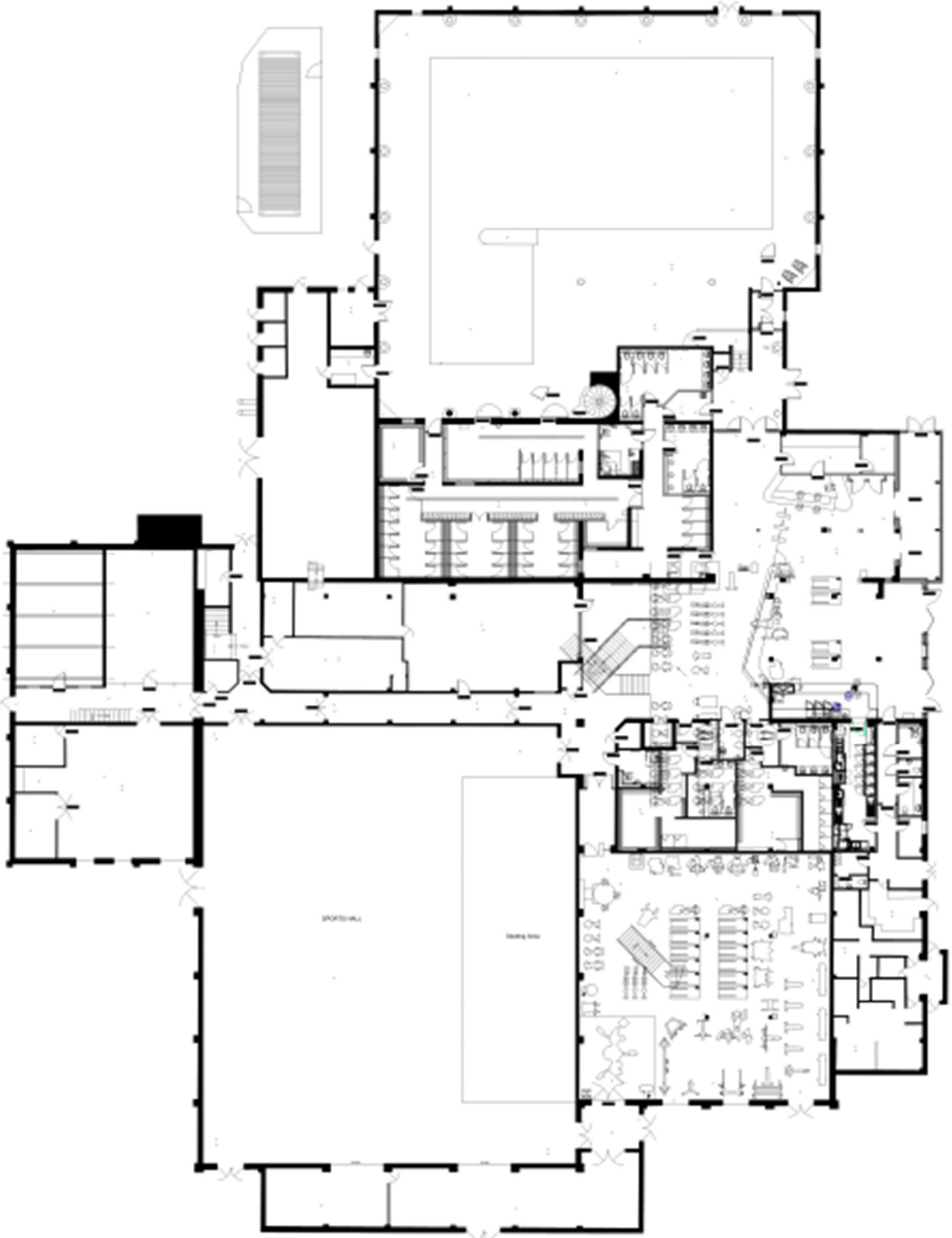
Low carbon heating options include either installing an ASHP, GSHP or direct electric heating to replace the existing gas boilers to provide space heating. ASHP and GSHP would provide a greater emissions reduction but at significantly higher cost than direct electric heating.

A solar thermal system could be implemented to provide part of the pool water and DHW loads but this has potential to impact performance of the existing biomass system which also serves these loads. The site would also be suitable for additional solar PV capacity in addition to that already installed.

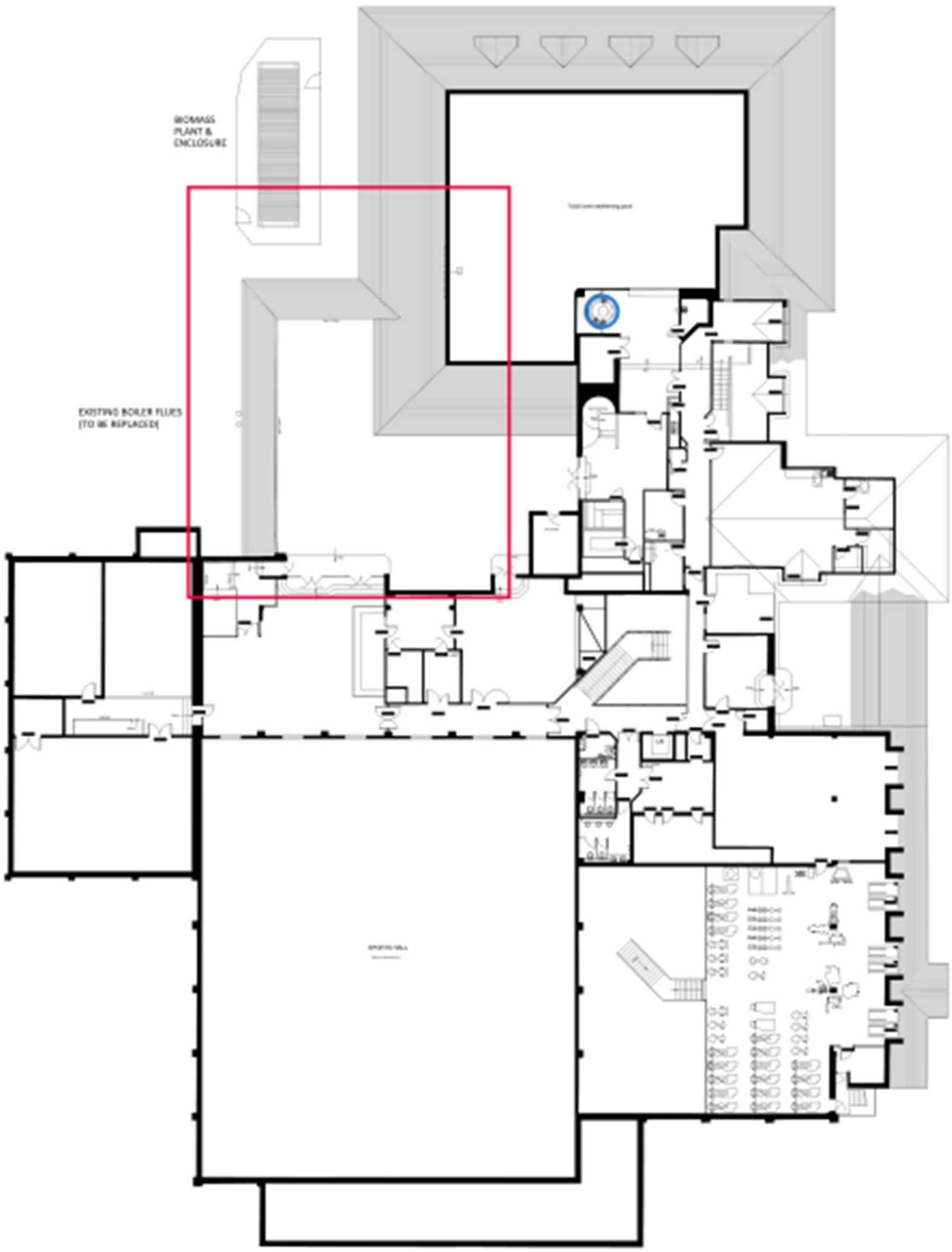
The financial analysis suggests that plant room pipe and valve insulation, replacement of AHUs, variable speed pumping, control upgrade for A/C in studio, replacement of T8 and CFL lighting and solar PV measures would give a positive NPV, while all other measures give a negative NPV.

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 166.2 $tCO_2e$ 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 43.3 $tCO_2e$ within a 5-year period.

# Appendix A – Floor Plan



Ground floor


BIOMASS
PLANT &
ENCLOSURE
EXISTING BOILER FLUES
(TO BE REPLACED)

First floor

# Appendix B – 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 | 0.114 |
| Electricity unit rate, £/kWh | 0.4425 |
| Wood pellets unit rate, £/tonne | 390.62 |
| ASHP seasonal efficiency | 300% |
| GSHP seasonal efficiency | 400% |
| Direct electric heating seasonal efficiency | 100% |
| Existing boilers seasonal efficiency | 81.5% |
| Biomass boiler seasonal efficiency | 64% |

# Appendix C – 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. | 938,014 | - | - |
| Option 1 - ASHP | 0 | 938,014 | 171,225 |
| Option 2 - GSHP | 0 | 938,014 | 171,225 |
| Option 3 - Direct electric heating | 0 | 938,014 | 171,225 |