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University of Plymouth

Heating & Cooling Decarbonisation Plan

29th March 2023

AVISON YOUNG

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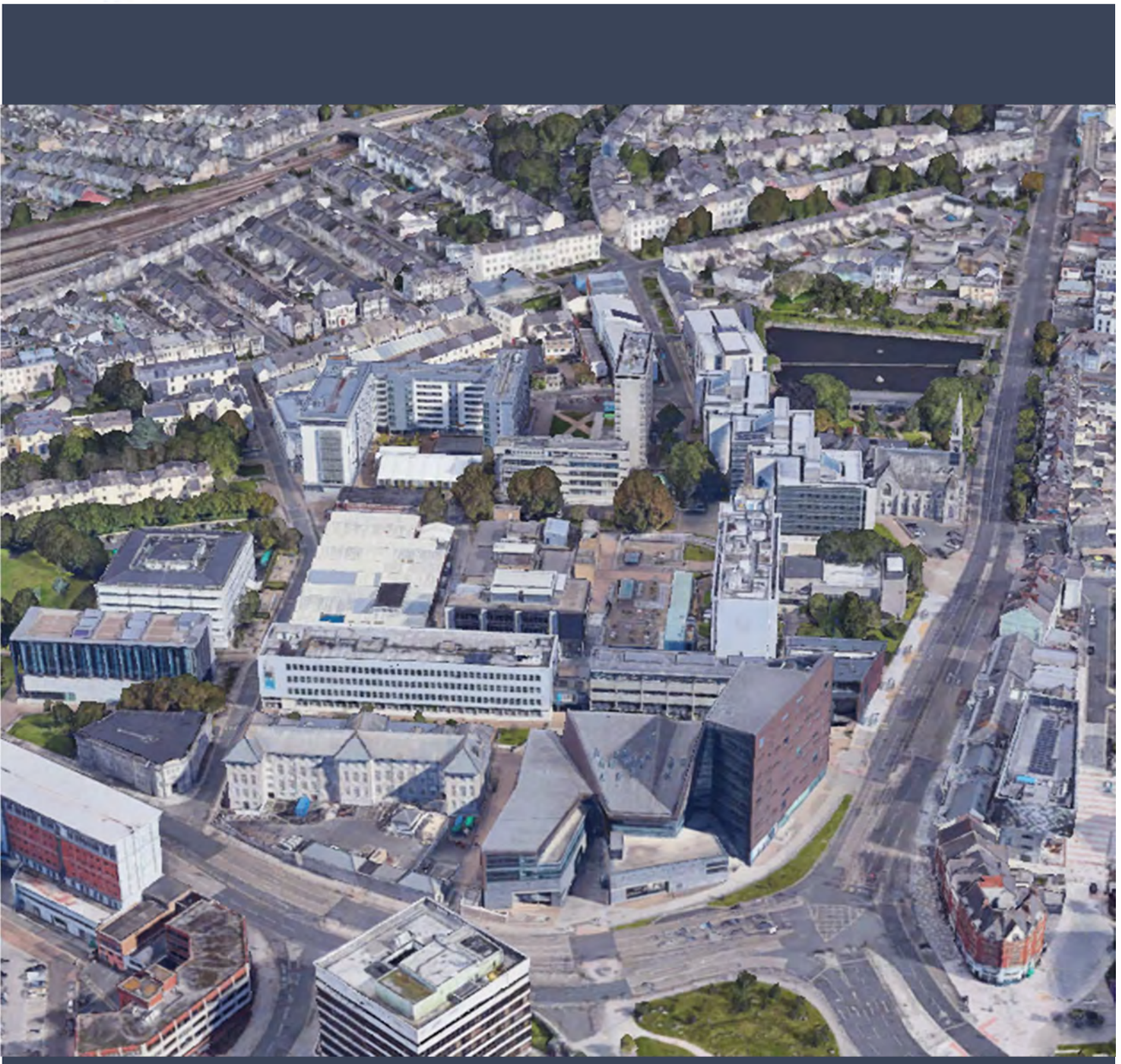
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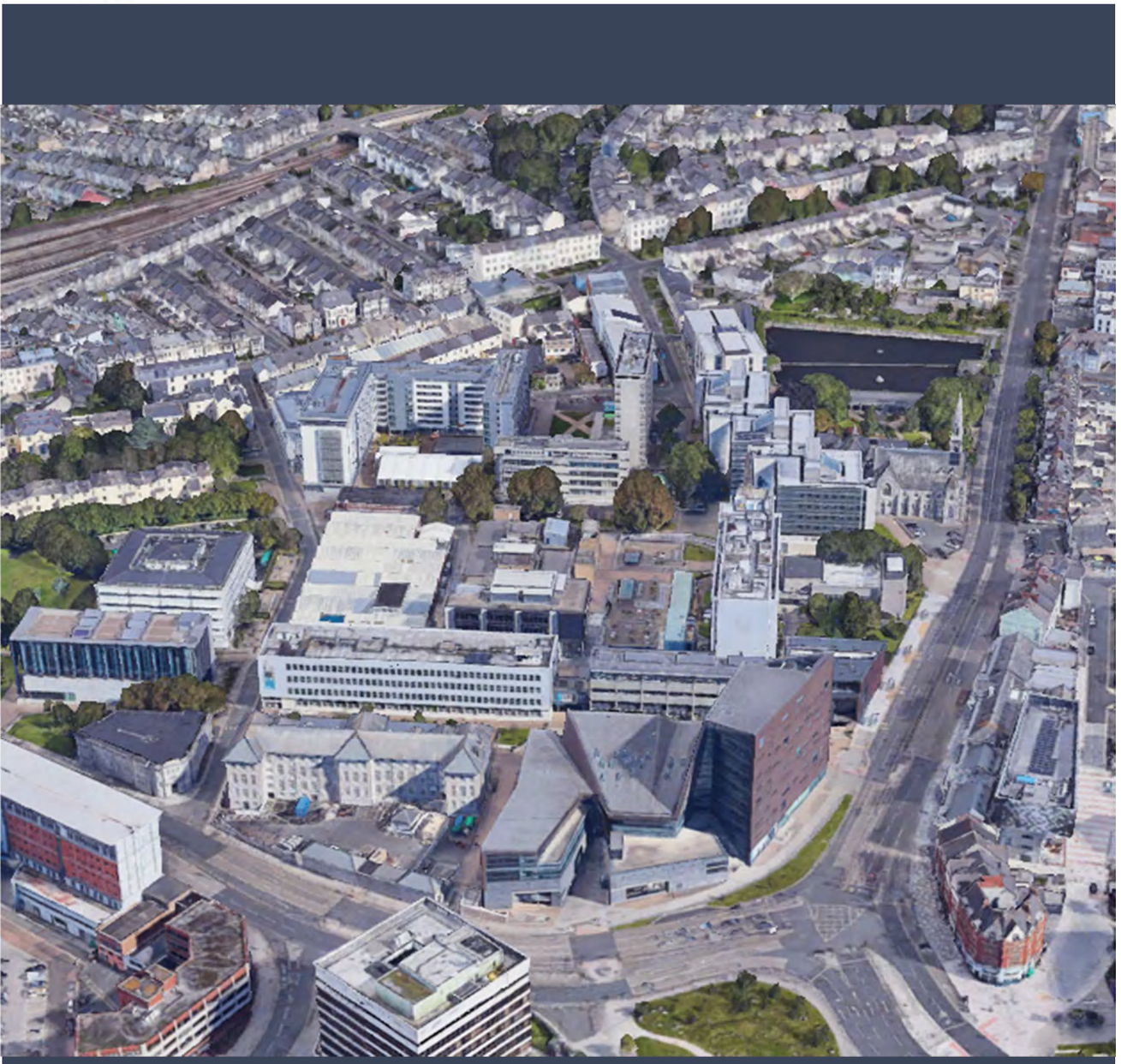
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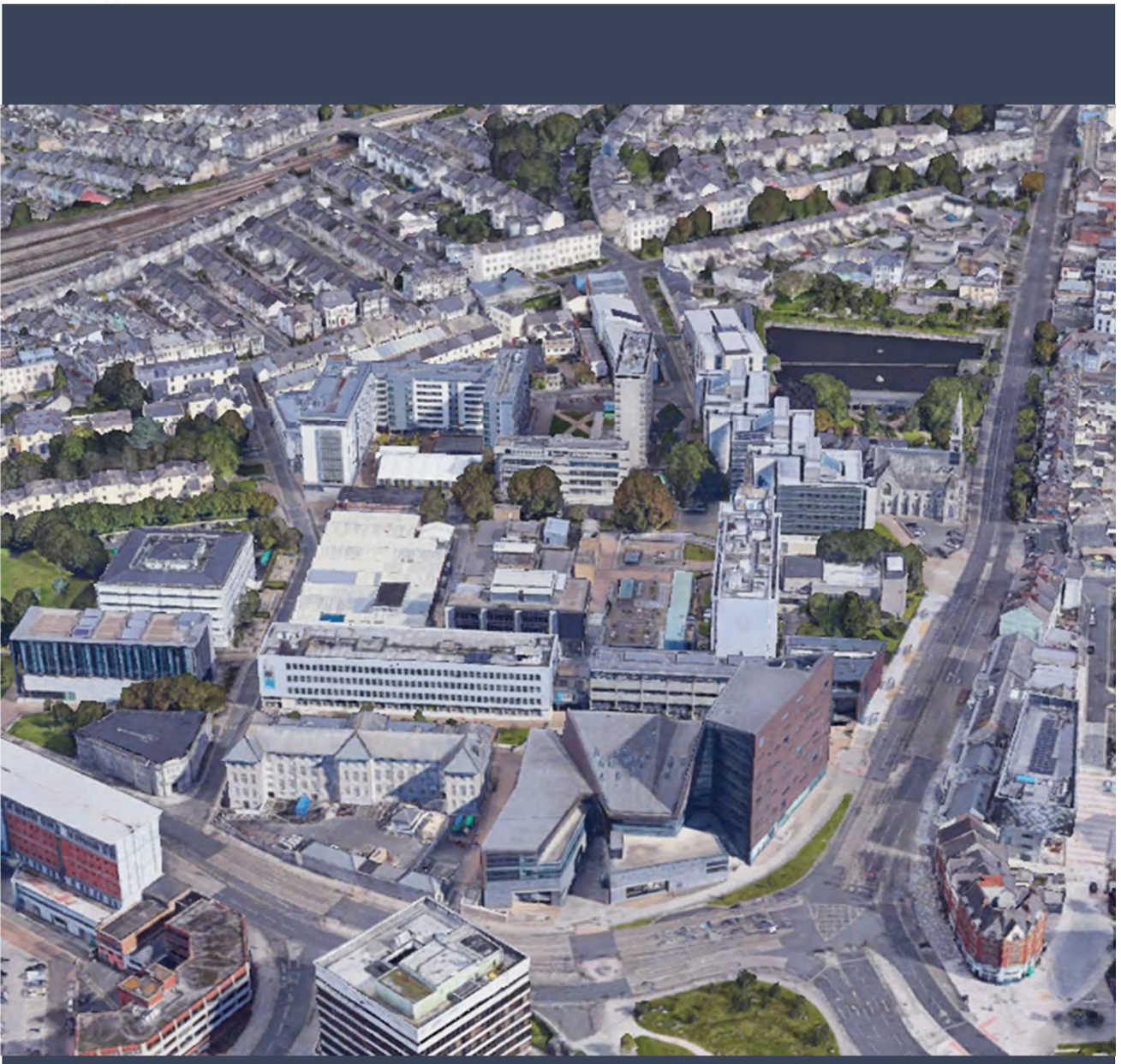
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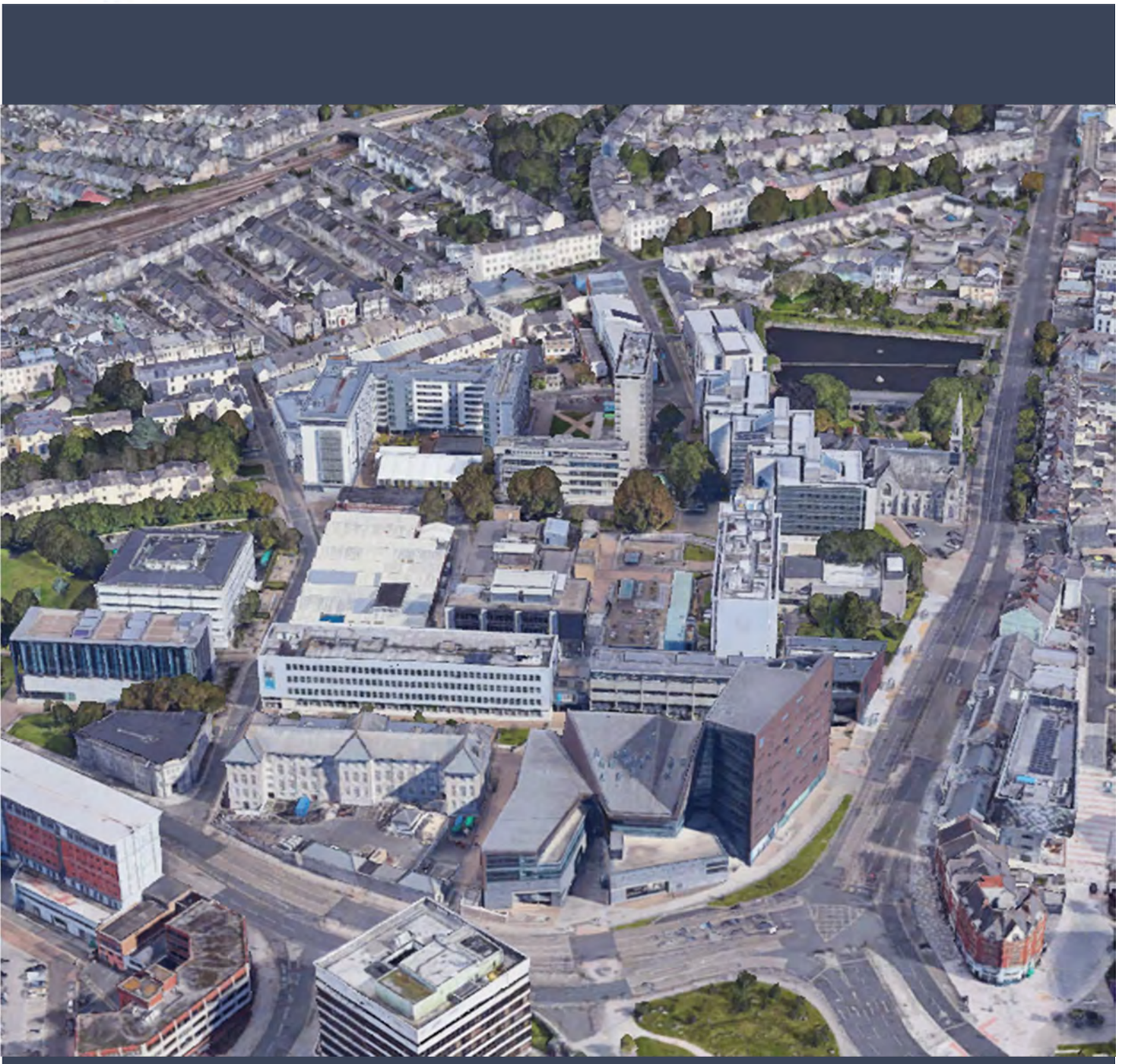
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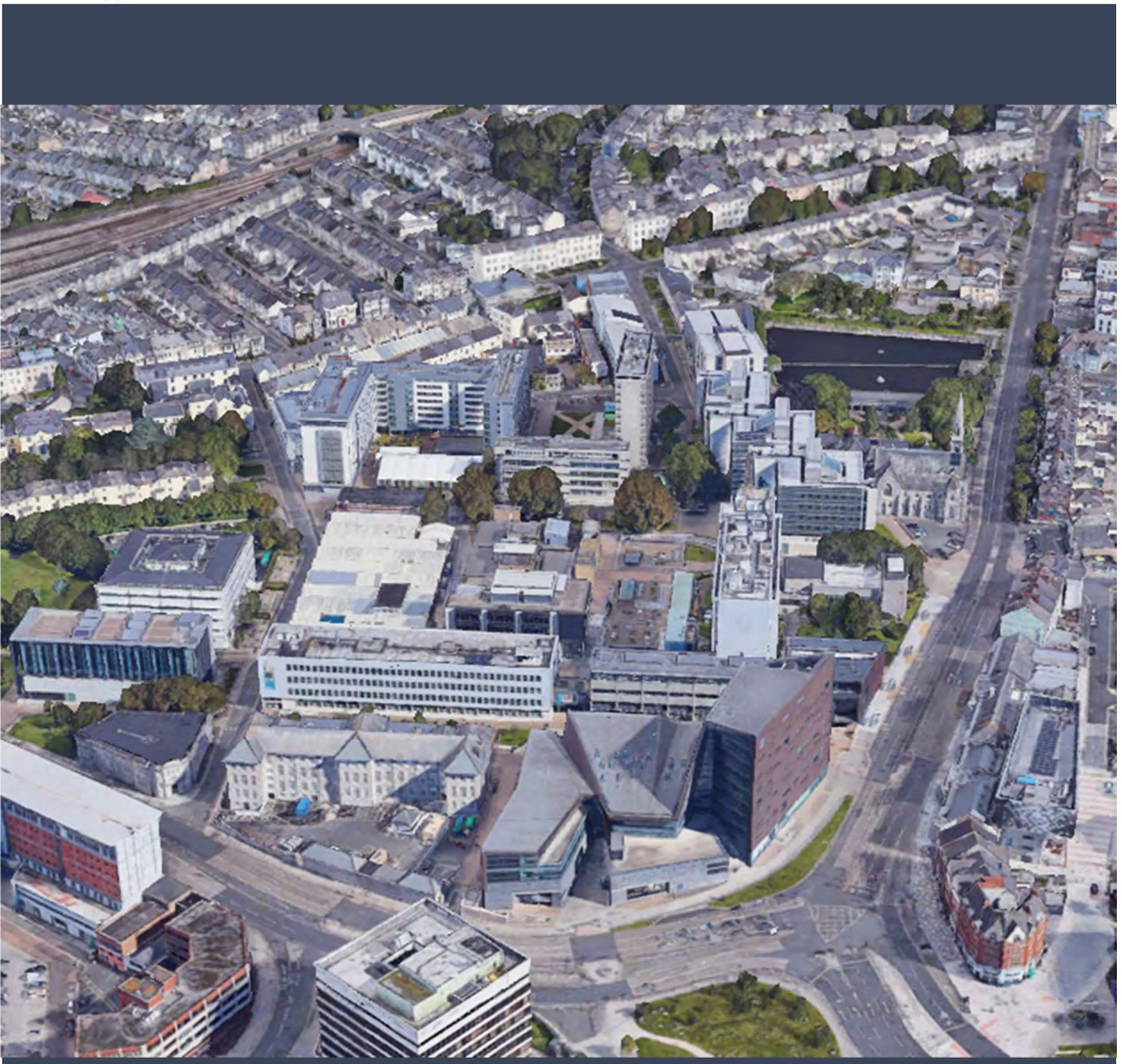


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Status: Draft
Draft date: 29 March 2023

For and on behalf of Avison Young (UK) Limited

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Revision	Approved By	Signature
23.03.2023 (Draft)	A. Frangiamore	

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1. Executive Summary

1.1.1. The University of Plymouth appointed Avison Young to develop this Heating and Cooling Decarbonisation Plan (HCDP) which covers a total of 40 buildings located across on four sites.

1.1.2. The buildings range from those constructed in the 1800's to those constructed less than 10 years ago. The average age of the buildings is estimated at circa 80 years however the services installations are estimated to be circa 20-25 years old on average.

1.1.3. The University of Plymouth Campus heating and cooling requirements are predominantly served by mains gas and grid electricity. The campus operates two separate existing heat networks which are served by a combination of gas fired boilers and CHP units. Buildings which are not connected to the heat networks are generally served by dedicated gas fired boiler plant.

1.1.4. Within larger buildings, Domestic Hot Water (DHW) is generated via Low Temperature Hot Water (LTHW) calorifiers and/or storage vessels although there are some direct gas-fired water heaters on site, for example in the Roland Levinsky and Nancy Astor buildings. Elsewhere the hot water systems generally comprise low volume local unvented electric water heaters or gas-fired combi boilers.

1.1.5. Mechanical comfort cooling across the site is generally limited to larger buildings such as Roland Levinsky and the Library. Local cooling is provided to key areas such as individual offices, server/comms rooms etc. via DX systems. Dedicated cooling systems are installed for University data centres and lecture theatres, for example in Portland Square.

1.1.6. Ventilation in simpler buildings such as terraces or older buildings such as Reynolds is generally provided via natural means such as opening windows with local extract ventilation provided to toilets, cleaners cupboards and kitchens in many areas. More complex buildings are provided with mechanical supply and extract ventilation via packaged Air Handling Units (AHUs) which are generally supplied with LTHW and cooling coils (either chilled water (CHW) or Direct Expansion (DX).

1.1.7. The lighting across the site is generally fluorescent however some buildings have been upgraded to LED and we understand the University has a programme in place to ultimately upgrade all lighting to LED luminaires.

1.1.8. The engineering services across the site are generally considered to be in fair condition, although Building Management Systems (BMS) and major plant items are ageing. The gas fired boilers in Mary Newman which serve the District Heat Network (DHN) are in poor condition and prone to failure. At the time of writing, the plant in understood to have suffered a catastrophic failure and temporary boiler plant is in operation.

1.1.9. The total annual energy consumption for the buildings within this study is circa 24.0GWh which comprises 13.3GWh or natural gas and 10.7GWh of grid electricity. This study comprises a sample of only 40 buildings and does not represent the entire University estate. All figures relating to consumption and potential improvements apply only to the buildings within the study and not the whole UoP portfolio.

1.1.10. Based on 2022 carbon emission factors, applied to the buildings identified within this study, this results in total estimated carbon emissions of circa 3,560 TCO2e/yr of which approximately 2,440 TCO2e/yr are attributable to natural gas consumption and 1,120 TCO2e/yr to electricity consumption.

1.1.11. The proposed measures in this report could potentially deliver an overall reduction in energy consumption of circa 15.9GWh per annum by 2030 compared to 2022 consumption which reflects a reduction of around 67%. This would represent an overall EUI of 65.25kWh/m² against a target of 163.45kWh/m² as defined within the University's Carbon Management Plan (CMP).

1.1.12. The proposed measures in this report could potentially deliver an overall reduction in carbon emissions of over 2,990 Tonnes of CO_2 per annum by 2030 compared to 2022 emissions which reflects a reduction of around 86%. The estimated lifetime carbon saving would be over 40,300 Tonnes of CO_2 when considering a typical life expectancy of 20 years.

1.1.13. The data suggests that the buildings included in the assessment will retain residual annual carbon emissions of circa 480 TCO_2e by 2030 compared with potential emissions of 3,470 TCO_2e if no action is taken.

1.1.14. Total estimated aggregate carbon emissions between 2022 and 2030 would be 19,630 TCO_2e compared to 30,630 TCO_2e if no action were taken, a reduction of circa 37%.

1.1.15. The proposed solution to decarbonise the main campus sites is to replace existing gas fired plant with water-to-water heat pump technology fed with low grade heat via an ambient water loop fed from a borehole installation beneath the Brunel building which is to be demolished.

1.1.16. The borehole/heat pump solution is to be supported by a programme of fabric energy efficiency improvements to walls, roofs and windows on buildings across the estate (where feasible) to reduce the energy demand and improve the effectiveness of the proposed decarbonisation measures.

1.1.17. In the interim period, larger buildings with sufficient space and access could be retrofitted with water-to-water heat pump technology fed with low grade heat via dry air coolers. Subject to design and selection, the dry air coolers could subsequently be replaced with heat exchangers fed from the ambient loop when it becomes available.

1.1.18. The borehole installation is the subject of a separate study, however initial indications suggest that the borehole system could deliver between 7 and 10 GWh of thermal energy from the proposed borehole site beneath the Brunel building supporting a peak load of around 5-7MW. This is well in excess of the estimated requirement for the buildings included in the assessment and would potentially allow the whole site to be fed from such an installation.

1.1.19. Initial calculations suggest that based on an electrical demand of 7.85MW the site will require an electrical capacity of 8.26MVA (based on an assumed power factor of 0.95) compared with a current agreed supply capacity of 3.985MVA.

1.1.20. The total estimated budget cost for the recommended measures across the study is circa £67M including VAT, professional fees and contingencies, however the costs have not been reviewed by a VAT specialist and we have only applied a flat rate of 20%. This cost excludes the potential cost of the borehole installation which will be covered in a separate study.

2. Introduction, Policy & Context

2.1 Brief

2.1.1. The University of Plymouth have committed to reducing carbon emissions and achieve Net Zero (Scope 1 & 2) emissions by 2025 and Scope 3 between 2030 and 2050.

2.1.2. The Carbon Management Plan (CMP) produced by the University sets out five key areas where action can be taken to achieve the ambitious targets.

- Improving space utilisation
- Carbon reduction projects
- Fuel and power conversion
- Institutional change
- Behaviour change

2.1.3. The University has identified Government funding as a key source of investment into the CMP. The Public Sector Decarbonisation Scheme (PSDS) provides funding via Salix which could be used to support the University in delivering on its carbon reduction objectives.

2.1.4. Through the CMP the University has identified the need to produce a Heating and Cooling Decarbonisation Plan (HCDP) for around 40 buildings which include a high proportion of the main city centre campus and some remote sites located further afield.

2.1.5. Hoare Lea were appointed to develop a Heat Decarbonisation Plan (HDP) for some of the large buildings on the main campus. Avison Young have been appointed to build on this work and develop the HCDP for the wider site.

2.1.6. The HCDP will identify a suitable strategy to achieve decarbonisation of heating and cooling including budget costs in order to meet the Quality Assurance requirements for future funding bids and applications.

2.2 University of Plymouth Carbon Policy

2.2.1. The University has reduced emissions by 48% compared to a 1990 baseline and by 39% since 2005. The University also achieved the Department for Business, Energy and Industrial Strategy (BEIS) target of a 30% reduction in Scope 1 & 2 emissions by 2020/21 from a 2009/10 baseline. The University has identified six goals within the CMP.

- Net zero emissions from direct emissions (scope 1 & 2) by 2025.
- Continue to reduce mains grid electricity use by 20% and mains gas by 25% as a minimum by 2030 from 2005-06 levels, with the intention to support further reductions through wider energy generation projects.
- Develop a 'net positive' framework accounting for the positive environmental impact of research outputs to balance the negative output of the University's carbon footprint.
- Raise awareness and build a carbon community with their staff and student population, including engagement with target and action plan setting.
- Be actively involved in projects that seek to encourage and enable large scale carbon reduction and promote low carbon transitions in the city and nationally.
- Reduce emissions outside of the University's direct control (scope 3) to net zero by 2030-50 in line with local and national targets.

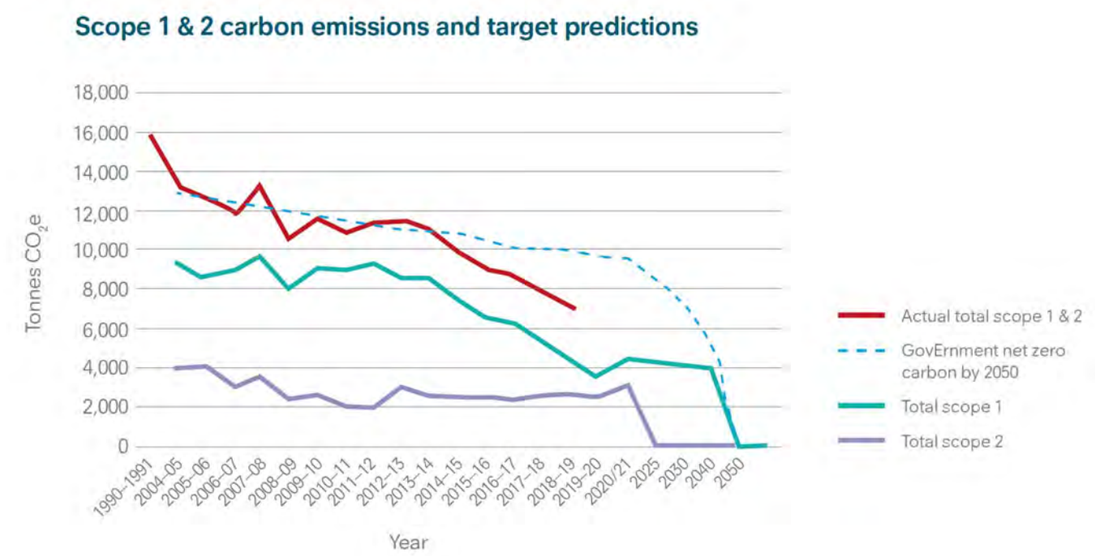


Fig. 1.1 Carbon emissions projections

2.3 Plymouth City Council

2.3.1. In January 2022 Plymouth City Council introduced their latest Climate Emergency Action Plan (CEAP) in response to their declaration of a climate emergency in March 2019. The Council have instigated measurable actions which will move the city toward their target of net zero carbon emissions by 2030. The Council review progress against the plan in a public forum every 6 months and will introduce a new plan each year up to 2030.

2.3.2. As part of the CEAP approach to buildings, the University has committed to the following:

"The University of Plymouth will continue to work towards net zero emissions (scope 1 and 2) by 2025 and deliver fuel and power conversion to renewables through onsite photovoltaic and heat pump installations."

"The University of Plymouth will continue to deliver energy reduction projects (and work towards reducing mains grid electricity use by 20% and mains gas by 25% as a minimum by 2030 from 2005/06 levels) including: remaining LED lighting conversion projects; smart building management

system upgrades for advanced controls; transformer replacements; big data project, using data driven analytics to reduce energy use."

2.4 Plymouth Heat Network (4DHC & 5DHC)

2.4.1. The development of a District Energy Network will be the key to achieving Plymouth City Council's goal of becoming a carbon neutral city by providing local businesses and housing with heat and power from more sustainable sources. The Plymouth City-Wide District Energy Strategy (PDES) produced in 2017 identifies opportunity areas where district heat networks should be considered a part of all new development proposals.

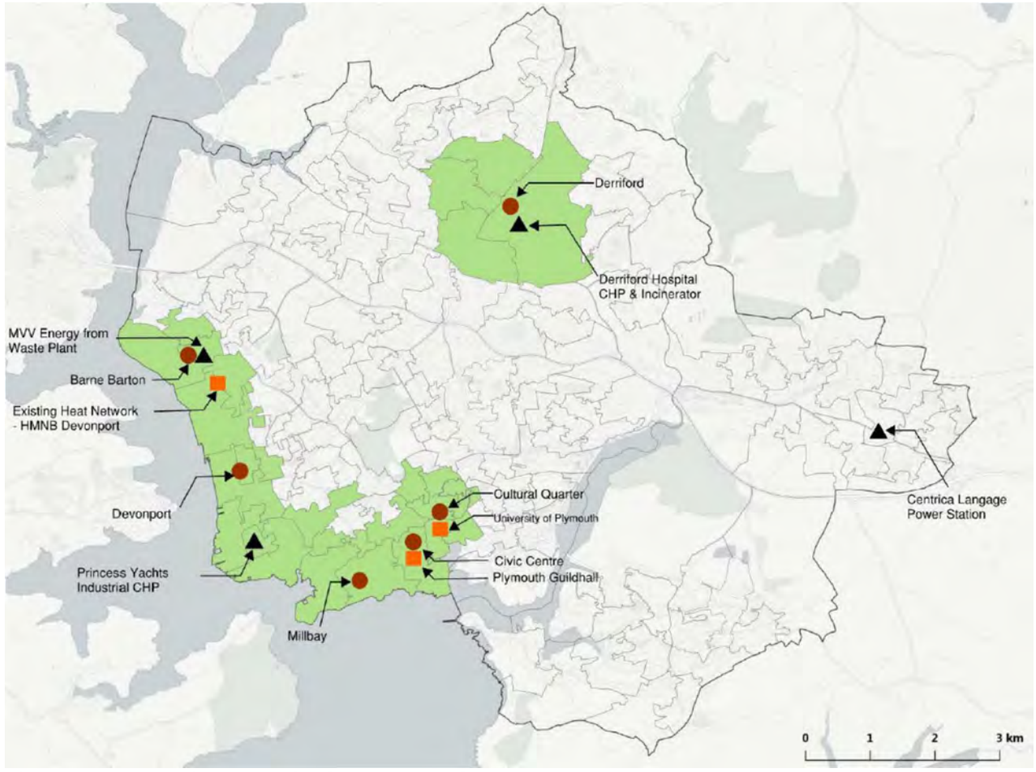


Fig. 1.2 Opportunity areas for heat networks

2.4.2. The University currently operates a 3rd generation DHN on their main campus site in the Cultural Quarter which serves a number of University buildings. Heat is provided by CHP and gas boilers and the University are considering options to expand their heat network to other buildings on the campus and potentially beyond to serve buildings in Plymouth. Avison Young have also been appointed to carry out a feasibility exercise in respect of a 5th generation heating and cooling network (5DHC) which will be presented as a separate report.

2.4.3. As part of the short-term opportunities identified within the PDES, the Council has recommended in the short term (2017-20) to:

- Undertake detailed feasibility study to assess scheme viability for eastern and western extension. Potential new customers have emerged e.g. Train Station development, reboilering of student residences.
- Assess and develop business case viability for Eastern and Western Extension."
- Continue engagement with University of Plymouth (UoP) to devise mutually beneficial scheme to extend UoP DHN.
- Establish extension to UoP DHN beyond UoP boundary.
- Futureproof planned new developments as part of planning application process.

2.4.4. For the medium term (2021-25) the Council has made the following recommendations:

- Support stakeholder engagement as part of viability assessment of additional heat customers for connection to UoP DHN.
- Maintain stakeholder engagement to ensure that connection to DHN is considered at times of plant replacement for existing buildings

2.4.5. For the long term (2025-40) the Council has made the following recommendations:

- Consider extension to link up to proposed Civic Centre DHN.
- Transition to zero carbon heat source(s).

2.4.6. Plymouth is participating in a European funded project called HeatNet NWE, together with project partners from Ireland, UK (Scotland), France, Belgium and the Netherlands exploring the use of fourth generation or smart approaches to district energy (4DHC). The project has funding from the European Regional Development Fund of the European Union, under the Interreg NWE Programme 2014 to 2020 with support until 2021.

2.4.7. The construction of Plymouth City Council's 5th-generation district heating and cooling (5DHC) network started in 2019, in the city centre. The ultra-low temperature network will allow usually rejected energy to be recovered and shared within, as well as between, buildings that are heating and cooling, simultaneously reducing primary energy and increasing system efficiency.

2.4.8. This report will consider the university DHN in isolation with more detailed feasibility in respect of integration with Plymouth City Council's DHN considered within a separate report.

2.5 Key Requirements of the HCDP

2.5.1. In 2019, the UK Government set out one of the world's most ambitious carbon emissions targets: to achieve net zero greenhouse gas emissions across the whole UK by 2050. The following sets out the requirements of the HCDP as described within the Salix HDP Guidance document.

2.5.2. To meet our Net Zero goal, we urgently need to address the carbon emissions produced in heating our public buildings. We use energy for heating and cooling, lighting, hot water, and other energy using products. And while the electricity that powers our lighting and appliances is decarbonising fast, the majority of buildings still rely on burning fossil fuels for heating, hot water and catering.

2.5.3. There are around 30 million buildings in the UK which in total are responsible for around 30% of our national emissions. The vast majority of these emissions result from heating: 75% of buildings emissions and about 22% of all UK emissions.

2.5.4. The purpose of a heat decarbonisation plan is to describe how an organisation intends to reduce direct greenhouse gas emissions by replacing fossil fuel heating systems with low carbon alternatives (for example heat pumps, electric heating, or other low-carbon fuel sources) within its estate.

2.5.5. Heat decarbonisation plans should outline the most cost-effective pathways to decarbonising heat through integration of energy efficiency measures that reduce a site's heat demand, taking a 'whole building approach' to decarbonisation.

2.5.6. It is also recognised that the plans need to be approached in a way that supports the type of estate an organisation operates. Estate and property portfolios can range from one building to multiple buildings, to campus style activities, or a combination of the above.

2.5.7. A decarbonisation plan is a live document and should be updated regularly to reflect the current status and to track progress towards decarbonisation and/or a net zero strategy.

3. Description of Estate

3.1 Main University Campus

Main Campus



Fig. 3.1 Main campus

3.1.1. The main University campus is located in central Plymouth, to the north-east of the city centre. The main pedestrian access to the site is via the B3250 (Alexandra Road) with vehicle access via North Road East or James Street.

3.1.2. The campus is home to a range of teaching, research and office/administration spaces supporting over 18,000 students and 2,500 staff. The overall campus comprises approximately 100,000m² and is identified above.

3.1.3. The buildings on site vary significantly in age and construction from 100+ year old repurposed houses to modern multi-storey commercial buildings constructed within the last 10 years. There is also ongoing construction work as part of the campus masterplan, including construction of the Babbage building and Intercity Place and the refurbishment of the Fitzroy building.

3.1.4. The University is currently in the middle of a 10-year campus masterplan, which aims to redevelop significant elements of the campus. Projects underway include the redevelopment of the Babbage building into a new engineering and design facility, the refurbishment of the Fitzroy building into a new business school and the purchase and redevelopment of Intercity Place into a home for Faculty of Health programmes.

3.1.5. The subject of this study encompasses some 40 buildings within the University's portfolio. 36 of these are on or near the main campus site with the Marine Station located approximately 1 mile to the south-east in Sutton Harbour. Derriford Research Laboratory (DRL) and John Bull Building (JBB) are located at Plymouth Science Park, adjacent to Derriford Hospital approximately 4 miles north of the main campus site. Brixham laboratory is a stand-alone site located adjacent to Brixham Marina approximately 35 miles east of Plymouth City centre.

4. Decarbonisation Plan Methodology

4.1 Desktop Review

4.1.1. The HCDP has been developed using a data-driven process utilising site consumption data and information provided from site via the estates team. We have reviewed all available building data to gain an in-depth understanding of the site prior to conducting site surveys and inspections. The information requested covered the following elements:

- Basic description of the age, construction and use of the buildings.
- Basic description of the engineering services systems operating within the buildings.
- Energy consumption data or access to energy metering/monitoring platforms.
- Details of the incoming electricity infrastructure including the High Voltage (HV) network and agreed supply capacity.
- Details of any potential redevelopment/refurbishment works.

4.1.2. The University provided Avison Young with access to their online energy management system, C3ntinel which provides very high-resolution data and is considered sufficient for use in analysis and benchmarking where we would typically use half-hourly or hourly data.

4.1.3. The data provided for the desktop review informed the baseline scenario for current energy consumption and carbon emissions which provides the reference for each building to which all potential options are applied.

4.2 Site Surveys

4.2.1. The site surveys were undertaken on 23rd, 24th & 25th of November 2022 to validate the information provided by the estates team and to establish a better understanding of the site layout, infrastructure and conditions. We also inspected each building where possible to gain a high-level understanding and identify potential options for improving energy efficiency and decarbonising heating and cooling. The survey was carried out by specialist Mechanical & Electrical Engineers and Building Surveyors.

4.2.2. The site surveys were non-intrusive and were carried out visually from ground, floor or roof level only and did not involve any opening up of fabric. We entered plantrooms where necessary and, where accessible service risers however access to roofs was limited for safety reasons due to high winds.

4.2.3. The surveys were undertaken in term-time and during normal university opening hours and are considered to provide a representative reflection of typical site activity.

4.3 Technical Assessment

4.3.1. The desktop and site surveys have given the team the opportunity to develop a schedule of potential energy efficiency improvements to the building envelopes in order to optimise the energy consumption of the estate as far as possible. The team have also identified potential options for decarbonisation of heating and cooling within each building. The optimisation and decarbonisation measures considered include:

- Optimisation/improvement of thermal performance of building fabric.
- Renewal/replacement of heating and/or cooling plant and services.
- Renewal/replacement of ventilation plant and systems.
- Renewal/replacement of hot water generation plant.
- Renewal/replacement of lighting and controls with automated LED technology.
- Renewal/replacement of automatic controls/Building Management Systems (BMS) to optimise energy consumption.
- Addition of high efficiency fans, pumps and drives to provide greater plant efficiency.
- Heat recovery systems to reduce wasted heating/cooling energy.
- Renewable energy generation and expansion/integration.
- Fuel switching to zero carbon alternatives such as Hydrogen.

4.4 Thermal Performance of Building Fabric

4.4.1. The team have surveyed each building both internally and externally to identify the scope for fabric improvements. The options considered include:

- Additional wall insulation to improve U-Value.
- Additional roof insulation/roof replacement to improve U-Value.
- Replacement windows/addition of secondary glazing to improve thermal performance and/or heat gain.
- Inspect and seal building fabric to improve air tightness.
- Repair/addition of thermal insulation to pipework and ductwork.

4.4.2. The purpose of this "fabric first" approach is to reduce the current heating and cooling requirements and minimise energy consumption which should reduce the overall requirement of the final solution for decarbonisation and minimise the associated installation costs.

4.5 Assumptions and Benchmarks

Building Fabric

4.5.1. Where the year of construction is known, we will assume that the thermal performance of the building fabric meets the relevant standards that were current at the time. Where the age of construction is not known, the team will estimate the period of construction based on available information, property characteristics and professional judgement.

4.5.2. Where our recommendation is to improve the insulation within thermal elements, we will assume that the final solution meets the requirements of Building Regulations Approved Document L, Volume 2 (2021) Table 4.1 which proscribes the requirements for new and upgraded thermal elements within new and existing buildings.

Table 4.1 Limiting U-values for new or replacement elements in new and existing buildings and air permeability in new buildings

Element type	Maximum U-value[1] W/(m²·K) or air permeability
Roof (flat roof)[2]	0.18
Roof (pitched roof)[2]	0.16
Wall[20]	0.26
Floor[4][5]	0.18
Swimming pool basin[6]	0.25
Windows in buildings similar to dwellings[7][8]	1.6 or Window Energy Rating[9] Band B
All other windows,[8][10][11] roof windows, curtain walling	1.6
Rooflights[12][13]	2.2
Pedestrian doors (including glazed doors)[14]	1.6
Vehicle access and similar large doors	1.3
High-usage entrance doors	3.0
Roof ventilators (including smoke vents)	3.0
Air permeability (for new buildings)	8.0m³/(h·m²) @ 50Pa

NOTES:

1. Area-weighted average values, except for new windows, rooflights and doors in existing buildings.
2. For dormer windows, 'roof' includes the roof parts of the windows and 'wall' includes the wall parts (cheeks).
3. If meeting such a standard in an existing building would reduce by more than 5% the internal floor area of the room bounded by the wall, a lesser provision may be appropriate.
4. The U-value of the floor of an extension may be calculated using the exposed perimeter and floor area of either the whole enlarged building or the extension alone.
5. If meeting such a standard in an existing building, would create significant problems in relation to adjoining floor levels, a lesser provision may be appropriate.
6. The U-value of a swimming pool basin (walls and floor) calculated according to **BS EN ISO 13370**.
7. For example, student accommodation, care homes and similar uses where the occupancy levels and internal heat gains are essentially domestic in character.
8. If other performance (e.g. wind load, safety, security or acoustic attenuation) requires thicker glass to be used, an equivalent window unit with standard thickness glazing should be shown to meet the required standard.
9. The methods for calculating Window Energy Rating are set out in the Glass and Glazing Federation's Glazing Manual Data Sheet 2.3, Guide to the Calculation of Energy Ratings for Windows, Roof Windows and Doors.
10. No maximum U-value is set for display windows and similar glazing. There are no limits on the design of display windows and similar glazing, but for new buildings their impact must be taken into account in the calculation of primary energy and CO_2 emissions.
11. In buildings with high internal heat gains, the average U-value for windows can be relaxed from the values given above if this can be shown to be an appropriate way of reducing overall CO_2 emissions and primary energy. However, values should be no higher than 2.7W/(m²·K).
12. U-values for rooflights or rooflight-and-kerb assemblies should be based on the developed surface area of the rooflight (U_{rl} values), which is often greater than the area of the roof opening. Further guidance on U_{rl}-values is given in the Building Research Establishment's BR 443 and the National Association of Rooflight Manufacturers' Technical Document NTD02.
13. The limiting value for rooflights also applies to kerbs that are supplied as part of a single rooflight-and-kerb assembly sourced from the same supplier and for which the supplier can provide a combined U_{rk}-value for the assembly. An upstand built on site should have a maximum U-value of 0.35W/m²·K.
14. For external fire doorsets, as defined in Appendix A of Approved Document B, Volume 2, in new and existing non-domestic buildings, a maximum U-value of 1.8W/(m²·K) is permissible.

Fig. 4.1 Target construction standards

4.5.3. In the absence of evidence to the contrary, the type of insulation within a building described by the University estates team will be assumed as accurate.

4.5.4. Where recommendations are made to replace engineering services installations, we will assume that the final solution has been designed to provide a good standard of performance and efficiency in line with good practice guidance and based on empirical evidence. As a minimum, we will assume that any new system meets the requirements of the Energy Technology List (ETL) which is administered by the Department for Business, Energy and Industrial Strategy (BEIS).

4.5.5. The above will apply to system parameters such as chiller/heat pump Energy Efficiency Ratios (EERs)/Coefficients Of Performance (COPs), heat recovery efficiency, lighting efficacy etc. A summary of assumed system efficiencies is shown below.

Table 4.1 – System Efficiencies

System Type	Assumed System Efficiency
LTHW Gas Boiler (existing)	92%
Air-cooled comfort chillers that provide cooling only (existing)	185%
Air-cooled, simultaneous heating and cooling comfort chillers that provide heating and cooling (existing)	Cooling EER: 3.30 Heating COP: 3.70
Low Temperature Air Source Heat Pumps (<52°C outlet temp. @ -7°Cdb)	Heating COP: 1.55
Medium/High Temperature Air Source Heat Pumps (>52°C outlet temp. @ -7°Cdb)	Heating COP: 1.30
Large Irreversible Air Source Heat Pumps (>45kW rated output)	Heating COP: 1.25
5th Generation heat network utilising water-to-water heat pump fed via traditional "U-Tube" ambient loop ground source vertical borehole array or dry air coolers	Heating COP: 4.00 Cooling EER: 3.75
5th Generation heat network utilising water-to-water heat pump fed via co-axial ambient loop ground source inclined borehole array	Heating COP: 4.75 Cooling EER: 4.50
Direct electric heating (new/existing)	100%
Instantaneous electric domestic hot water system (new/existing)	100%
Direct gas fired central domestic hot water system (existing)	97%
Fluorescent Lighting (existing)	60 lumens/W
LED Lighting	Existing: 100 lumens/W New: 120 lumens/W
Heat recovery efficiency	70%

4.6 Simulation & Analysis

4.6.1. A key element of the technical assessment is Dynamic Simulation Modelling (DSM). The DSM has been produced within Integrated Environmental Solutions (IES) Virtual Environment (VE) and allows us to carry out dynamic thermal simulations to test the efficacy of the potential energy efficiency and decarbonisation solutions. The results from the VE will deliver expected percentage improvements in energy consumption which will be applied to the baseline figures for each building to calculate the expected impact on carbon emissions.

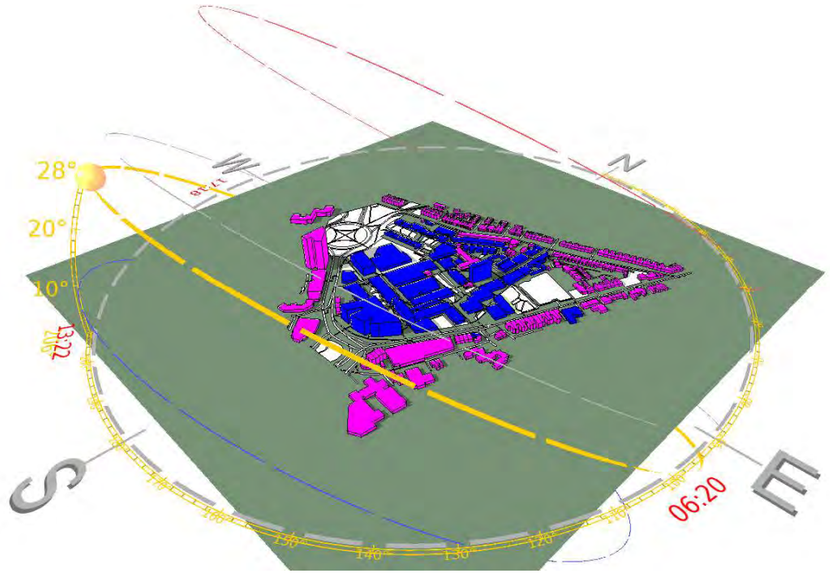


Fig. 4.2 IES site model

4.6.2. The DSM is based on drawings and mapping data with the simulation parameters based on the information provided and data gathered during site surveys. The simulations are carried out using the relevant CIBSE Test Reference Year (TRY) Weather file for the local area. CIBSE has produced a set of weather files specifically for Plymouth which reflect current and future weather scenarios.

4.7 Development of Budget Costs

4.7.1. Our in-house Quantity Surveying (QS) team has provided expertise in the development of a cost model utilising typical cost rates for the various interventions based on industry rates, historic tenders and previous information provided by the University. The building surveyors and engineers have developed a list of potential options which could reasonably be applied to the buildings within the assessment.

4.7.2. The cost model allows the selection of any combination of the potential energy efficiency and decarbonisation options identified in this report for each building which also feeds into the energy model to provide robust estimates for the carbon savings and the budget cost required to implement the various options.

4.7.3. We have measured all building perimeters and heights from the drawings and information provided. We have also made an assessment of the proportion of glazing for each building. Each building has been assigned to a category either simple, complex or terrace.

4.7.4. Each category of building has a cost rate for each potential intervention, as well as multiple cost rates based on the proportion of glazing identified; low, medium, high or curtain walling. The cost rates are applied to the Gross Internal Area (GIA) on a £/m² basis.

4.8 Maintenance Costs

4.8.1. The University have extensive knowledge of annual maintenance costs and have provided an indicative figure for maintenance of £21.50/m² which we have applied to the Gross Internal Area (GIA) of the buildings to provide an estimate for the likely maintenance budgets.

5. Current Energy Consumption & Carbon Emissions

5.1 University Campus Overview

5.1.1. Reviewing the University's Carbon Management Plan (CMP) they have compared their historic and projected emissions following carbon reduction projects against their ambitious targets to identify the current shortfall in delivery of carbon savings. The current projection suggests that the University will need to deliver a further 64TCO2e savings in scope 1 & 2 carbon emissions to meet the net zero target by 2030.

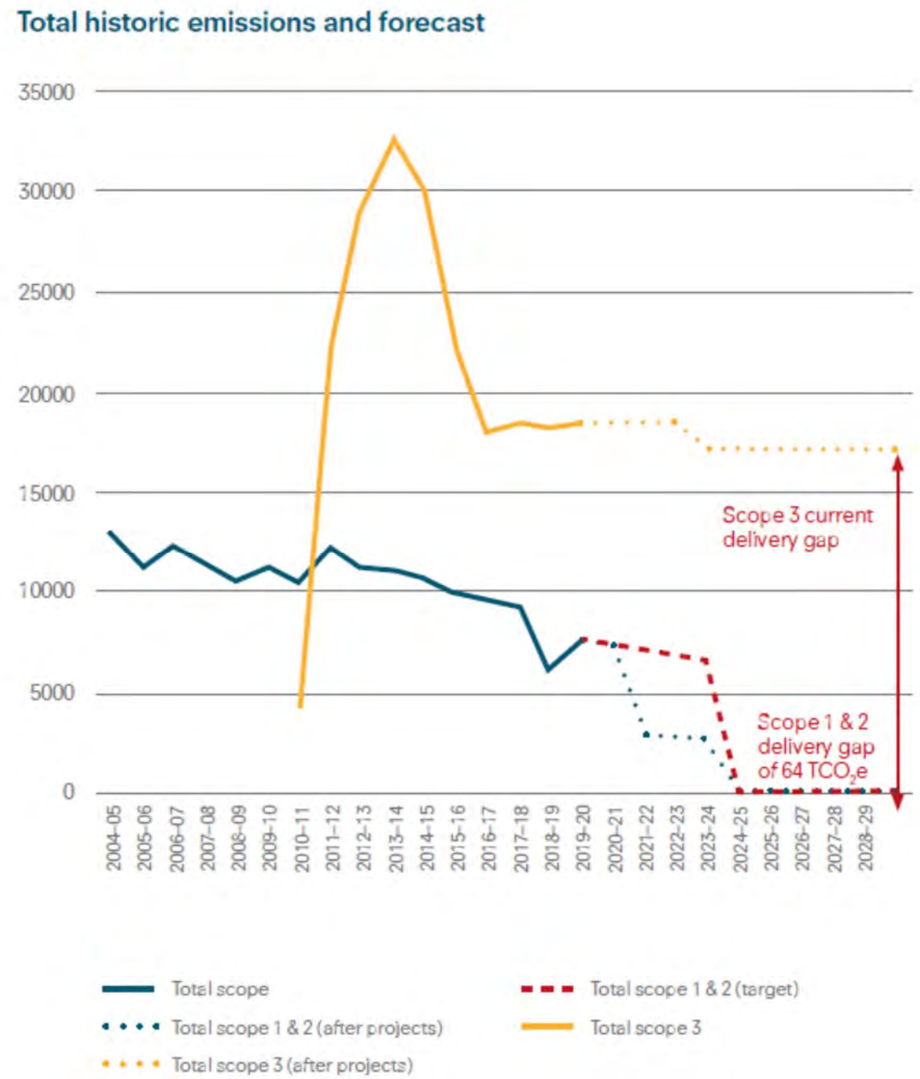


Fig. 5.1 Historic emissions and forecast

5.1.2. The projections for energy usage suggest a medium-term increase in gas usage across the site as the gas-powered Combined Heat and Power (CHP) plant is utilised to provide on-site electricity generation with a corresponding fall in grid supplied electricity. However, electricity consumption is expected to increase due to the focus on decarbonisation and the ongoing removal of fossil fuels.

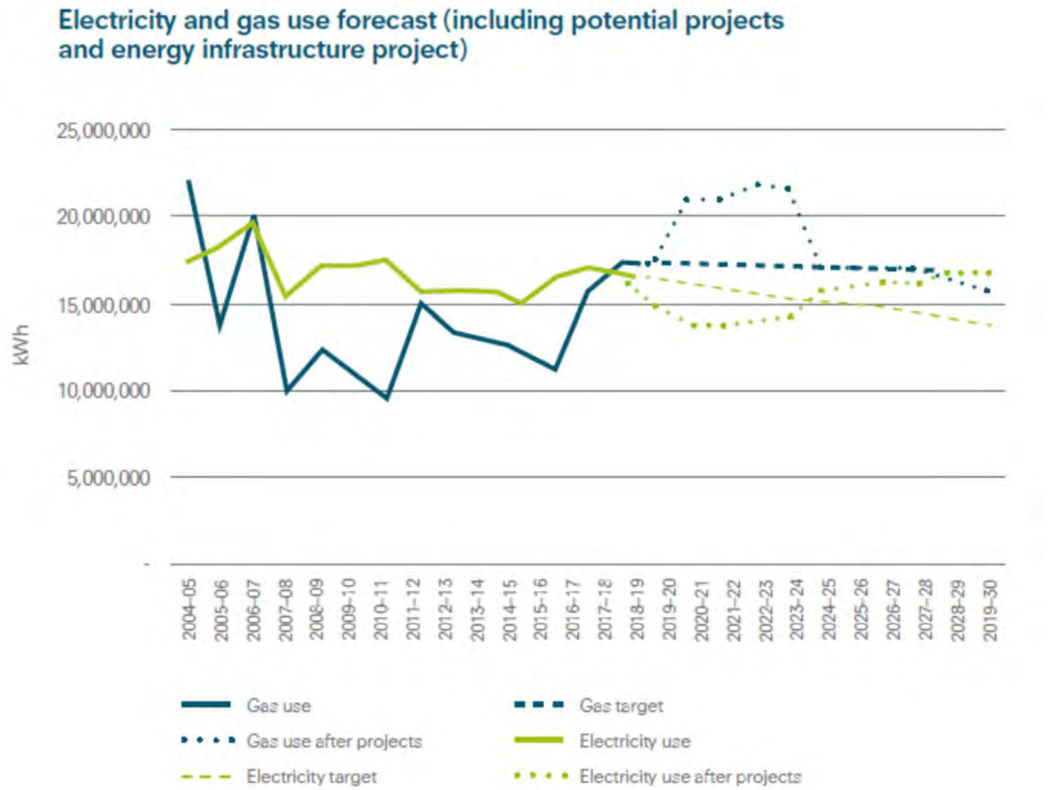


Fig. 5.2 Energy use forecast

5.2 HCDP Portfolio Properties

5.2.1. We have been provided with energy consumption data for the 40No. properties forming part of the study for the HCDP. The data suggests the total annual consumption figures are as follows:

Table 5.1 – Energy Consumption & Carbon Emissions

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Natural Gas	13,277,960 kWh	0.184 $kgCO_2e/kWh$	2,443 TCO_2e
Grid Electricity	10,704,754 kWh	0.105 $kgCO_2e/kWh$	1,124 TCO_2e
Total	23,982,714 kWh	N/A	3,567 TCO_2e

5.3 Site Energy & Carbon Intensities

5.3.1. The University Carbon Management Plan (CMP) established that the baseline scenario across the campus in respect of carbon intensity (1990) was 219kgCO2e/m². This fell to 69kgCO2e/m² in 2013/14 and was recorded at 44kgCO2e/m² in 2018/19.

5.3.2. Based on the emissions calculated in Table 5.1 across a sample size of circa 120,086m², the carbon intensity across the buildings in this study is 29.7kgCO2e/m².

Table 5.2 – EUI Comparison Against UoP Targets

Fuel Type	2021-22 Campus Target EUI (University CMP)	Current EUI (HCDP Buildings)	2029-30 Campus Target EUI (University CMP)
Natural Gas	92.17 kWh/m²	110.57 kWh/m²	89.05 kWh/m²
Grid Electricity	85.12 kWh/m²	89.14 kWh/m²	74.40 kWh/m²
Total	177.29 kWh/m²	199.71 kWh/m²	163.45 kWh/m²

6. Decarbonisation Options Appraisal

6.1 Building Fabric

Roofs and External Walls

6.1.1. We have assumed that the U-Values for building fabric elements meet the minimum standard as required by the edition of UK building regulations that were in force at the time of construction. Where two potential editions exist, the least onerous values will be used to avoid overestimating the impact of any improvement in performance. See table 7.1 for further details.

6.1.2. Where our investigations determine that upgrading thermal insulation to walls and roofs is feasible we have assumed that the upgrade will meet the minimum requirements of Building Regulations Approved Document L, Volume 2 (2021) Table 4.1 (see Fig. 4) which requires a maximum U-Value of 0.26W/m².K for new or replacement walls.

Table 6.1 – U-Values of Thermal Elements

Thermal Element	U-Value at time of construction (W/m².K)						
	Pre 1980	1980-1989	1990 1999	2000-2006	2007-2012	2013-2021	Target U-Value
External Wall –	1.6	1.0	0.60	0.45	0.35	0.35	0.26
Roof (Flat)	1.5	0.68	0.40	0.35	0.25	0.25	0.18
Roof (Pitched)	1.5	0.68	0.40	0.35	0.25	0.25	0.16
Windows	4.8	4.8	4.8	3.1	2.2	2.2	1.60
Doors	4.8	4.8	4.8	3.1	2.2	2.2	1.60
High Usage Doors	4.8	4.8	4.8	3.1	6.0	3.5	3.0

Note: We have excluded ground floors as the feasibility of undertaking such works is generally complex and potentially cost prohibitive.

6.1.3. Options for improving the thermal performance of building fabric are limited to the following:

- Option F1: The addition of internal or external wall insulation (depending on existing construction details).
- Option F2: The installation of new or additional roof insulation. This will involve further intrusive investigation to establish the current insulation detail.
- Option F3: The installation of double glazing in place of existing single-glazed window units or the addition of secondary glazing where single-glazed units cannot be replaced (i.e. listed status etc.)
- Option F4: Repair or sealing of existing double-glazed units where existing seals are not present or have failed.

6.1.4. We have assessed the potential improvement in energy consumption according to the estimated percentage decrease in U-Values which is then applied to the figures provided within the end use breakdown in section 4 for heating and cooling.

6.1.5. For the repair/sealing of existing glazing units we have assumed this will deliver a percentage improvement in heat loss through the glazing which has also been applied to the energy use breakdown in section 4.

6.2 MEP Services

Option: S1 Renewal/replacement of heating and/or cooling plant and services with heat pump technology.

6.2.1. To assess the impact of replacing heating and/or cooling plant we have assumed system efficiencies as shown in Table 4.1 section 3. The improvement in energy and carbon emissions is based on the net change in system efficiency between the existing system and the proposed solution, accounting for any potential fuel switching. For example, replacing a gas boiler with a stand-alone heat pump chiller required estimating the heat demand based on 92% efficiency, which is then used to calculate a new energy consumption using a heating system efficiency of 370% (COP of 3.70). The new energy consumption is then used to calculate the estimated carbon emissions based on the electrical carbon emission factor which is included in lieu of the existing estimated carbon emissions.

Option S2: Renewal/replacement of hot water generation plant.

6.2.2. To assess the impact of replacing Domestic Hot Water generation plant we have followed the process described in 7.2.1 and applied it to the base Domestic Hot Water energy consumption.

Option S3: Renewal/replacement of lighting and controls with automated LED technology.

6.2.3. We have assumed that the energy consumption of LED lighting is approximately 1/3 of that for fluorescent lighting therefore to assess the impact of installing LED lighting we have taken the estimated lighting energy consumption and applied a factor of 35%.

Option S4: Renewal/replacement of automatic controls/Building Management Systems (BMS) to optimise energy consumption.

6.2.4. We have assumed that the renewal/replacement of the BMS could deliver around 5% improvement in energy consumption which is applied to the overall energy consumption figure for each building.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency.

6.2.5. We have assumed that the addition of high efficiency fans, pumps and drives could deliver around 5% improvement in energy consumption which is applied to the heating, fans and cooling energy consumption breakdown figures for each building.

6.2.6. Option S6: Heat recovery systems to reduce wasted heating/cooling energy.

We have assumed that the addition of heat recovery, where not already installed, could deliver around 10% improvement in energy consumption which is applied to the heating and cooling energy consumption breakdown figures for each building.

Option S7: Renewable energy generation and expansion/integration.

6.2.7. Where it is considered feasible to install building mounted renewable energy generation such as solar PV we will consider the available roof area, assuming that up to 60% of the available roof area could be utilised for an array. The estimated yield will be deducted from the electrical energy consumption figures at a rate of 250 kWh/m² of PV.

Option S8: Fuel switching to zero carbon alternatives such as Hydrogen.

6.2.8. Hydrogen technology is its infancy however there are potential options for hydrogen storage and distribution within a campus environment. We have considered the feasibility of a hydrogen network separately however our current recommendations are based on robust, mature technology.

6.2.9. Table 6.2 identifies which options have been considered for each building and which options have been judged to be inappropriate.

Table 6.2 – Fabric and building services improvement assessment summary

Building Name	Option F1	Option F2	Option F3	Option F4	S1	S2	S3	S4	S5	S6	S7	5DHC Borehole Compatibility (Y/N)
1 Kirkby Place	✓	✓	✓	✗	✗	✓	✓	✓	✗	✓	✗	Yes
12 Kirkby Place	✓	✓	✓	✗	✗	✓	✓	✓	✗	✓	✗	Yes
Babbage												Yes
Brixham Laboratory	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	No
Brunel (To be demolished)	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	N/A
Caprera Cottage	✓	✓	✓	✗	✗	✗	✓	✓	✗	✗	✗	No
Cookworthy	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	No
Derriford Research Facility	✓	✓	✓	✗	✓	✗	✓	✓	✓	✓	✓	No
Endsleigh Place (No. 14-24)	✓	✓	✓	✗	✓	✓	✓	✓	✗	✗	✗	Yes
Fitness Complex	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	Yes
Fitzroy	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	Yes
Francis Drake Café												Yes
Hepworth House	✓	✓	✓	✗	✓	✓	✓	✓	✗	✓	✗	Yes
Intercity Place												No
John Bull Building					✓	✗	✓	✓	✓	✓	✓	No
Kirkby Lodge	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	Yes
Kirkby Place	✓	✓	✓	✗	✗	✓	✓	✓	✗	✓	✗	Yes
Kirkby Terrace	✓	✓	✓	✗	✓	✓	✓	✓	✗	✓	✗	Yes
Library					✓	✓	✓	✓	✓	✓	✓	Yes
Main Hall	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	Yes – Fed from Davy
Marine Station	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	No
Mary Newman												Yes
Nancy Astor	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	Yes
Nursery Building												Yes
Portland Mews	✓	✓	✓	✗	✓	✓	✓	✓	✗	✗	✓	Yes
Portland Square	✓	✓	✗	✗	✓	✓	✗	✓	✓	✗	✓	Yes

Portland Villas	✓	✓	✓	✗	✓	✓	✓	✓	✗	✗	✓	Yes
Reynolds	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	Yes
Robbins Conference Centre	✗	✗	✓	✗	✓	✓	✓	✓	✓	✓	✓	No
Roland Levinsky Building	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	Yes
Rolle Academic Building	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	Yes
Rolle Marquee	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	No
Sherwell Centre (Lecture Theatre)	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✗	Yes
Skardon Place (Greenhouses)	✗	✗	✗	✗	✗	✗	✗	✓	✗	✗	✗	No
Thomas Pitts Hall	✓	✓	✓	✗	✓	✓	✓	✓	✗	✗	✗	No
Wellbeing Centre	✓	✓	✓	✗	✓	✓	✓	✓	✗	✗	✓	Yes

7. Portland Square

7.1 Description of Building

7.1.1. General

Portland Square is located to the east of the main campus and is primarily a teaching block for the factulties of Dentistry, Mathematics, Robotics and Biomedical Sciences. The building contains teaching spaces, lecture theatres, medical training and office/administration areas as well as a cafeteria.



Fig. 7.1 Portland Square

7.1.2. Building Fabric

Portland Square is a six-storey building constructed between 2001 and 2010 comprising of a steel frame construction enclosed with a combination of powder coated aluminium framed units incorporating sealed double-glazed walling and opening lights and stone and concrete cladding.

To some ground and first floor elevations powder coated aluminium framed double-glazed windows are set within reconstituted stone mullions. The roofs were not inspected however, from our review of Google Maps the roofs are understood to comprise flat roofs incorporating sloped glazing panels set within a metal frame that provide natural light to the atriums.

Powder coated aluminium framed doors incorporating double glazed units are provided to the main entrance and exit to the building.

During our inspection of Portland Square, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe insulation and rigid insulation boards are installed within the construction of perimeter walls and roofs respectively however, the detailed specification has not been provided.

Given the date of construction we assume the wall and roof insulation to have been designed to meet Building Regulations.

We would recommend consideration is given to the upgrade of insulation to these areas should subsequent clarification of the existing wall and roof insulation allow for upgrade to achieve enhanced thermal transmittance rates. Any potential insulation upgrade would be subject to liaison with specialist consultants however we would expect it to meet the requirements of current building regulations.

Much of Portland Square is enclosed with double-glazed curtain walling with open atria between ground and upper floors. Subject to a review of as-built information and specialist consultants, the installation of window film may provide an area for the reduction in energy consumption.

7.1.3. Mechanical Services

Portland Square is supplied with LTHW via the campus DHN boilers in the Mary Newman building which feeds a plate heat exchanger in the main plantroom. The secondary side of the plate heat exchanger feeds an LTHW heating and hot water system comprising radiators and door curtains.

The building is now provided with comfort cooling via roof mounted packaged air-cooled chillers generating chilled water however this serves only the lecture theatres, data centre and dental facilities. Cooling is supplemented via a series of plank vents which provide night-time cooling of the building fabric. Local cooling is provided to key areas (comms rooms etc.) via DX cooling systems.

The building is generally naturally ventilated via opening windows to atmosphere and to the atrium areas. Stale air is discharged at roof level via Automatic Opening Vents (AOVs). Mechanical extract ventilation is provided to toilets and cleaners stores etc.

Domestic Hot water is generated by the DHN via a central hot water calorifier.

7.1.4. Electrical Services

The electricity supply to Portland Square is served from the privately owned HV electricity supply which terminates at a 1250kVA rated substation located within the building. The electrical installation includes provision for standby power generation for supplies to essential services.

Power is distributed throughout from the main LV switch panel on the ground floor via vertical risers located throughout the building. The LV distribution system feeds local metered distribution boards on each level.

Lighting is generally provided via a variety of LED luminaires with occupancy sensing controls serving communal, offices and teaching spaces.

7.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides data for the electrical system, however although there is a sub-meter installed, there is no dedicated sub-metering data available for Portland Square in respect of the heat network therefore we have relied on data provided by the estates team for analysis. The full list of electrical sub-meters is as follows:

- Com A RBus
- Com B RBus
- Kitchen Atrium
- MCCP1 Boiler Room
- MCCP2 Lecture A
- MCCP3 Lecture B
- MCCP4 Lecture C
- MCCP5 Office A
- MCCP6 Offices B
- MCCP7 Offices C
- MCCP9 Offices B
- MCCP10 Block A Roof
- MCCP11 Block B Roof
- MCCP12 Block C Roof
- Rising Busbar A
- Rising Busbar B
- Rising Busbar C
- Data Centre – Chiller 1
- Data Centre – Chiller 2
- Data Centre – HVAC Panel
- Data Centre UPS

7.1.6. BMS/Controls

The building is provided with a Satchwell Sigma BMS. The Sigma family are legacy products manufactured by Satchwell which has subsequently been absorbed into the Schneider Electric group.

We understand support is still available in terms of software and components however the system is considered obsolete and is likely to require replacement as part of a wider BMS modernisation/integration exercise.

7.1.7. Condition & Operation

We understand that the building suffers from overheating in some areas during periods of hot weather. We have also received reports that the metal-framed glazing system induces cold draughts in cold weather which are not alleviated by the heating system.

We understand that the boiler plant in the Mary Newman building which serves the heating and hot water requirement is ageing and is generally unreliable which results in frequent periods of downtime due to failure and a regular requirement for temporary boilers to be deployed. We understand that the boilers have subsequently suffered a catastrophic failure following our inspection.

We understand that the building was constructed in the mid-2000s meaning the engineering services are circa 15-20 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 5-10 years, subject to appropriate maintenance.

The engineering services generally appear to be in good condition however we understand that the controls/BMS is in poor condition and requires renewal/refurbishment which is scheduled to be undertaken as soon as possible.

7.1.8. Planned Future CAPEX Works

We understand that a programme of capex works had recently been completed to renew ventilation plant and install the chillers. It is expected that the LTHW system will be disconnected from the campus DHN with dedicated heating plant installed, likely to be heat pump based. We understand that this has been scheduled for 2022/23 and this report will form the basis of the options appraisal to determine the best solution for the new heating system.

7.1.9. Opportunities for Heat Networks

The building is currently served with LTHW from the existing campus DHN however works are underway to disconnect it and create a standalone building.

The University is investigating the feasibility of providing a 5th Generation Heating & Cooling (5DHC) network which could potentially serve the Portland Square building. If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Portland Square to the 5DHC network when it becomes operational.

Typical future-proofing measures to consider could be:

- Ensure the heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
- Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

7.2 Energy & Carbon Emissions

7.2.1. The following table identifies the energy consumption and carbon emissions from the Portland Square building based on the energy consumption figures provided from site.

Table 7.1 – Energy Consumption & Carbon Emissions – Portland Square

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	1,364,792 kWh	0.184 $kgCO_2e/kWh$	251.12 TCO_2e
Grid Electricity	1,000,542 kWh	0.105 $kgCO_2e/kWh$	105.06 TCO_2e
Total	2,365,334 kWh	N/A	356.18 TCO_2e

7.2.2. Table 4 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 13260.4m². The performance of Portland Square is very good with overall energy usage and carbon emissions around half the current benchmark. The figures correspond closely with those stated on the current DEC.

Table 7.2 – Energy Consumption & Carbon Emissions Benchmarking – Portland Square

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity (kgCO2e/m²)	EUI (kWh/m²)	Carbon Intensity (kgCO2e/m²)	Annual Energy Use (kWh/m²)
Fossil Fuel	102.92	18.93	240	44.16	101.39
Grid Electricity	75.45	7.92	80	8.40	80.21
Total	178.37	26.85	320	52.56	181.60

7.2.3. The building would have been constructed to 2000/2006 building regulations therefore the thermal performance and energy efficiency standards should be reasonable when compared against typical University Campus building stock.

7.2.4. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2021 as the most recent full year. The metering data shows the energy consumption profile for Portland Square throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. The data shows an increase in electrical consumption through the winter when there is an increased demand for lighting however this is tempered by an increased demand for cooling in the summer which is provided via the roof mounted chiller plant.

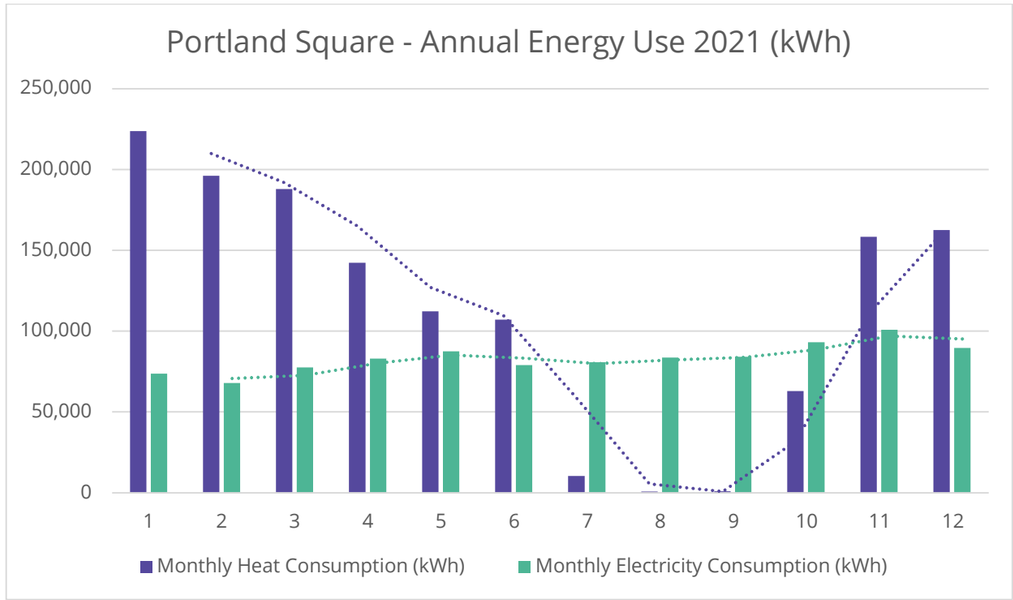


Fig. 7.2 Portland Square annual energy usage profile

7.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.7697 which suggests a relatively strong correlation between degree days and heat consumption, however this value suggests there is some inherent inefficiency in the system. This can be explained by the fact that the heat network is metered within the Mary Newman building and that there are likely to be significant pipework heat losses between the heat source and the emitters.

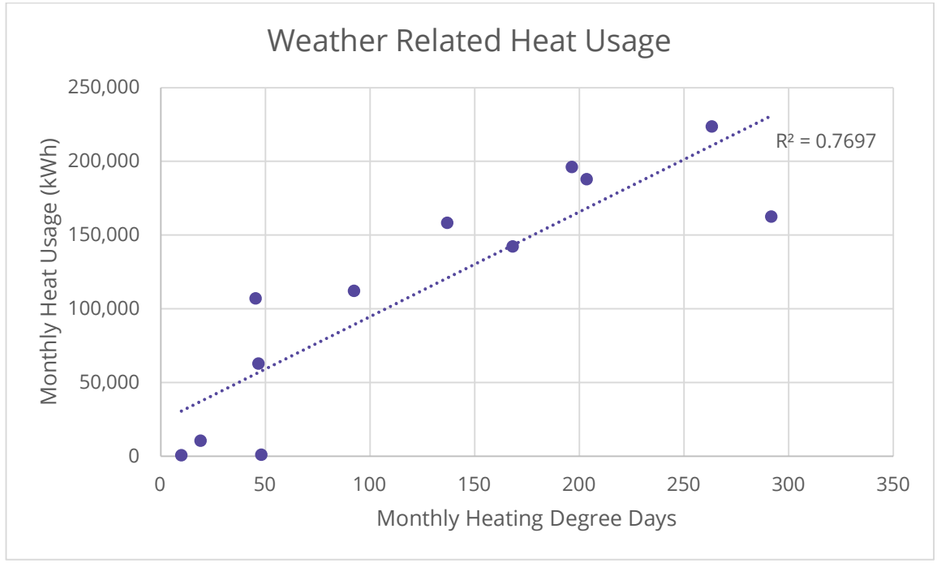


Fig. 7.3 Weather related heat usage compared to degree days

7.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

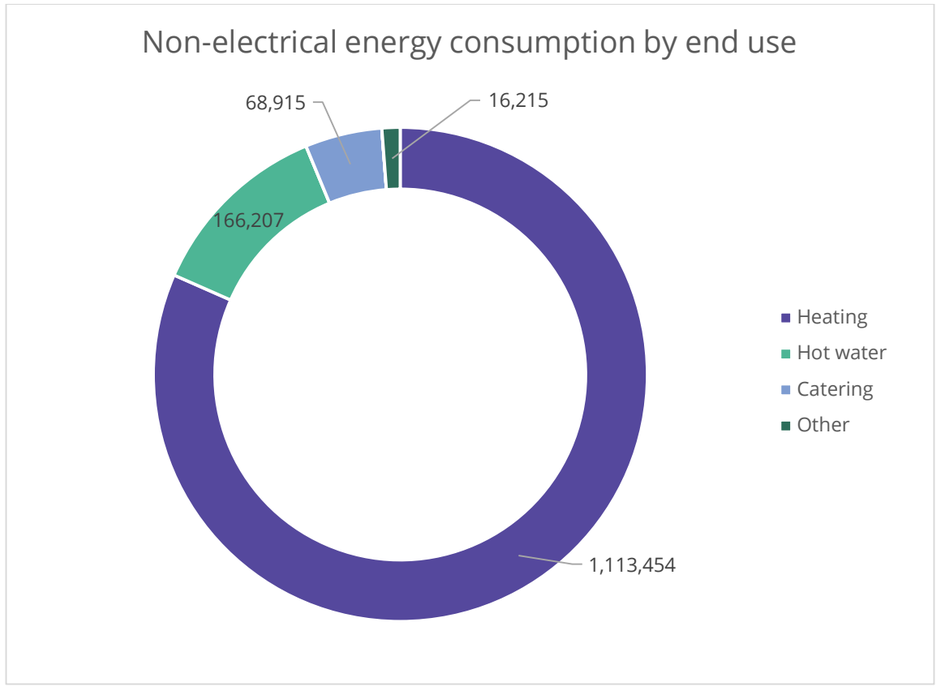


Fig. 7.4 Non-electrical energy consumption breakdown by end use

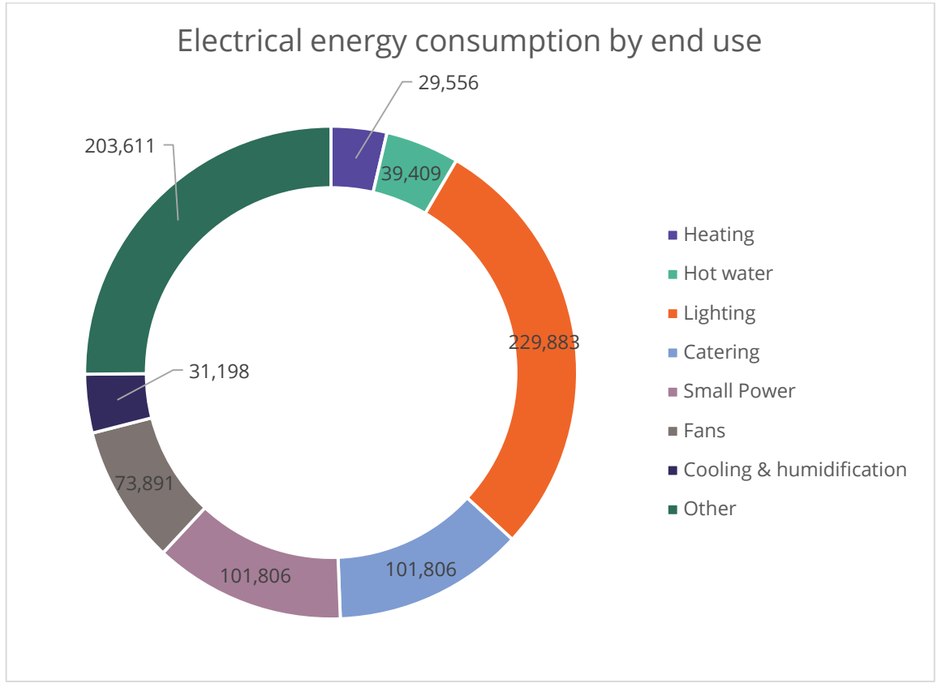


Fig. 7.5 Electrical energy consumption breakdown by end use

7.3 Technical Solution

Based on the summary in Table 7.2, the solution proposed for Portland Square is as follows:

Option F1: The addition of internal or external wall insulation

Additional wall insulation is fixed to the internal/external wall or a combination. The type and method of insulation to be recommended is dependent on confirmation of the existing insulation/U Values and the desired U value to be achieved. Typically, retrospective insulation is fitted internally by way of adhesive to existing walls or battens with insulation quilt/plasterboard, rigid insulation board or a mixture of the two. External insulation is generally, comprises of rigid insulation board either mechanically fixed/fixed within a steel cage system but often having an applied render coat or being of a prefinished insulation board.

Option F2: The installation of new or additional roof insulation

From our review of 'Google maps' the roofs are believed to comprise of flat, pitched and some glazed areas. Subject to review of as-built data, there may opportunity to mechanically fix rigid insulation to the internal of the roofs. This would avoid disruption to exiting roofs/plant and the requirement to overclad existing pitched roofs. In addition, glazed rooflights may benefit from the installation of reflective /absorptive film, subject the review of as-built data.

Option F3: Installation of reflective/ absorptive film on curtain glazing system to reduce heat gain

Reflective/absorptive film is installed to the internal glazing face. There are numerous types of reflective/absorptive window films, and this are agreed subject to the clarification of the existing window specification and U Value to achieved.

To assess the impact of installing a reflective/absorptive film we have assumed a 5% improvement in the cooling demand for the building due to reduced solar gain.

7.3.1. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Portland Square. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Portland Square we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

Option S7: Expansion of roof mounted solar PV installation.

With an available roof area of approximately 2048m² we anticipate that an additional 1,220m² of solar PV cells could be installed, subject to detailed design and structural feasibility assessment. This would also need to be considered within the design of the additional roof insulation and potential location of plant on the roof.

7.4 Energy & Carbon Savings – Portland Square

Table 7.3 – Carbon savings summary – Portland Square

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
-	Addition of external window film to reduce solar heat gain	107.98	£120,819	15	1,620	£75	£7,389	16.4
F1	Addition of wall insulation	117.33	£18	30	3,520	£0	£7,389	0.0
F2	Addition/replacement of roof insulation	118.18	£233,167	30	3,545	£66	£8,046	29.0
F3	Replacement of glazing to improve thermal performance	117.91	£2,929,527	20	2,358	£1,242	£7,837	373.8
F4		0.00	£0		0	£0	£0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	237.81	£1,989,060	25	5,945	£335	£78,184	25.4
S2	Installation of new centralised domestic hot water generation, pipework and controls	113.30	£464,114	25	2,832	£164	£91,833	5.1
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	118.35	£165,755	20	2,367	£70	£26,217	6.3
S5	Addition of high efficiency fans, pumps and drives	108.21	£132,604	25	2,705	£49	£966	137.3
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	111.21	£655,360	15	1,668	£393	£8,435	77.7

7.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 995kW (based on a rule of thumb of 75W/m²) with the peak cooling demand of 955kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 209kW and 239kW for heating and cooling respectively.

7.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Portland Square which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Portland Square will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

Solar PV installations will be subject to G99 applications to the district electricity supply company for each building to seek approval for connections and without comprising the integrity of electricity network.

Consideration could be given to the application of battery technologies to harness the kWp energy from the Solar PV installation. In addition, the private HV ring main could be extended to service the power requirements for those metered LV power supplies across the West Campus.

LED lighting technologies has seen a significant improvement in lighting with increased lumen efficacies per luminaire circuit watts. These should be considered for the initial replacement of fluorescent lamped lighting installations and phased improvement plan for all existing LED lighting installations.

8. Brunel (TO BE DEMOLISHED)

8.1 Description of Building

8.1.1. General

Brunel is located toward the centre of the main campus site. The building houses most of the University's technology resources and comprises materials, engineering and fluid labs, cleanrooms and workshops which are used by the schools of Biological and Marine Sciences, Engineering and Computing and Mathematics.



Fig. 8.1 Brunel

8.1.2. Building Fabric

Brunel is a single-storey building constructed in the 1950's comprising of a steel frame construction enclosed with cavity brickwork.

The roofs were not inspected however, from our review of Google Maps the roofs are understood to comprise a saw-tooth roof profile with sheet metal covering and northlights.

During our inspection of Brunel, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. We understand the building is to be fully demolished in the short term to create a new green space.

8.1.3. Planned Future CAPEX Works

We understand that the Brunel Laboratories are due to be demolished in order to create a new green space and potential borehole installation.

8.2 Energy & Carbon Emissions

8.2.1. The following table identifies the energy consumption and carbon emissions from the Brunel building based on the energy consumption figures provided from site.

Table 8.1 – Energy Consumption & Carbon Emissions – Brunel

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	313,603 kWh	0.184 $kgCO_2e/kWh$	57.7 TCO_2e
Grid Electricity	442,920 kWh	0.105 $kgCO_2e/kWh$	46.51 TCO_2e
Total	756,523 kWh	N/A	104.21 TCO_2e

8.2.2. Table 4 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for Laboratory buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 3,685.1m². The performance of Brunel is very good with overall energy usage and carbon emissions around half the current benchmark. The figures correspond closely with those stated on the current DEC.

Table 8.2 – Energy Consumption & Carbon Emissions Benchmarking – Brunel

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	85.10	15.66	160	30.40	182.93
Grid Electricity	120.19	12.62	160	88.00	48.23
Total	205.29	28.28	320	52.56	231.16

8.2.3. The building was constructed in the 1950's therefore the thermal performance and energy efficiency standards are likely to be poor when compared against typical University Campus building stock.

8.2.4. Gas meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have compiled the data from 2020 & 2022 to generate a representative period. The Brunel building is metered within the Davy plantroom however the circuit serves both Brunel and Smeaton. Although we are unable to separate the heat consumption between the two buildings the data still provides an opportunity to check weather related heat usage. We have not been able to extract monthly electrical consumption data as this is not available within the C3ntinel portal.

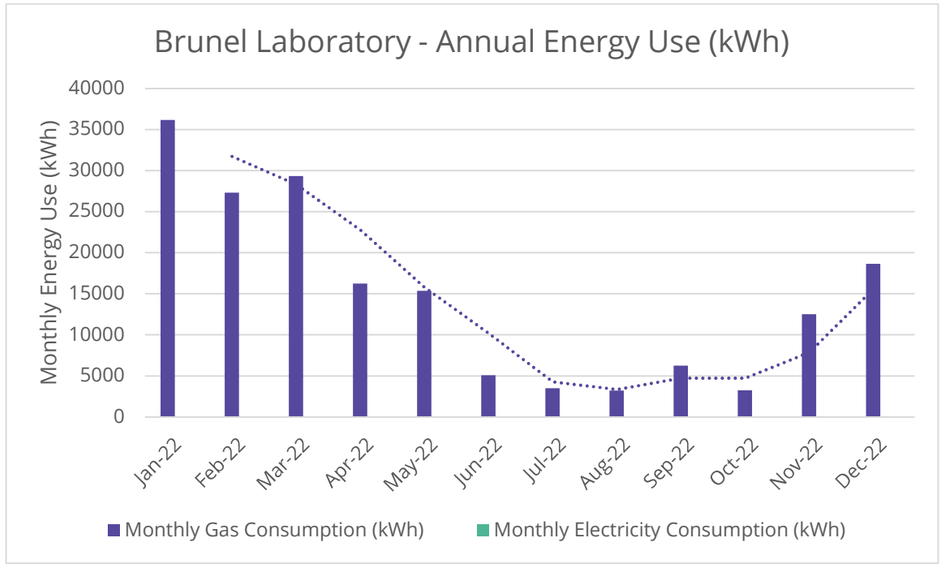


Fig. 8.2 Brunel annual energy usage profile

8.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.033 which suggests a very poor correlation between degree days and heat consumption. This is likely the result of poor fabric efficiency and a lack of data as the figures suggest no energy consumption in January, February and March which is unlikely.

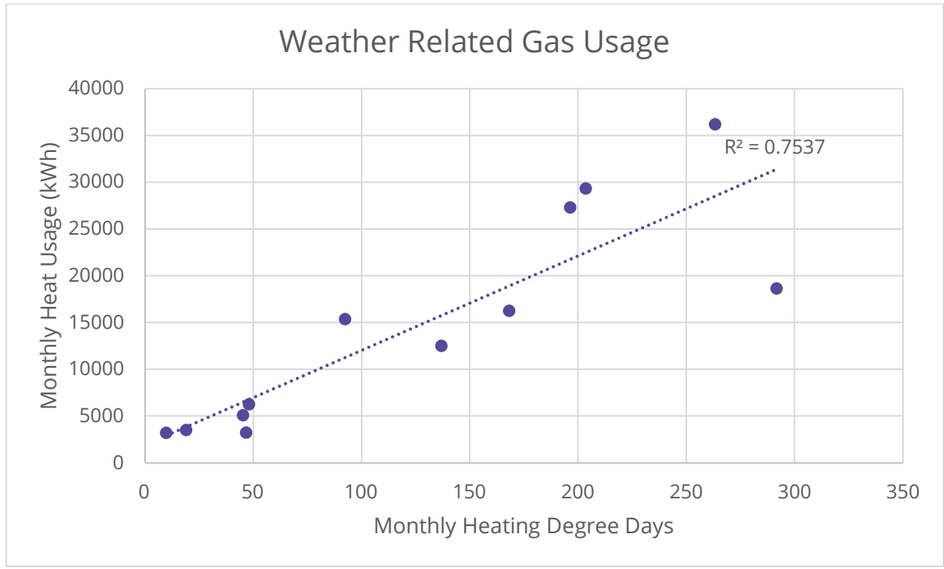


Fig. 8.3 Weather related heat usage compared to degree days

8.2.6. It should be noted that the Brunel Laboratory building is to be demolished to make way for a new green space and possible borehole installation therefore we have not provided further analysis on this building, save for assessing the reduction in carbon emissions associated with its demolition.

8.3 Technical Solution

8.3.1. The Brunel building is to be demolished and the area transformed into a green space with a potential borehole installation. We have not carried out an options appraisal or developed a technical solution, save for assessing the reduction in carbon emissions and utilities demand associated with the building being removed.

9. Caprera Cottage

9.1 Description of Building

9.1.1. General

Caprera Cottage is located on North Road East to the north of the main campus. The building contains office accommodation for the University's commercial services department.



Fig. 9.1 Caprera Cottage

9.1.2. Building Fabric

Caprera Cottage comprises a two-storey building constructed 1800 to 1900 with more recent single-storey extension. The buildings are of masonry construction with brick, stonework, cement render elevations and timber framed units incorporating single-glazed opening lights.

The roofs were not inspected however, from our review of Google Maps the roofs are understood to comprise pitched tiled and profiled metal sheet roof coverings. The pitched tiled roofs incorporating rooflights.

Where seen doors are timber and aluminium framed, some incorporated within double glazed walling.

During our inspection of Caprera Cottage, we did not observe any issues of major concern in respect of the building fabric, and none was reported by site management. From information provided by site management we believe there is no wall insulation. The glass rock and mineral wool roof insulation is recorded as fair however, the detailed specification has not been provided.

We would recommend consideration is given to the provision and upgrade of insulation to the walls and roofs respectively. Any potential improvements would be subject to the commissioning of a thermographic survey to identify in detail where improvements could be made to the thermal performance of the building envelope.

The above-mentioned report records the existing single glazed windows as in poor condition and as such their replacement would be recommended. These works would be subject to liaison with consultants and building regulations.

9.1.3. Mechanical Services

Caprera Cottage is supplied with electric heating via wall mounted panel heaters. The panel heaters are provided with integral programmable controls. There is a large redundant domestic-type gas fire with stainless steel flue which terminates through the roof.

The building is generally naturally ventilated via opening windows to atmosphere with opening roof lights. Local extract ventilation is provided to toilets etc.

Domestic Hot water is generated by local electric water heaters and instantaneous water boilers.

9.1.4. Electrical Services

The electricity supply to Caprera Cottage is served with a metered Low Voltage (LV) single phase connection derived from the electricity supply network operated by the local district network operator.

Power is distributed throughout from the main LV distribution board on the ground floor via final circuits to sockets and lighting installation.

Lighting is generally provided via a variety of LED luminaires with occupancy sensing controls serving communal and offices spaces.

9.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides data from the gas meter, however there is no dedicated sub-metering data for Caprera Cottage in respect of the electrical system therefore we have relied on bulk data provided by the estates team for analysis.

9.1.6. BMS/Controls

All controls are local to appliances and there is no link to the site BMS except for the gas metering data.

9.1.7. Condition & Operation

The engineering services generally appear to be in good condition. We understand that the existing services are around 10 years old so should provide a further 5-10 years of service, subject to satisfactory maintenance.

9.1.8. Planned Future CAPEX Works

We understand that there are no planned CAPEX works at Caprera Cottage.

9.1.9. Opportunities for Heat Networks

Although bordering the main campus Caprera Cottage is remote from the majority of buildings and is accessed via North Road East. The grounds to the rear are directly linked to the grounds belonging to Portland Villas and Hepworth House which creates difficulties in routing services from the main campus.

Caprera cottage is therefore considered low priority in respect of the potential to connect to any future 5DHC network.

9.2 Energy & Carbon Emissions

9.2.1. The following table identifies the energy consumption and carbon emissions from the Caprera Cottage building based on the energy consumption figures provided from site.

Table 9.1 – Energy Consumption & Carbon Emissions – Caprera Cottage

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	879 kWh	0.184 $kgCO_2e/kWh$	0.16 TCO_2e
Grid Electricity	22,377 kWh	0.105 $kgCO_2e/kWh$	2.35 TCO_2e
Total	23,256 kWh	N/A	2.51 TCO_2e

9.2.2. Table 4 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for General office buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 126.7m². The performance of Caprera Cottage is good with overall energy usage and carbon emissions below the current benchmark. There is no current DEC available. The fossil fuel and electricity figures vary significantly from the benchmarks however we consider that this is due heating and hot water being heated by electricity with only a gas fire which is used occasionally.

Table 9.2 – Energy Consumption & Carbon Emissions Benchmarking – Caprera Cottage

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	6.94	1.28	120	22.80	N/A
Grid Electricity	176.61	18.54	95	52.30	N/A
Total	183.55	19.82	215	75.10	N/A

9.2.3. The building was constructed in the 1800's and is over 120 years old therefore the thermal performance and energy efficiency standards are likely to be poot when compared against typical University Campus building stock although the building has been subject to some improvements.

9.2.4. Gas meter readings have been provided for the building via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2020 as the most recent full year however we acknowledge that data from 2020 is potentially compromised due to the covid-19 pandemic. However, as the building is predominantly heated via electric panel heaters, the gas consumption figures do not provide an accurate heating profile therefore we are unable to produce an accurate degree day analysis. There is no electrical consumption data available.

9.2.5. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

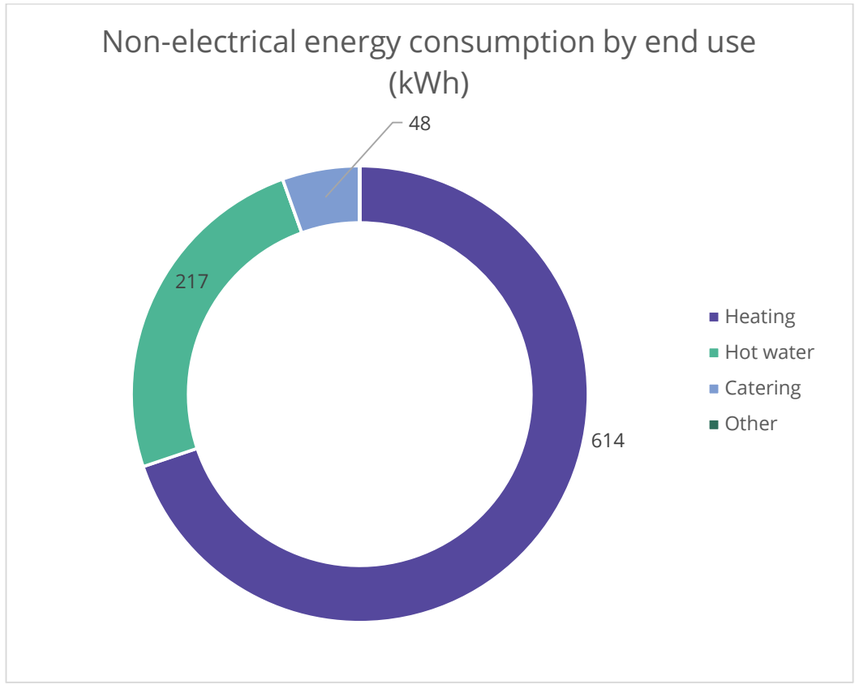


Fig. 9.2 Non-electrical energy consumption breakdown by end use

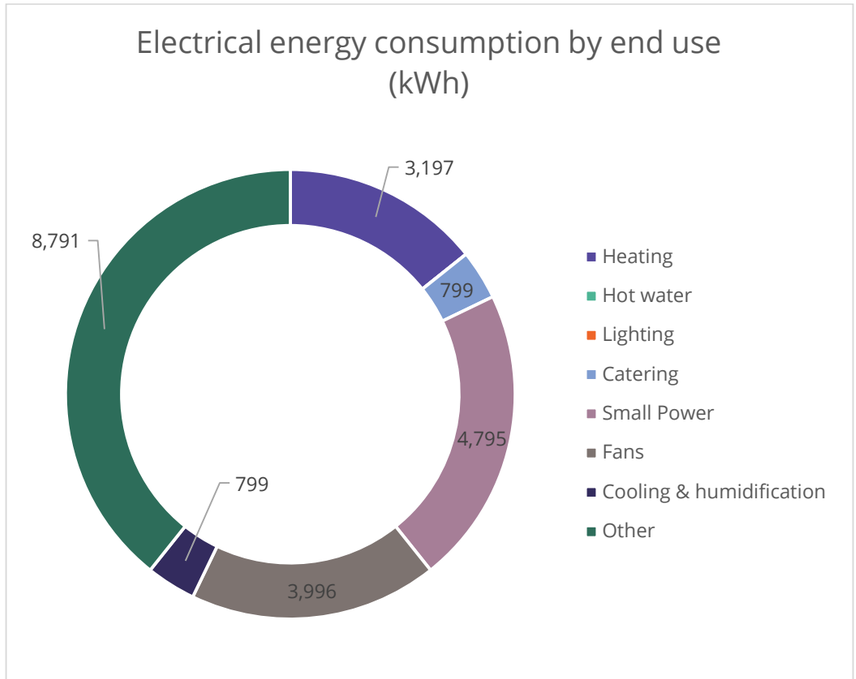


Fig. 9.3 Electrical energy consumption breakdown by end use

9.3 Technical Solution

Based on the summary in Table 7.2, the solution proposed for Caprera Cottage is as follows:

Option F1: The addition of internal or external wall insulation

Given, the existing faced stone/brick elevations and possible listed building/planning restrictions for this building the option to upgrade is limited. The anticipation would be to retrospectively install insulation to the internal wall face. These works would involve insulation fixed to walls by way of adhesive or battens with insulation quilt/plasterboard, rigid insulation board or a combination of the two. This method would impact on internal use whilst the works are in progress and reduce the overall internal floor area.

Option F2: The installation of new or additional roof insulation

The assumption is the existing roof is of a timber construction. Therefore, the envisaged works would comprise of upgrade of existing glass rock/mineral wool insulation with the similar product, rigid insulation boards or installation of a foam insulation. All would be subject to confirmation of the existing and the desired U Value to be achieved.

Option F3: Installation of replacement windows

The options are to replace the existing single-glazed windows with new UPVC/powder coated aluminium framed double-glazed windows. These works would include the replacement of existing doors with new composite panel doors. The works assume there would be no potential for listed building/planning restriction for these works. However, should this not be the case there would be alternate option to provide internal secondary window glazing. Either of the fore-mentioned options would provide for energy saving however, wholesale window and door replacement would provide greater benefit.

9.3.1. Building Services Solution

Option S3: Renewal/replacement of lighting and controls with automated LED technology

The existing lighting is generally provided via fluorescent luminaires. The lighting should be upgraded to LED to reduce energy consumption and provide a better visual environment for the building users.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing controls are noted as being in poor condition and would therefore benefit from replacement. The existing controllers are ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

Refurbish existing heating and domestic hot water systems and controls.

The existing systems are ageing, however the building is highly domestic in the nature of the services and equipment. The existing strategy of electric heating and hot water generation remains appropriate for the type of building.

9.4 Energy & Carbon Savings – Caprera Cottage

Table 9.3 – Carbon savings summary – Caprera Cottage

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	0.19	£2,707	30	6	£472	£94	28.7
F2	Addition/replacement of roof insulation	0.20	£3,732	30	6	£631	£99	37.6
F3	Replacement of glazing to improve thermal performance	0.17	£15,007	20	3	£4,514	£75	199.6
F4		0.00	£0		0	£0	£3	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	0.11	£19,005	25	3	£7,008	-£61	-312.5
S2	Installation of new decentralised domestic hot water generation, pipework and controls	0.08	£1,901	25	2	£1,011	-£46	-40.9
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	0.19	£3,801	20	4	£1,016	£293	13.0
S5	Addition of high efficiency fans, pumps and drives	0.00	£0	25	0	£0	£52	0.0
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£33	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	0	0	£0	£0	0.0

9.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 12.7kW (based on a rule of thumb of 100W/m²). We do not anticipate an increased electrical load requirement as the servicing strategy would be unchanged.

9.6 Key Risks & Challenges

The building is over 120 years old and will present challenges dependent on structural alterations and possible planning restrictions.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

10. Cookworthy

10.1 Description of Building

10.1.1. General

The Cookworth Building is located approximately 300m to the south-east of the main University campus. The building houses the Faculty of Business and contains teaching rooms, computing facilities and a specialist interactive learning suite.



Fig. 10.1 Cookworthy

10.1.2. Building Fabric

Cookworthy is a six-storey building constructed 1993 comprising of a concrete framed construction enclosed with aluminium framed units incorporating sealed double-glazed opening lights and face brick and concrete blockwork.

The roofs were not inspected however, from our review of Google Maps the roofs are understood to comprise concrete roof tiles over pitched roofs.

A combination of timber framed doors some incorporating double glazed units are observed.

During our inspection of Cookworthy, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe cavity wall insulation and rigid insulation roof board are in fair condition. However, a detailed specification has not been provided.

We would recommend consideration is given to enhance existing wall and roof insulation. Any potential insulation upgrade would be subject to liaison with consultants and building control.

The above-mentioned report states the existing double-glazed windows to be in poor condition. Based on this and subject to a review of as-built data and liaison with consultants, consideration may be given for the overhaul and replacement of the window units.

In addition to the above, it is recommended to consider a thermographic survey to identify in detail the areas where meaningful improvements could be made to the thermal performance of the building envelope.

10.1.3. Mechanical Services

Cookworthy is supplied with LTHW via dedicated gas fired boilers serving radiators. Local extract ventilation is provided to toilets, cleaner's cupboards etc. with opening windows elsewhere.

Mechanical cooling is provided to some areas via Direct Expansion (DX) systems with condensers mounted on external walls and in banks on the roof.

Domestic Hot water is generated by a series of local electric water heaters which are considered end of life.

The mechanical services are generally in excess of 10 years old and the boiler plant is approaching 30 years old therefore the majority of services are considered end of life.

10.1.4. Electrical Services

The electricity supply to Cookworthy Building is served with the privately owned HV electricity supply to the East Campus which terminates at 500kVA rated transformer and substation located at the building.

Power is distributed throughout from the main LV main switch gear and local distribution board on the ground floor via final circuits to electric heating, sockets and lighting installation.

Lighting is generally provided via a variety of LED luminaires, with some evidence of fluorescent luminaires replaced for LED equivalents with manually switched and automatic lighting controls serving communal and training spaces.

10.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides half-hourly data for the main electricity, gas and water meters serving the property which are collated via the BMS and accessible via the portal.

10.1.6. BMS/Controls

We understand that the existing BMS is based on an obsolete Andover Continuum system which has been transitioned to a new EcoStruxture Building Operation (EBO) system, while retaining the obsolete Andover Continuum controllers.

The Continuum system was manufactured by Andover Controls who have been absorbed into the Schneider Electric Group of Companies. Schneider manufacture the EcoStruxture family of products which provide a secure open-source building management platform.

The University have installed the EBO BMS in some of the campus buildings where obsolete Andover Continuum systems have been replaced.

10.1.7. Condition & Operation

We understand that the building suffers from overheating in some areas during periods of hot weather. We have also received reports that the metal-framed glazing system induces cold draughts in cold weather which are not alleviated by the heating system.

We understand that the boiler plant in the Mary Newman building which serves the heating and hot water requirement is ageing and is generally unreliable which results in frequent periods of downtime due to failure and a regular requirement for temporary boilers to be deployed. We understand that the boilers have subsequently suffered a catastrophic failure following our inspection.

We understand that the building was constructed in the 1980's with the last significant refurbishment over 10 years ago meaning the engineering services are between circa 15 and 40 years old. The engineering services generally appear to be in fair condition however according to CIBSE Guide M some of the systems should have a remaining serviceable life of 5-10 years, (subject to appropriate maintenance). The majority of the engineering services are considered end of life.

10.1.8. Planned Future CAPEX Works

We understand that the windows are planned for replacement and that the future use of the building is under review.

10.1.9. Opportunities for Heat Networks

The building is remote from the main campus and is not adjacent to other university buildings, however the building is located within an opportunity area for heat networks as identified by Plymouth Council.

If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Cookworthy to a local heat network if and when it becomes operational.

Typical future-proofing measures to consider could be:

- Ensure the heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
- Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

10.2 Energy & Carbon Emissions

The following table identifies the energy consumption and carbon emissions from the Cookworthy building based on the energy consumption figures provided from site.

Table 10.1 – Energy Consumption & Carbon Emissions – Cookworthy

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	190,950 kWh	0.184 $kgCO_2e/kWh$	35.13 TCO_2e
Grid Electricity	253,658 kWh	0.105 $kgCO_2e/kWh$	26.63 TCO_2e
Total	444,607 kWh	N/A	61.76 TCO_2e

10.2.1. Table 4 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for General Accommodation and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 6,662.6m². The performance of Cookworthy is very good with overall energy usage and carbon emissions well below the current benchmark. The figures correspond closely with those stated on the current DEC.

Table 10.2 – Energy Consumption & Carbon Emissions Benchmarking – Cookworthy

Fuel Type	(Actual 2022)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	28.66	4.73	300	57	28.55
Grid Electricity	38.07	4.00	60	33	35.17
Total	66.73	8.73	360	90	63.62

10.2.2. The building would have been constructed to 1985 building regulations therefore the thermal performance and energy efficiency standards are likely to be relatively poor when compared against typical University Campus building stock.

10.2.3. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2022 as the most recent full year. The metering data shows the energy consumption profile for Cookworthy throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. The data shows an increase in electrical consumption through the winter when there is an increased demand for lighting however this is tempered by an increased demand for cooling in the summer which is provided via the roof mounted chiller plant.

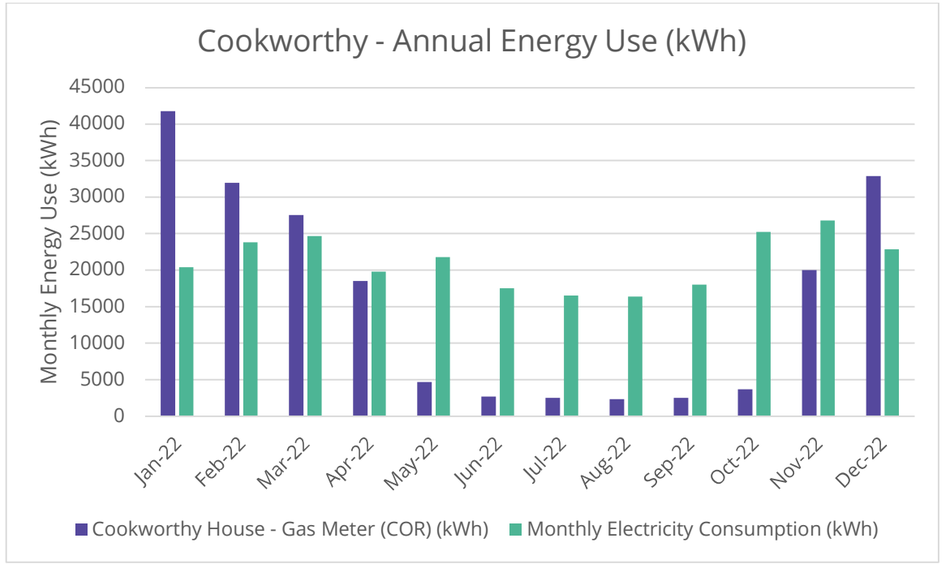


Fig. 10.2 Cookworthy annual energy usage profile

10.2.4. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.9152 which suggests a strong correlation between degree days and heat consumption, with limited inefficiency in the system.

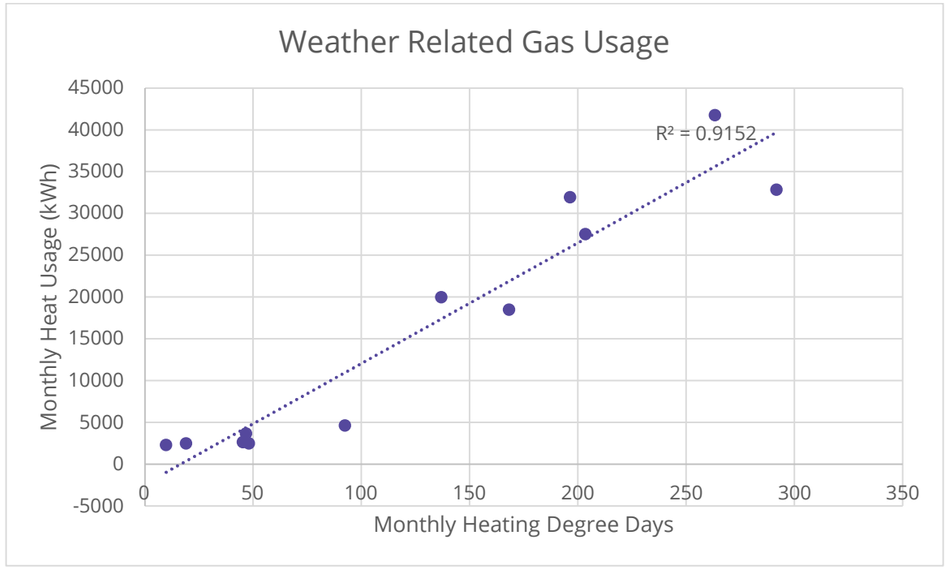


Fig. 10.3 Weather related heat usage compared to degree days

10.2.5. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

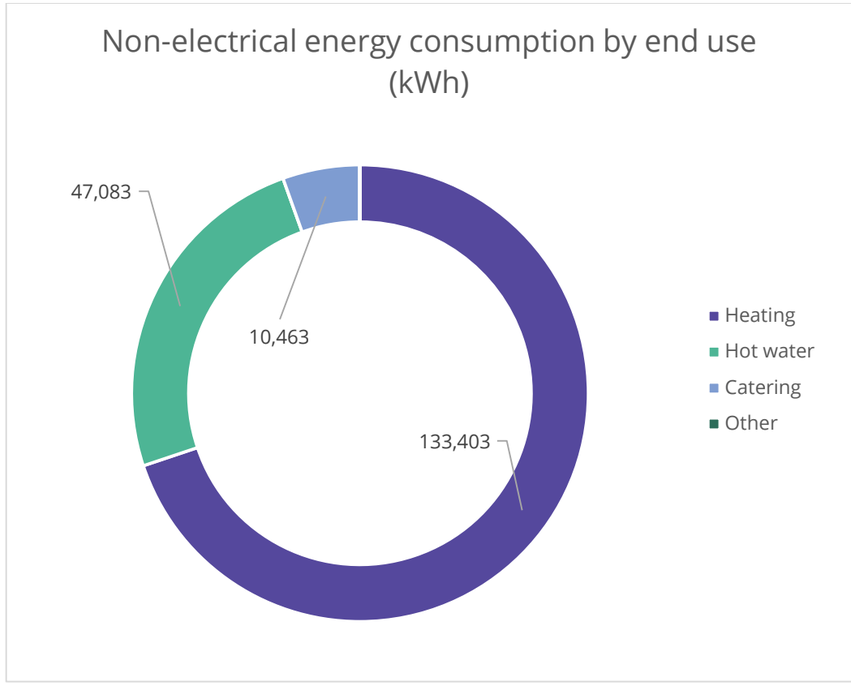


Fig. 10.4 Non-electrical energy consumption breakdown by end use

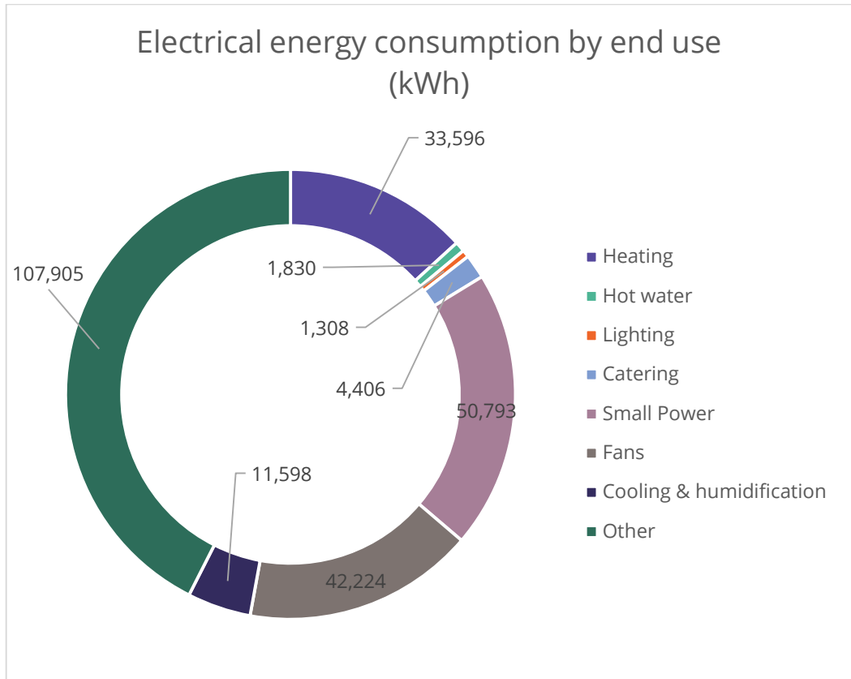


Fig. 10.5 Electrical energy consumption breakdown by end use

10.3 Technical Solution

10.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Cookworthy is as follows:

Option F1: The addition of internal or external wall insulation

Subject to the findings of a thermographic survey report we anticipate the upgrade of wall insulation to be a considered option. However, given the face brick elevations are likely a feature to remain as is, consideration would have to be given, for the installation of internal insulation. These works would involve insulation fixed to walls by way of adhesive or battens with insulation quilt/plasterboard, rigid insulation board or a combination of the two. This method would impact on internal use whilst works are in progress and reduce the overall internal floor area.

Option F2: The installation of new or additional roof insulation

The assumption is the existing roof is of a timber construction. Therefore, the envisaged works would comprise of upgrade of existing glass rock/mineral wool insulation with the similar product, rigid insulation boards or installation of a foam insulation. All would be subject to confirmation of the existing and the desired U Value to be achieved.

Option F3: Installation of replacement windows

The options are to replace the existing double-glazed windows with new powder coated aluminium framed double-glazed windows. These works would include the replacement of existing doors with new composite panel doors. There, may be the option to retain the existing frame and replace the double-glazed unit only. However, this would be subject to further investigation.

10.3.2. Building Services Solution

Option S1: Replace existing LTHW system with a new high temperature air-cooled simultaneous heating and cooling heat pump chiller.

This system will replace the existing gas fired boilers and remove any requirement for fossil fuel consumption on site in connection with Cookworthy. The proposal of a water-water heat pump chiller assumes that a new DHN or ambient loop will not be available until the next plant lifecycle.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 40 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S3: Renewal/replacement of lighting and controls with automated LED technology

The existing lighting is generally provided via fluorescent luminaires. The lighting should be upgraded to LED to reduce energy consumption and provide a better visual environment for the building users.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Cookworthy we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

Option S7: Expansion of roof mounted solar PV installation.

With an available roof area of approximately 400m² we anticipate that an additional 240m² of solar PV cells could be installed, subject to detailed design and structural feasibility assessment. This would also need to be considered within the design of the additional roof insulation and potential location of plant on the roof.

10.4 Energy & Carbon Savings – Cookworthy

Table 10.3 – Carbon savings summary – Cookworthy

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	22.33	£117,361	30	670	£175	£5,625	20.9
F2	Addition/replacement of roof insulation	22.28	£117,153	30	668	£175	£5,589	21.0
F3	Replacement of glazing to improve thermal performance	21.61	£834,686	20	432	£1,931	£5,067	164.7
F4		0	£0		0	£0	£0	0.0
S1	Installation of new high temperature Air Source Heat Pump (ASHP), ancillaries and controls	31.35	£399,756	25	784	£510	£6,147	65.0
S2	Installation of new decentralised domestic hot water generation, pipework and controls	18.01	£66,626	25	450	£148	£13,424	5.0
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	17.29	£83,283	20	346	£241	£5,494	15.2
S5	Addition of high efficiency fans, pumps and drives	15.09	£66,626	25	377	£177	£0	0.0
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	18.47	£76,800	15	277	£277	£8,435	9.1

10.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 500kW (based on a rule of thumb of 75W/m²) with the peak cooling demand of 480kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 125kW and 128kW for heating and cooling respectively.

10.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is plant currently located on the roof of Cookworthy which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Cookworthy will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

Solar PV installations will be subject to G99 applications to the district electricity supply company for each building to seek approval for connections and without comprising the integrity of electricity network.

Consideration could be given to the application of battery technologies to harness the kWp energy from the Solar PV installation. In addition, the private HV ring main could be extended to service the power requirements for those metered LV power supplies across the East Campus.

LED lighting technologies has seen a significant improvement in lighting with increased lumen efficacies per luminaire circuit watts. These should be considered for the initial replacement of fluorescent lamped lighting installations and phased improvement plan for all existing LED lighting installations.

11. Derriford Research Facility

11.1 Description of Building

11.1.1. General

Located adjacent to the University's Peninsula Schools of Medicine and Dentistry at Plymouth Science Park, and next to Derriford Hospital, the Derriford Research Facility contains laboratories and research facilities for medical, dental and biomedical sciences. Research at the DRF focuses on the development of new therapeutics, diagnostics, interventions and approaches to prevent, diagnose and treat devastating diseases, enhance patient outcomes and improve global healthcare

The Derriford Research Facility is home to the University of Plymouth's internationally renowned Brain Tumour Research Centre of Excellence.



Fig. 11.1 Derriford Research Facility

11.1.2. Building Fabric

Derriford Research Facility is a four-storey building with lower ground provision constructed circa 2011 comprising of a steel frame construction enclosed with a combination of powder coated aluminium framed units incorporating sealed double-glazed walling and opening lights and stone, timber effect and concrete cladding.

The roofs were not inspected however, from our review of 'Google Maps' the roofs are understood to comprise flat and shallow sloped roofs covered with proprietary membranes.

Powder coated aluminium framed doors incorporating double glazed units are provided to the main entrance and exit to the building. Doors to storage and plantroom areas are of steel powder coated finish, some incorporating vision panels.

During our inspection of Derriford Research Facility, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe external wall insulation and rigid insulation roof boards are in good condition, having been recently upgraded. However, the detailed specification has not been provided.

Given the date of construction we assume the wall and roof insulation to have been designed and upgraded to meet more recent Building Regulations and therefore, there may be limited requirement to improve on the building fabric. However, it is recommended to consider a thermographic survey to identify in detail the areas where meaningful improvements could be made to the thermal performance of the building envelope.

The site management report previously referred to records the double-glazed windows as being in good condition having been recently upgraded. Subject to a thermographic survey report the expanse of double-glazing and open atria may provide area for enhancement.

11.1.3. Mechanical Services

Derriford Research Facility is supplied with LTHW via 2No 652kW gas fired boilers located in the main plantroom. The boilers feed a low loss header which is also fed by 2No. CHP units via 2No. 1000 litre thermal stores. The low loss header feeds separate primary flow and return headers which in turn feed 3No. Constant Temperature (CT) circuits for AHUs and hot water generation and a Variable Temperature (VT) circuit for space heating via radiators. The CT circuit serving AHU 5 is provided with a 144kW electric backup boiler.

Mechanical ventilation is provided via a series of packaged AHUs located in the main plant areas. The AHUs are complete with heat exchangers, heating and cooling coils, fans, dampers and controls to Health Technical Memoranda (HTM) specification for healthcare applications.

11.1.4. The building is provided with comfort cooling via 2No. roof mounted packaged air-cooled chillers generating chilled water. Local cooling is provided to key areas (comms rooms etc.) via DX cooling systems. The building contains a high volume of laboratory space for the home office which creates relatively high demand for heating and cooling along with associated electrical demand for laboratory/research equipment.

Domestic Hot water is generated by the LTHW system via 2No. packaged 77kW Plate Heat Exchangers (PHX) and 1500 litre storage cylinders.

11.1.5. Electrical Services

Power is distributed throughout from the main LV switch panel on the ground floor via vertical risers located throughout the building. The LV distribution system feeds local metered distribution boards on each level.

Lighting is generally provided via LED with occupancy sensing controls.

11.1.6. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides half-hourly data for the gas, water and electrical systems.

11.1.7. BMS/Controls

The BMS system comprises a Trend IQ4 microprocessor-based BMS system incorporating a Trend 963 head end. The system includes multiple control panels and motor control centres to provide over-arching control of the mechanical plant and equipment.

11.1.8. Condition & Operation

We understand that the building suffers from overheating in some areas during periods of hot weather. We have also received reports that the metal-framed glazing system induces cold draughts in cold weather which are not alleviated by the heating system.

The engineering services generally appear to be in good condition however we understand that the building suffers from poor energy performance due to the BMS/controls strategy and that the chiller plant is not sized to provide 100% standby meaning cooling capacity is reduced if one of the chiller units fails. We also understand that the LTHW system is not delivering design flow rates.

We understand that the building was constructed in 2016 meaning the engineering services are circa 6-7 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 10-20 years, subject to appropriate maintenance.

11.1.9. Planned Future CAPEX Works

We understand that there are no CAPEX works currently planned for Derriford Research Facility.

11.1.10. Opportunities for Heat Networks

The building is currently served with LTHW from the existing boilers and there is significant spare plant space available. The building is remote from the main city centre campus however it is located adjacent to the Derriford Hospital site which is located within an opportunity area for heat networks as identified by Plymouth Council.

If suitable technology is installed as part of the planned HCDP works along with appropriate future-proofing measures it would potentially be feasible to connect Derriford Research Facility to a new heat network when it becomes operational.

Typical future-proofing measures to consider could be:

- Ensure the heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
- Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

11.2 Energy & Carbon Emissions

The following table identifies the energy consumption and carbon emissions from the Derriford Research Facility building based on the energy consumption figures provided from site.

Table 11.1 – Energy Consumption & Carbon Emissions – Derriford Research Facility

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	1,084,204 kWh	0.184 $kgCO_2e/kWh$	199.49 TCO_2e
Grid Electricity	1,182,876 kWh	0.105 $kgCO_2e/kWh$	124.20 TCO_2e
Total	2,365,334 kWh	N/A	323.69 TCO_2e

11.2.1. Table 4 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 3,805.1m². The overall EUI of Derriford Research Facility is well above the current benchmarks and the electrical consumption is almost four times greater. The figures do however correspond closely with those stated on the current DEC. The building could be compared against hospital benchmarks however the operation of the building does not reflect the assumptions for this category (24hr continuous operation, space for medical care, operating theatres etc.)

Table 11.2 – Energy Consumption & Carbon Emissions Benchmarking – Derriford Research Facility

Fuel Type	(Actual 2022)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	284.93	52.43	240	44.16	304.71
Grid Electricity	310.87	32.64	80	8.40	344.60
Total	595.80	85.07	320	52.56	649.31

The building would have been constructed to 2010 building regulations therefore the thermal performance and energy efficiency standards should be good when compared against typical University building stock.

11.2.2. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2022 as the most recent full year. The metering data shows the energy consumption profile for Derriford Research Facility throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. The data shows an increase in electrical consumption through the winter when there is an increased demand for lighting however this is tempered by an increased demand for cooling in the summer which is provided via the roof mounted chiller plant.

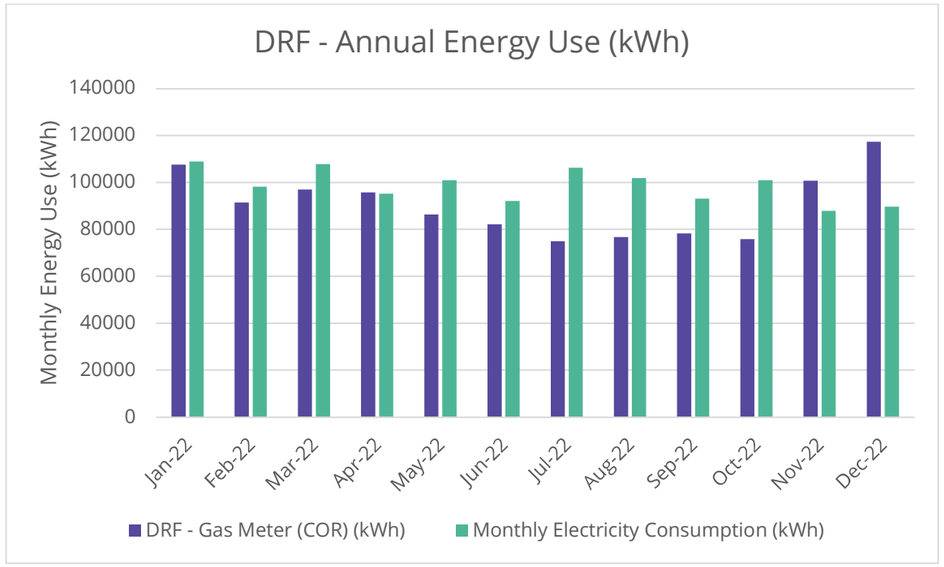


Fig. 11.2 Derriford Research Facility annual energy usage profile

11.2.3. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.896 which suggests a relatively strong correlation between degree days and heat consumption, however the values shown on the chart suggest there is a high base gas consumption. This can be explained by the presence of the CHP units which operate year-round to generate electricity.

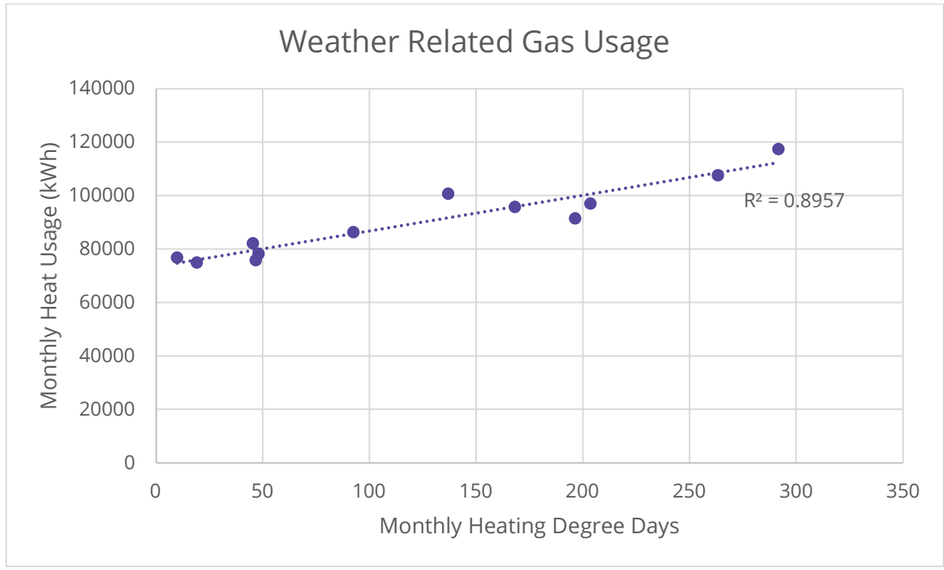


Fig. 11.3 Weather related heat usage compared to degree days

11.2.4. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

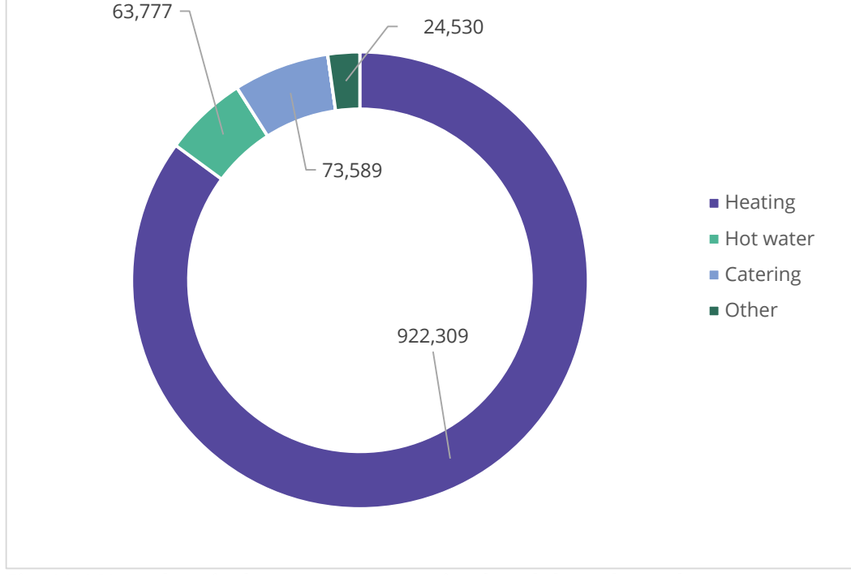


Fig. 11.4 Non-electrical energy consumption breakdown by end use

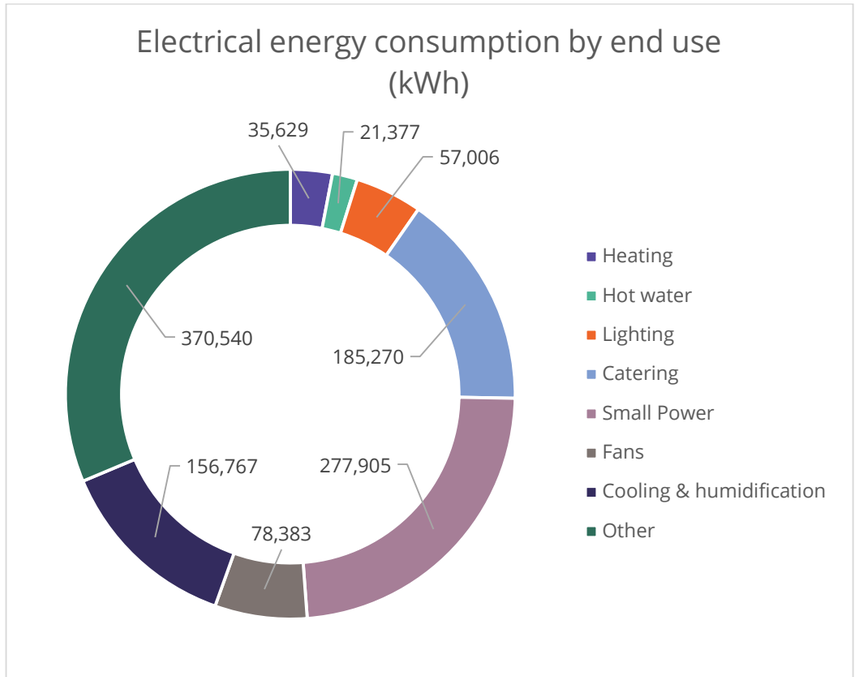


Fig. 11.5 Electrical energy consumption breakdown by end use

11.3 Technical Solution

11.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Derriford Research Facility is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management states the existing wall insulation as being in good condition, having been recently upgraded. However, we do recommend a thermographic survey to identify in detail the areas where meaningful improvements could be made to the thermal performance of the building envelope.

Option F2: The installation of new or additional roof insulation

The above-mentioned report states the existing roof insulation as being in good condition, having been recently upgraded. 'Refer to above comment for recommended thermographic survey'.

Option F3: Installation of replacement windows

The above-mentioned report states the existing double windows as being in good condition, having been recently upgraded. 'Refer to above comment for a recommend a thermographic survey'.

11.3.2. Building Services Solution

Option S1: Replace existing LTHW plant with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Derriford Research Facility. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop as the facility is within a heat network opportunity area.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would be mounted in the ground floor plantroom with the dry air coolers located on the roof or at ground level, subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is only circa 10 years old, we do not anticipate that the heating system will require lifecycle renewal in the medium term.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S3: Renewal/replacement of lighting and controls with automated LED technology

The existing lighting is generally provided via fluorescent luminaires. The lighting should be upgraded to LED to reduce energy consumption and provide a better visual environment for the building users.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

For Derriford Research Facility we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

Option S7: Expansion of roof mounted solar PV installation.

Derriford is already provided with an extensive solar PV array, however there is additional roof space which would allow this to be extended.

With an available roof area of approximately 790m² we anticipate that an additional 475m² of solar PV cells could be installed, subject to detailed design and structural feasibility assessment. This would also need to be considered within the design of the additional roof insulation and potential location of plant on the roof.

11.4 Energy & Carbon Savings – Derriford Research Facility

Table 11.3 – Carbon savings summary – Derriford Research Facility

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	117.33	£29,024	30	3,520	£8	£7,014	4.1
F2	Addition/replacement of roof insulation	118.18	£75,276	30	3,545	£21	£7,638	9.9
F3	Replacement of glazing to improve thermal performance	117.91	£546,525	20	2,358	£232	£7,439	73.5
F4		0	£0		0	£0	£0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	237.81	£570,765	25	5,945	£96	£109,943	5.2
S2	Installation of new centralised domestic hot water generation, pipework and controls	113.30	£152,204	25	2,832	£54	£115,595	1.3
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£5,217	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	118.35	£114,153	20	2,367	£48	£26,257	4.3
S5	Addition of high efficiency fans, pumps and drives	108.21	£38,051	25	2,705	£14	£1,025	37.1
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	111.21	£152,000	15	1,668	£91	£8,435	18.0

11.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 285kW (based on a rule of thumb of 75W/m²) with the peak cooling demand of 274kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 71kW and 73kW for heating and cooling respectively.

11.6 Key Risks & Challenges

No significant risks/challenges identified.

It is likely that the available electrical capacity for Derriford Research Facility will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

Solar PV installations will be subject to G99 applications to the district electricity supply company for each building to seek approval for connections and without comprising the integrity of electricity network.

Consideration could be given to the application of battery technologies to harness the kWp energy from the Solar PV installation.

LED lighting technologies has seen a significant improvement in lighting with increased lumen efficacies per luminaire circuit watts. These should be considered for the initial replacement of fluorescent lamped lighting installations and phased improvement plan for all existing LED lighting installations.

12. Endsleigh Place (Nos. 14-24)

12.1 Description of Building

Endsleigh Place is located to the north of the main campus and comprises 5No. terraced buildings containing office space and storage.



Fig. 12.1 Endsleigh Place

12.1.1. Building Fabric

Endsleigh Place is a two-storey terrace constructed between 1800 and 1900 comprising of a masonry construction, UPVC framed units incorporating sealed double-glazed opening lights and stucco, cement render and faced brick elevation finishes.

The roofs were not close inspected however, from our street level and review of 'Google Maps' these comprise pitched tiled roofs some incorporating chimney stacks.

Where observed entrance and exits are provided with timber door-sets.

During our inspection of Endsleigh Place, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we understand the glass rock and mineral wool roof insulation is in fair condition however, there is no thermal insulation to walls. The double-glazed opening lights are recorded as being in poor condition. No detailed specification has not been provided for further review.

We would recommend consideration is given to the installation and upgrade of insulation to walls and roofs respectively. Any potential insulation upgrade would be subject to liaison with consultants and building control.

Given, the existing double-glazed opening lights are recorded as poor and coupled with the existing timber door-sets the recommendation would include upgrade to windows and replacement of current doors. These recommendations would be subject to further inspections liaison.

It is further recommended to consider a thermographic survey to identify/substantiate in detail where improvements could be made to the thermal performance of the building envelope

12.1.2. Mechanical Services

Endsleigh Place was formerly a series of terraced dwellings and is still arranged as such. Each individual property is provided with a wall mounted gas fired boiler to generate LTHW which feeds a central heating system comprising radiators. Hot water is generally provided via local unvented electric water heaters.

Local extract ventilation is provided to toilet areas and kitchens with ventilation generally via opening windows.

12.1.3. Electrical Services

The electricity supplies to Endsleigh Place are served via a series metered Low Voltage (LV) single phase electricity supply derived from the electricity supply network operated by the local district network operator.

Power is distributed throughout from the main LV main switch gear and local distribution board on the ground floor via final circuits to sockets and lighting installation.

Lighting is generally provided via a variety of fluorescent lamped luminaires, with some evidence of failed luminaires replaced for LED equivalents with manually switched lighting controls serving communal and offices spaces.

12.1.4. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides data for the electrical system, however the data is inconsistent between properties in respect of fossil fuel and electricity so we have relied on bulk data and assessed Endsleigh place as a single building.

12.1.5. BMS/Controls

The BMS serving the properties within Endsleigh Place comprises a mix of obsolete Andover Continuum controllers and Schneider Electric 'Building Expert' controllers which have replaced previous Andover controls.

12.1.6. Condition & Operation

Endsleigh Place is generally in poor condition and the engineering services are approaching end of life.

We understand that the building was constructed in the 1800s with the last major refurbishment over 10 years ago. The engineering services are circa 15-20 years old and the buildings themselves over 120 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 5-10 years, subject to appropriate maintenance.

12.1.7. Planned Future CAPEX Works

We understand that a programme of capex works is schedule for 2022-2024 to include internal and external refurbishment.

12.1.8. Opportunities for Heat Networks

The location and arrangement of the building/properties would allow for individual connections to a heat network. The building is located on the main campus site and is well positioned for connection to any proposed ambient loop.

12.2 Energy & Carbon Emissions

The University is investigating the feasibility of providing a 5th Generation Heating & Cooling (5DHC) network which could potentially serve the Endsleigh Place building. If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Endsleigh Place to the 5DHC network when it becomes operational.

Typical future-proofing measures to consider could be:

- Ensure heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
  Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

The following table identifies the energy consumption and carbon emissions from the Endsleigh Place building based on the energy consumption figures provided from site.

Table 12.1 – Energy Consumption & Carbon Emissions – Endsleigh Place

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	110,765 kWh	0.184 $kgCO_2e/kWh$	20.38 TCO_2e
Grid Electricity	42,201 kWh	0.105 $kgCO_2e/kWh$	4.43 TCO_2e
Total	130,928 kWh	N/A	24.81 TCO_2e

12.2.1. Table 4 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for General Office buildings however building has not been issued with a Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 1,239.9m². The performance of Endsleigh Place is very good with overall energy usage and carbon emissions around half the current benchmark. The figures correspond closely with those stated on the current DEC.

Table 12.2 – Energy Consumption & Carbon Emissions Benchmarking – Endsleigh Place

Fuel Type	(Actual 2022)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	89.33	16.44	120	22.80	N/A
Grid Electricity	34.04	3.57	95	52.30	N/A
Total	123.37	20.01	215	75.1	N/A

12.2.2. The building would have been constructed prior to the introduction of minimum standards for thermal performance therefore the thermal performance and energy efficiency standards are likely to be poor when compared against typical University Campus building stock.

12.2.3. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2022 as the most recent full year. The metering data shows the energy consumption profile for Endsleigh Place throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. The data shows a slight increase in electrical consumption through the winter when there is an increased demand for lighting however the electrical demand is considered relatively stable throughout the year.

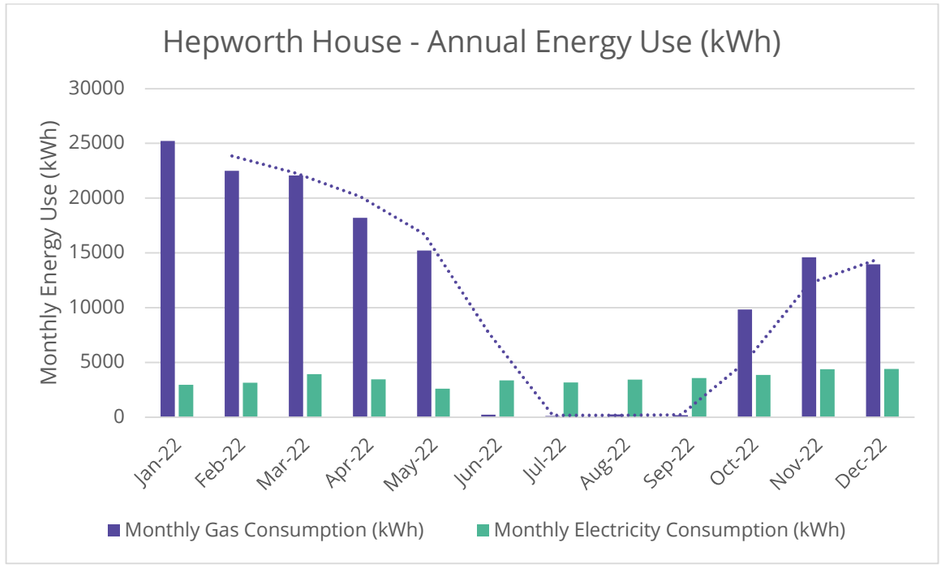


Fig. 12.2 Endsleigh Place annual energy usage profile

12.2.4. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.692 which suggests a reasonable correlation between degree days and heat consumption however there is a lack of efficiency and/or poor control.

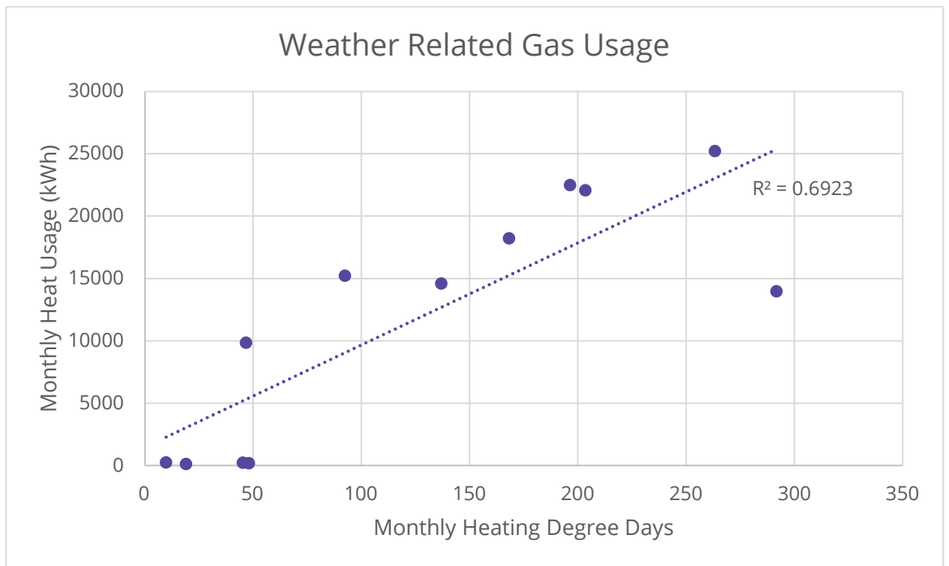


Fig. 12.3 Weather related heat usage compared to degree days

12.2.5. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

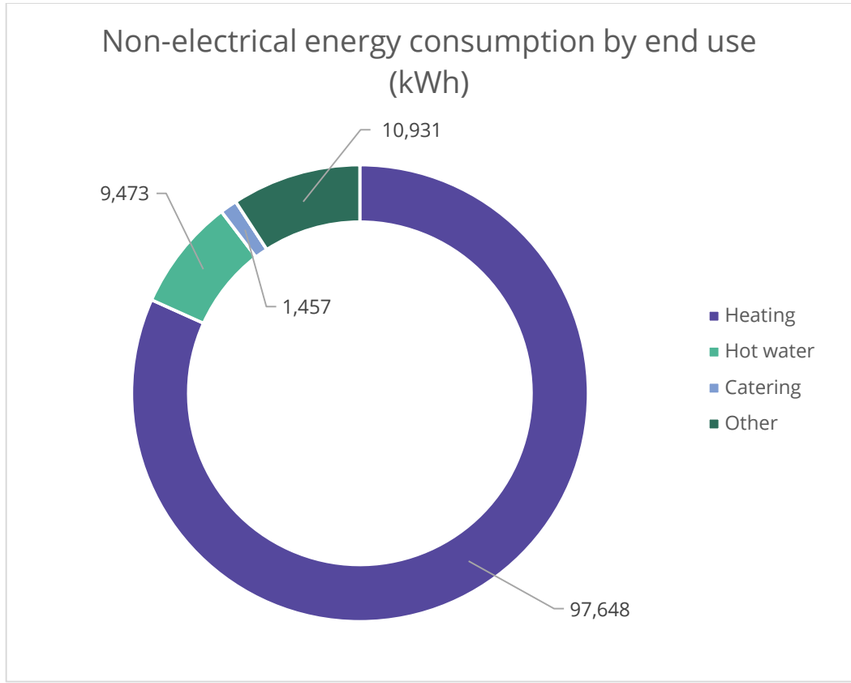


Fig. 12.4 Non-electrical energy consumption breakdown by end use

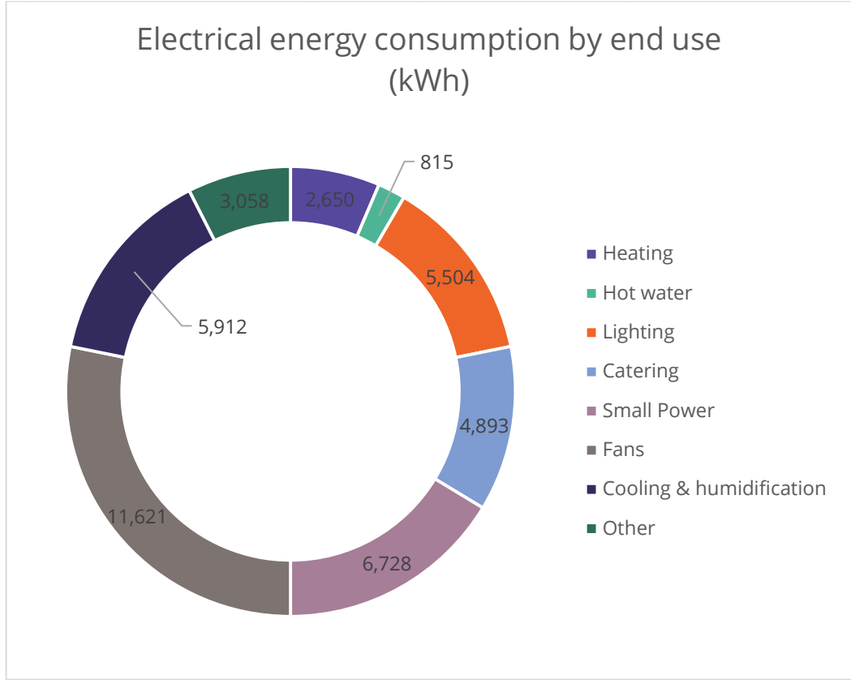


Fig. 12.5 Electrical energy consumption breakdown by end use

12.3 Technical Solution

12.3.1. Building Fabric Solution

Option F1: The addition of internal or external wall insulation

The report provided by site management records there being no insulation to walls. The options would be to either retrospectively install external or internal to the entirety of the masonry elevations or a multiple of the two. The agreed insulation would be fitted internally by way of adhesive to existing walls or battens with insulation quilt/plasterboard, rigid insulation board or a mixture of the two. External insulation generally, comprises of rigid insulation board either mechanically fixed to the existing walls or within a steel cage system but often having an applied render coat to either option or being of a prefinished insulation board/panel. However, these options may be subject/limited by existing listed building and planning restrictions.

Option F2: The installation of new or additional roof insulation

The assumption is the existing roof is of a timber construction. Therefore, the anticipated works would comprise of upgrade of existing glass rock/mineral wool insulation with the similar product, rigid insulation boards or installation of a foam insulation. All would be subject to confirmation of the existing and the desired U Value to be achieved.

Option F3: Installation of replacement windows

The abovementioned report records the existing windows as be in poor condition. The recommendation would be to replace all windows with new double-glazed windows. This would be subject to confirmation of the desired U Value to be achieved and there being no planning restrictions. This recommendation would include the replacement of existing doors with composite type door-sets.

12.3.2. Building Services Solution

Option S1: Replace existing LTHW boilers with new high temperature water-water heat pumps with ambient water loop and dry air coolers.

This system will remove the existing gas fired boiler plant and remove any requirement for fossil fuel consumption on site in connection with Endsleigh Place. The proposal of a water-water heat pump and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump units would be mounted internally with the dry air coolers located externally subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S3: Renewal/replacement of lighting and controls with automated LED technology

The existing lighting is generally provided via fluorescent luminaires. The lighting should be upgraded to LED to reduce energy consumption and provide a better visual environment for the building users.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Endsleigh Place we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Replace hot water system with new decentralised hot water generation system fed from local unvented water heaters.

This system will involve the replacement of the central hot water system to facilitate hot water local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

12.4 Energy & Carbon Savings – Endsleigh Place

Table 12.3 – Carbon savings summary – Endsleigh Place

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	11.55	£26,490	30	347	£76	£2,177	12.2
F2	Addition/replacement of roof insulation	11.69	£36,524	30	351	£104	£2,287	16.0
F3	Replacement of glazing to improve thermal performance	10.98	£146,864	20	220	£669	£1,733	84.8
F4		0.00	£0		0	£0	£0	0.0

S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	9.67	£185,985	25	242	£769	-£17,640	-10.5
S2	Installation of new decentralised domestic hot water generation, pipework and controls	9.02	£18,599	25	226	£82	-£16,957	-1.1
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	9.56	£37,197	20	191	£195	£2,018	18.4
S5	Addition of high efficiency fans, pumps and drives	0.00	£0	25	0	£0	£0	0.0
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	15	0	£0	£0	0.0

12.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 93kW (based on a rule of thumb of 100W/m²) Assuming system efficiencies in line with Table 4.1 (4.00 heating) provides an indicative increase in electrical load of circa 20kW for heating.

12.6 Key Risks & Challenges

The installation of heat pumps and dry air coolers will require significant enabling works and potential structural alterations.

It is unlikely that the available electrical capacity for Endsleigh Place will need to be increased to supply the additional requirements for the heat pump installation as each property is provided with a dedicated power supply which should be sufficient to run a domestic-sized heat pump unit. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

Consider extending the private HV ring main to service the power requirements for those metered LV power supplies across the West Campus.

LED lighting technologies has seen a significant improvement in lighting with increased lumen efficacies per luminaire circuit watts. These should be considered for the initial replacement of fluorescent lamped lighting installations and phased improvement plan for all existing LED lighting installations.

13. Fitness Complex

13.1 Description of Building

13.1.1. General

The fitness complex houses the campus gym and fitness studio and is located to the north of the main campus site.



Fig. 13.1 Fitness Complex

13.1.2. Building Fabric

The Fitness Complex was constructed between 2001 and 2010 comprising of a steel frame construction enclosed with a combination of powder coated aluminium framed units incorporating sealed double-glazed walling and opening lights and aluminium 'type' composite cladding panels.

The roofs were not inspected however, from our review of 'Google Maps' the roofs are understood to comprise curved roofs covered with profiled metal roof sheets.

Powder coated aluminium framed doors incorporating double glazed units are provided to the main entrance and exit to the building. Some timber framed doors incorporating Georgian wired vision panels are observed.

During our inspection of the Fitness Complex, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. However, isolated decayed timber exit doors, cracked mortar bed joints and misaligned rainwater downpipe is observed to the south-west corner. From information provided by site management we believe the cavity wall insulation, rigid insulation roof boards and double-glazed walling are in fair condition. However, the detailed specification has not been provided.

it is recommended to consider a thermographic survey to identify in detail the areas where meaningful improvements could be made to the thermal performance of the building envelope.

Any potential upgrade would be subject to the review of the thermographic survey report, review of as-built, liaison with consultants and building control

13.1.3. Mechanical Services

The Fitness Complex is supplied with LTHW via gas fired boilers serving heating and hot water system comprising radiators and fan convectors.

Local cooling is provided to key areas (comms rooms etc.) via DX cooling systems.

The building is generally mechanically ventilated via AHUs with local extract ventilation provided to key areas.

Domestic Hot water is generated by the LTHW system via a central hot water calorifier.

13.1.4. Electrical Services

Power is distributed throughout from the main LV switch panel on the ground floor via vertical risers located throughout the building. The LV distribution system feeds local metered distribution boards on each level.

Lighting is generally provided via LED with occupancy sensing controls.

13.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and water consumption.

13.1.6. BMS/Controls

We understand that the building is provided with a Trend IQ3 microprocessor-base control system however there is no head end for monitoring/adjustment. The system is now considered obsolete.

13.1.7. Condition & Operation

We consider that the Fitness complex is in fair condition with no significant defects. We understand that the building was constructed in the mid-2000s meaning the engineering services are circa 15-20 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 5-10 years, subject to appropriate maintenance.

The engineering services generally appear to be in good condition however we understand that the controls/BMS is in poor condition and requires renewal/refurbishment which is scheduled to be undertaken as soon as possible.

13.1.8. Planned Future CAPEX Works

We understand there are no significant CAPEX works planned for the Fitness complex, save for a potential light refurbishment in 2024/25.

13.1.9. Opportunities for Heat Networks

The building is currently standalone and is not connected to either of the campus heat networks.

The University is investigating the feasibility of providing a 5th Generation Heating & Cooling (5DHC) network which could potentially serve the Fitness Complex building. If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Fitness Complex to the 5DHC network when it becomes operational.

Typical future-proofing measures to consider could be:

- Ensure the heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
- Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

13.2 Energy & Carbon Emissions

13.2.1. The following table identifies the energy consumption and carbon emissions from the Fitness Complex building based on the energy consumption figures provided from site.

Table 13.1 – Energy Consumption & Carbon Emissions – Fitness Complex

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	21,124 kWh	0.184 $kgCO_2e/kWh$	3.89 TCO_2e
Grid Electricity	89,481 kWh	0.105 $kgCO_2e/kWh$	9.40 TCO_2e
Total	110,605 kWh	N/A	13.29 TCO_2e

13.2.2. Table 4 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 658.4m². The performance of Fitness Complex is very good with overall energy usage and carbon emissions well below the current benchmark. The figures do not correspond very closely with those stated on the current DEC and the overall performance is poorer than expected.

Table 13.2 – Energy Consumption & Carbon Emissions Benchmarking – Fitness Complex

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	32.08	5.90	440	83.6	49.00
Grid Electricity	135.91	14.27	160	88.0	86.00
Total	167.99	20.17	600	171.6	135.00

13.2.3. The building would have been constructed to 2000/2006 building regulations therefore the thermal performance and energy efficiency standards should be reasonable when compared against typical University Campus building stock.

13.2.4. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2021 as the most recent full year. The metering data shows the energy consumption profile for Fitness Complex throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. The data shows an increase in electrical consumption through the winter when there is an increased demand for lighting however this is tempered by an increased demand for cooling in the summer which is provided via the roof mounted chiller plant.

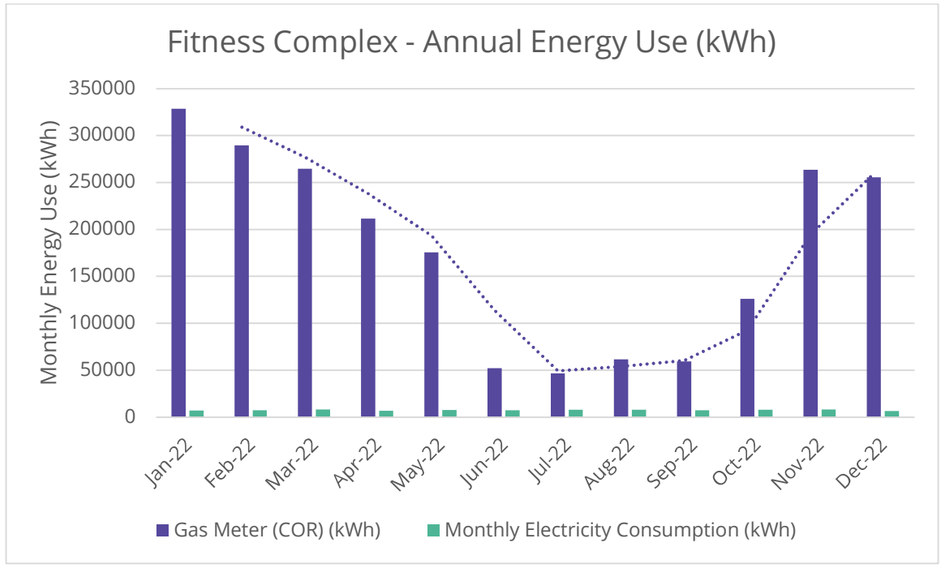


Fig. 13.2 Fitness Complex annual energy usage profile

13.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.823 which suggests a relatively strong correlation between degree days and heat consumption, however this value suggests there is significant inefficiency or lack of control within the system.

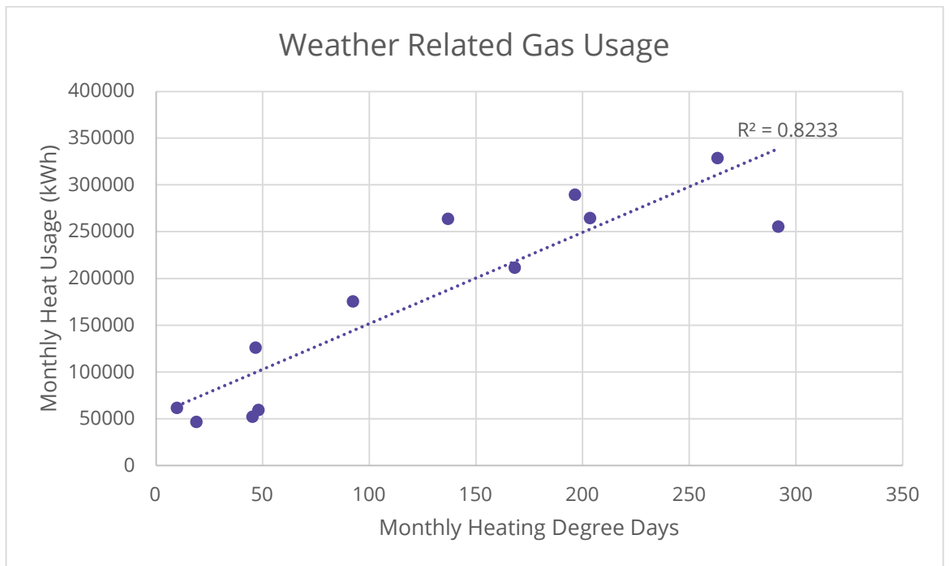


Fig. 13.3 Weather related heat usage compared to degree days

13.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

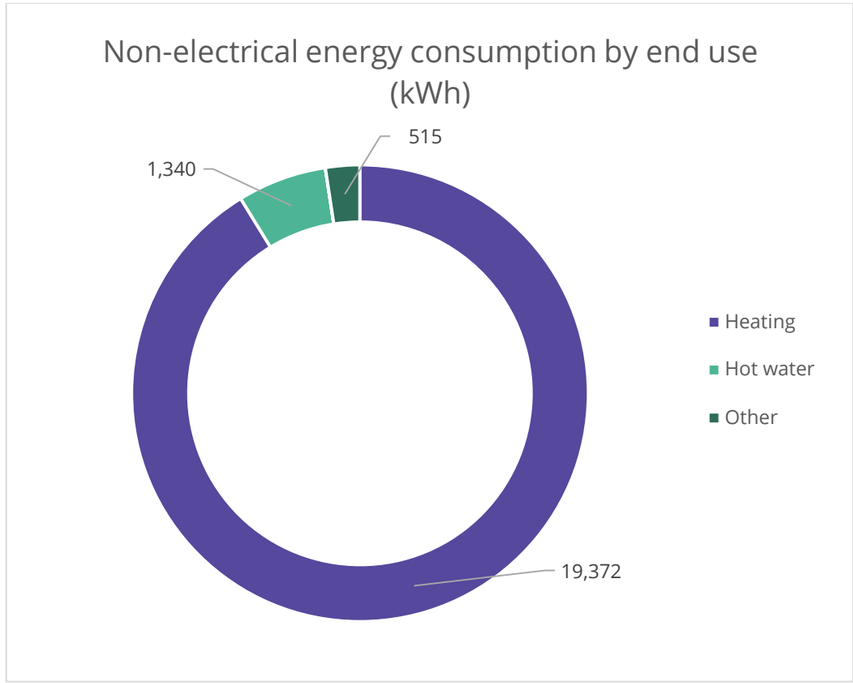


Fig. 13.4 Non-electrical energy consumption breakdown by end use

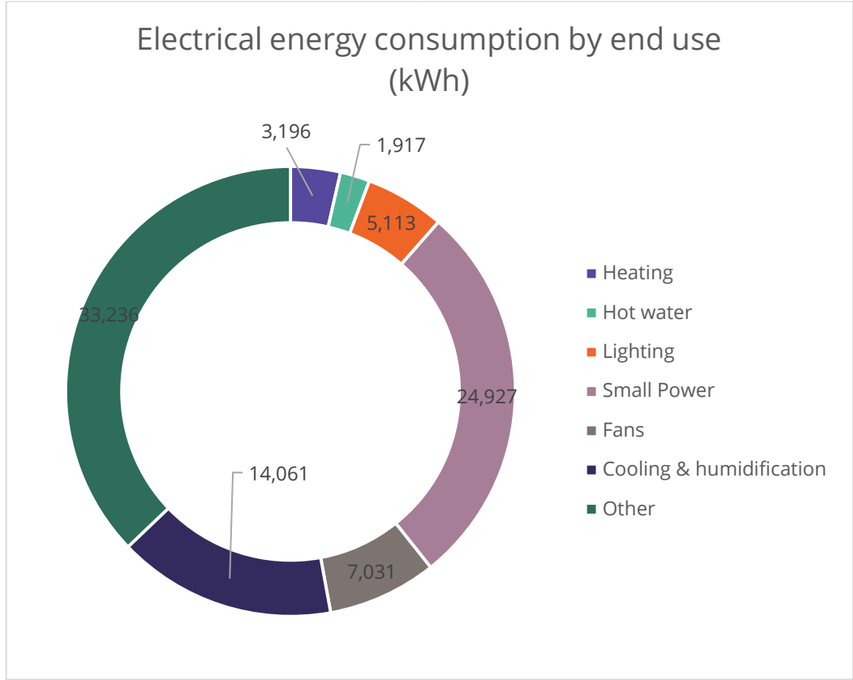


Fig. 13.5 Electrical energy consumption breakdown by end use

13.3 Technical Solution

13.3.1. Building Fabric Solution

Option F1: The addition of internal or external wall insulation

The report provided by site management states the existing external wall insulation to be in fair condition. The options are to consider the upgrade/replacement to the existing elevation cladding or retrospectively install internal wall insulation or a multiple of the two. The agreed insulation would be fitted internally by way of adhesive to existing walls or battens with insulation quilt/plasterboard, rigid insulation board or a mixture of the two. External insulation generally, comprises of rigid insulation board either mechanically fixed to the existing walls or within a steel cage system but often having an applied render coat to either option or being of a prefinished insulation board/panel. However, these options would be subject to review of as-built data.

Option F2: The installation of new or additional roof insulation

The above-mentioned report states the existing roof insulation as being in fair condition. Consider the provision of spray foam or rigid board insulation to the internal of the flat roofs. These works would be subject to review of as-built data and thermographic survey findings. consideration.

Option F3: Installation of reflective/ absorptive film on curtain glazing system to reduce heat gain

The above-mentioned report states the existing double windows as being in fair condition. Subject to further inspection and a thermographic survey, upgrade works may include the installation of reflective/absorptive window film. The more intrusive option would be to replace the entirety of the existing glazing.

To assess the impact of installing a reflective/absorptive film we have assumed a 5% improvement in the cooling demand for the building due to reduced solar gain.

13.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Fitness Complex. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Fitness Complex we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

Option S7: Expansion of roof mounted solar PV installation.

With an available roof area of approximately 2048m² we anticipate that an additional 1,220m² of solar PV cells could be installed, subject to detailed design and structural feasibility assessment. This would also need to be considered within the design of the additional roof insulation and potential location of plant on the roof.

13.4 Energy & Carbon Savings – Fitness Complex

Table 13.3 – Carbon savings summary – Fitness Complex

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	1.97	£5,022	30	59	£85	£230	21.8
F2	Addition/replacement of roof insulation	1.99	£13,025	30	60	£218	£251	51.9
F3	Replacement of glazing to improve thermal performance	1.98	£94,566	20	40	£2,384	£244	386.8
F4		0.00	£0		0	£0	£0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	5.63	£98,760	25	141	£702	£6,060	16.3
S2	Installation of new centralised domestic hot water generation, pipework and controls	1.76	£26,336	25	44	£600	£6,276	4.2
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	10	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	2.25	£19,752	20	45	£439	£1,447	13.6
S5	Addition of high efficiency fans, pumps and drives	1.71	£6,584	25	43	£154	£92	71.6
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	1.67	£0	15	25	£0	£0	0.0

13.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 66kW (based on a rule of thumb of 100W/m²) with the peak cooling demand of 47kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 14kW and 12kW for heating and cooling respectively.

13.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Fitness Complex which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Fitness Complex will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

Solar PV installations will be subject to G99 applications to the district electricity supply company for each building to seek approval for connections and without comprising the integrity of electricity network.

Consideration could be given to the application of battery technologies to harness the kWp energy from the Solar PV installation.

LED lighting technologies has seen a significant improvement in lighting with increased lumen efficacies per luminaire circuit watts. These should be considered for the initial replacement of fluorescent lamped lighting installations and phased improvement plan for all existing LED lighting installations.

14. Fitzroy

14.1 Description of Building

14.1.1. General

Fitzroy is located centrally at the main University campus and houses the Faculty of Science and Engineering. The building comprises teaching spaces and administration as well as specialist facilities for the University's marine and coastal studies courses.



Fig. 14.1 Fitzroy

14.1.2. Building Fabric

Fitzroy is a five-storey building constructed 1967 and is believed to comprise reinforced concrete frame construction enclosed with a combination of concrete panels and aluminium framed sliding sash units incorporating single-glazed opening lights.

The roofs were not inspected however, from our review of 'Google Maps' the roofs are understood to comprise flat roofs covered with a proprietary covering and concrete slabs.

Timber and metal framed doors incorporating single-glazed units are provided to the main entrance and exit to the building.

During our inspection of Fitzroy building, we observed evidence of damp affected perimeter walls and upper ceilings including general degradation of windows. From information provided by site management we believe there is no thermal wall insulation. The rigid roof insulation boards tare recorded as being in poor condition. The above is subject to review of detailed specification.

It is further recommended to consider a thermographic survey to identify/substantiate in detail where improvements could be made to the thermal performance of the building envelope. We would anticipate these improvements to include the provision/upgrade of existing thermal insulation and the replacement of windows and doors throughout. These works would be subject to liaison with consultants, as-built data and building control.

14.1.3. Mechanical Services

Fitzroy is supplied with LTHW via the campus DHN boilers in the Mary Newman building which feeds a plate heat exchanger in the main plantroom. The secondary side of the plate heat exchanger feeds an LTHW heating and hot water system comprising radiators and fan coil units.

The building is not provided with comfort cooling. Local cooling is provided to key areas (comms rooms etc.) via DX cooling systems.

The building is generally naturally ventilated via opening windows to atmosphere and to the atrium areas. Emergency window vents are provided within lab areas. Mechanical extract ventilation is provided to toilets and cleaners stores etc.

Domestic Hot water is generated by the DHN via a central hot water calorifier.

14.1.4. Electrical Services

The electricity supply to Fitzroy Building is served from the site wide network, access wasn't available to the basement switch room for inspection.

Power is distributed throughout from the main LV main switch gear and local distribution board on the ground and upper floors via final circuits to sockets and lighting installation.

Lighting is generally provided via a variety of fluorescent lamped luminaires including some LED replacements with occupancy sensing controls serving communal and training spaces.

14.1.5. Metering

The C3ntinel metering system provides data in respect of electricity and water consumption. The system provides data for the electrical system, however there is no dedicated sub-metering data for Fitzroy in respect of the heat network therefore we have relied on data provided by the estates team for analysis.

14.1.6. BMS/Controls

The heating system is fed via the DHN from Mary Newman which is operated via A Satchwell Sigma BMS system. The Sigma family are legacy products manufactured by Satchwell which has subsequently been absorbed into the Schneider Electric group.

We understand support is still available in terms of software and components however the system is considered obsolete and is likely to require replacement as part of a wider BMS modernisation/integration exercise.

The BMS within the Fitzroy building is based on an obsolete Andover Continuum system. The Continuum system was manufactured by Andover Controls who have also been absorbed into the Schneider Electric Group of Companies. We understand that the building is scheduled to undergo a refurbishment in 2023 in which the BMS will be replaced.

Condition & Operation

We understand that the building suffers from overheating in some areas during periods of hot weather. We have also received reports that the metal-framed glazing system induces cold draughts in cold weather which are not alleviated by the heating system.

We understand that the boiler plant in the Mary Newman building which serves the heating and hot water requirement is ageing and is generally unreliable which results in frequent periods of downtime due to failure and a regular requirement for temporary boilers to be deployed. We understand that the boilers have subsequently suffered a catastrophic failure following our inspection.

We understand that the building was constructed in the mid-2000s meaning the engineering services are circa 15-20 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 5-10 years, subject to appropriate maintenance.

The engineering services generally appear to be in good condition however we understand that the controls/BMS is in poor condition and requires renewal/refurbishment which is scheduled to be undertaken as soon as possible. The main switchgear and electrical infrastructure would benefit from replacement in the medium due to the limited availability of serviceable components.

14.1.7. Planned Future CAPEX Works

We understand that a programme of capex works is scheduled to commence in summer of 2023 including fabric upgrades and decarbonisation works.

14.1.8. Opportunities for Heat Networks

The building is currently served with LTHW from the existing campus DHN however works are underway to disconnect it and create a standalone building.

The University is investigating the feasibility of providing a 5th Generation Heating & Cooling (5DHC) network which could potentially serve the Fitzroy building. If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Fitzroy to the 5DHC network when it becomes operational.

Typical future-proofing measures to consider could be:

- Ensure the heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
- Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

14.2 Energy & Carbon Emissions

14.2.1. The following table identifies the energy consumption and carbon emissions from the Fitzroy building based on the energy consumption figures provided from site.

Table 14.1 – Energy Consumption & Carbon Emissions – Fitzroy

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	224,295 kWh	0.184 $kgCO_2e/kWh$	41.27 TCO_2e
Grid Electricity	85,148 kWh	0.105 $kgCO_2e/kWh$	8.94 TCO_2e
Total	309,443 kWh	N/A	50.21 TCO_2e

14.2.2. Table 4 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 2,988.4m². The performance of Fitzroy is very good with overall energy usage and carbon emissions around half the current benchmark. The figures correspond closely with those stated on the current DEC.

Table 14.2 – Energy Consumption & Carbon Emissions Benchmarking – Fitzroy

Fuel Type	(Actual 2022)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	180.90	33.29	240	44.16	106.02
Grid Electricity	68.67	7.21	80	8.40	30.94
Total	249.57	40.50	320	52.56	136.96

14.2.3. The building was constructed in the 1960's therefore the thermal performance and energy efficiency standards is likely to be poor when compared against typical University Campus building stock.

14.2.4. The C3ntinel metering portal does not contain gas/heat consumption figures for the Fitzroy building therefore we are unable to complete an analysis of the energy profile. The heating system is fed from the Mary Newman plantroom, and we can assess the overall optimisation of the heating system using consumption of the Mary Newman boiler plant.

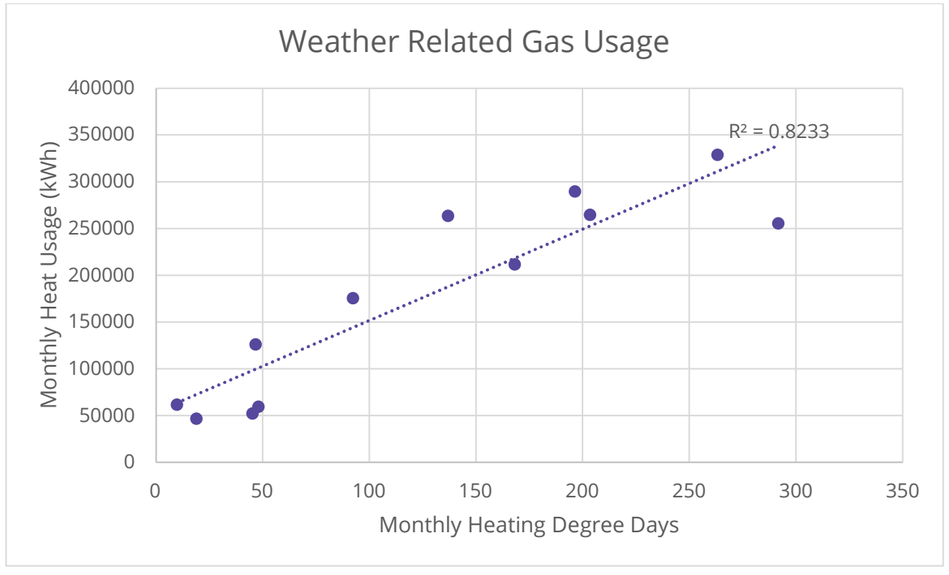


Fig. 14.2 Weather related heat usage compared to degree days

14.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.823 which suggests a relatively strong correlation between degree days and heat consumption, however this value suggests there is some inherent inefficiency in the system. This can be explained by the fact that the heat network is metered within the Mary Newman building and that there are likely to be significant pipework heat losses between the heat source and the emitters.

14.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

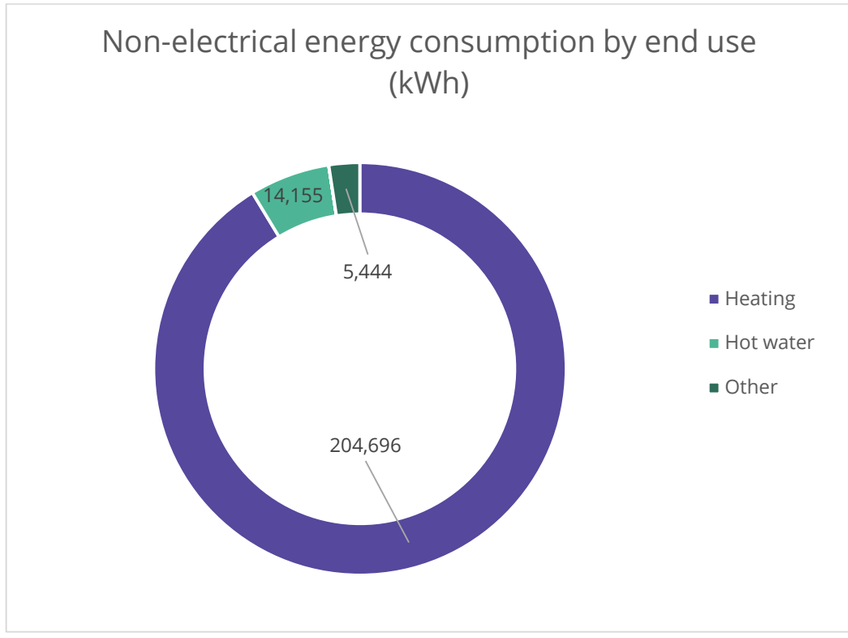


Fig. 14.3 Non-electrical energy consumption breakdown by end use

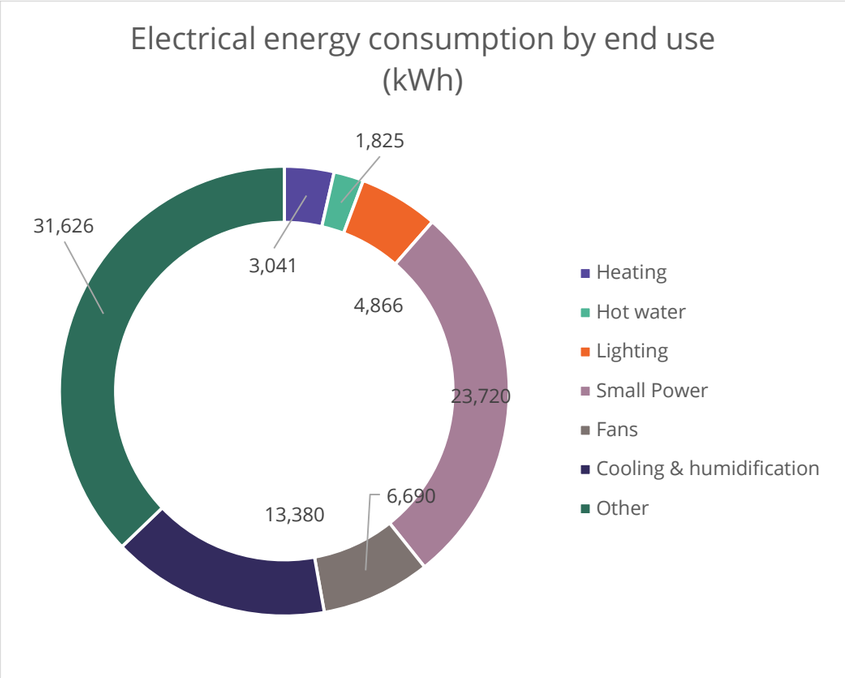


Fig. 14.4 Electrical energy consumption breakdown by end use

14.3 Technical Solution

14.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Fitzroy is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management records there being no insulation to walls. The options would be to retrospectively install external or internal to the entirety of the masonry elevations or a multiple of the two. The agreed insulation would be fitted internally by way of adhesive to existing walls or battens with insulation quilt/plasterboard, rigid insulation board or a mixture of the two. External insulation generally, comprises of rigid insulation board either mechanically fixed to the existing walls or within a steel cage system but often having an applied render coat to either option or being of a prefinished insulation board/panel. A third option would be more intrusive works comprising the wholesale removal of the concrete elevations/windows and the replacement with new glazed walling with spandrel panels or new insulated cladding incorporating double-glazing. These works would be subject to review of as-built information and design brief.

Option F2: The installation of new or additional roof insulation

The recommendation would for the whole refurbishment of the existing roofs to include upgrade of insulation in line with building regulations and U Values to be achieved.

Option F3: Installation of replacement of windows

Subject to the agreed works referred to in 'Option F1' the recommended scope would involve the replacement of all windows with new double-glazed windows or the installation of new curtain walling system. This recommendation would include the replacement of existing doors to incorporate double-glazing as required.

14.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Fitzroy. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S3: Renewal/replacement of lighting and controls with automated LED technology

The existing lighting is generally provided via fluorescent luminaires. The lighting should be upgraded to LED to reduce energy consumption and provide a better visual environment for the building users.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Fitzroy we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

Option S7: Expansion of roof mounted solar PV installation.

With an available roof area of approximately 500m² we anticipate that an additional 300m² of solar PV cells could be installed, subject to detailed design and structural feasibility assessment. This would also need to be considered within the design of the additional roof insulation and potential location of plant on the roof.

14.4 Energy & Carbon Savings – Fitzroy

Table 14.3 – Carbon savings summary – Fitzroy

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	23.55	£22,795	30	707	£32	£4,532	5.0
F2	Addition/replacement of roof insulation	23.85	£59,119	30	715	£83	£4,762	12.4
F3	Replacement of glazing to improve thermal performance	22.36	£429,222	20	447	£960	£3,607	119.0
F4		0.00	£0		0	£0	£0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	26.85	£448,260	25	671	£668	-£17,628	-25.4
S2	Installation of new centralised domestic hot water generation, pipework and controls	18.15	£119,536	25	454	£264	-£16,568	-7.2
S3	Replacement of existing lighting with LED technology and upgraded controls	17.90	£24,000	10	179	£134	£445	53.9
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	19.34	£89,652	20	387	£232	£4,046	22.2
S5	Addition of high efficiency fans, pumps and drives	17.75	£29,884	25	444	£67	£87	341.6
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£1,629	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	18.55	£24,000	15	278	£86	£2,059	0.0

14.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 299kW (based on a rule of thumb of 100W/m²) with the peak cooling demand of 215kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 63kW and 54kW for heating and cooling respectively.

14.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Fitzroy which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Fitzroy will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

15. Hepworth House

15.1 Description of Building

15.1.1. General

Hepworth House is located to the north of the main campus. The building houses the University's academic registry which is responsible for examinations, awards, graduations and other events. The building contains office space, storage and staff welfare facilities.



Fig. 15.1 Hepworth House

15.1.2. Building Fabric

Hepworth House is a four-storey building constructed circa 1800's comprising of a masonry construction with single and two storey extensions. Where observed windows comprise powder coated aluminium framed units incorporating sealed double-glazed opening lights and combination of stucco and concrete render elevation finishes.

The roofs were not inspected however, from our review of 'Google Maps' and street level the roofs are understood to comprise pitched and flat roofs.

The building has a mixture of timber framed and powder coated aluminium framed doors incorporating double glazed units.

During our inspection of Hepworth House, we observed vertical cracking spanning between door and window head and sills. This type of cracking is typical of this of render/masonry construction. However, we recommend the cracking be appraised by an engineer to confirm the extent of the failure and repairs required.

From information provided by site management the windows are recorded as single glazed and of poor condition, this is contrary to our observation of double-glazed units. Consideration should be given for the replacement of existing windows and doors, subject to the confirmation of the existing. In addition, the information states there is no thermal wall insulation and that the condition of the glass rock/mineral wool roof insulation is poor. However, the detailed specification has not been provided.

We would recommend a thermographic survey to identify/substantiate areas where improvements could be made to the thermal performance of the building envelope. We would anticipate works to include provision of thermal wall insulation and the upgrade of insulation to the roofs. Any potential insulation upgrade would be subject to liaison with consultants and building control.

15.1.3. Mechanical Services

Hepworth House is supplied with LTHW via gas fired boilers in the plantroom which feeds a heating circuit serving wall mounted radiators.

The building is not provided with any comfort cooling or local cooling.

The building is generally naturally ventilated via opening windows to atmosphere and to the atrium areas. Mechanical extract ventilation is provided to toilets and cleaners stores etc.

Domestic Hot water is generated by local unvented electric water heaters.

15.1.4. Electrical Services

The electricity supply to Hepworth House is served with a metered LV three phase electricity supply derived from the electricity supply network operated by the local district network operator. The service enters the basement office and is sub distributed to serve each floor.

Power is distributed throughout from the main LV switchgear in the basement via sub mains cabling to local distributions boards on each floor. The LV distribution system feeds local metered distribution boards on each level.

Lighting is generally provided via a variety of fluorescent lamped luminaires with manually switched lighting controls serving communal and offices spaces.

15.1.5. Metering

The C3ntinel metering system provides data in respect of gas and water consumption. There is no dedicated sub-metering data for Hepworth House in respect of electrical consumption therefore we have relied on data provided by the estates team for analysis.

15.1.6. BMS/Controls

The BMS within Hepworth House is based on an obsolete Andover Continuum system**.** Although support is still available for this family of products, the BMS is likely to require replacement in the medium term.

15.1.7. Condition & Operation

We understand that there are no significant concerns in respect of the building condition, performance and suitability.

We understand that the building was constructed in the 1800s meaning the building is over 120 years old. We understand that the engineering services are circa 15-20 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 5-10 years, subject to appropriate maintenance.

The engineering services generally appear to be in good condition however we understand that the controls/BMS is base on an obsolete Andover Continuum and requires renewal/refurbishment which is scheduled to be undertaken as soon as possible.

15.1.8. Planned Future CAPEX Works

We understand that a programme of capex works has been planned for 2024/25 in respect of internal decoration and works to the heating system.

15.1.9. Opportunities for Heat Networks

The building is currently served with LTHW via existing gas fired boilers however the system could be reconfigured to run on heat pumps fed from the proposed 5DHC.

The University is investigating the feasibility of providing a 5th Generation Heating & Cooling (5DHC) network which could potentially serve the Hepworth House building. If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Hepworth House to the 5DHC network when it becomes operational.

Typical future-proofing measures to consider could be:

- Ensure the heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
- Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

15.2 Energy & Carbon Emissions

15.2.1. The following table identifies the energy consumption and carbon emissions from the Hepworth House building based on the energy consumption figures provided from site.

Table 15.1 – Energy Consumption & Carbon Emissions – Hepworth House

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	142,376 kWh	0.184 $kgCO_2e/kWh$	26.20 TCO_2e
Grid Electricity	35,517 kWh	0.105 $kgCO_2e/kWh$	3.73 TCO_2e
Total	177,893 kWh	N/A	29.93 TCO_2e

15.2.2. Table 4 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 13260.4m². The performance of Hepworth House is considered good with overall energy usage and carbon emissions around half the current benchmark. The figures correspond closely with those stated on the current DEC.

Table 15.2 – Energy Consumption & Carbon Emissions Benchmarking – Hepworth House

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	87.31	16.07	120	22.8	68.85
Grid Electricity	21.78	2.29	95	52.3	48.23
Total	109.09	18.35	320	75.1	117.08

15.2.3. The building would have been constructed prior to the introduction of minimum standards for thermal performance therefore the thermal performance and energy efficiency standards are likely to be relatively poor when compared against typical University Campus building stock.

15.2.4. Gas meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2021 as the most recent full year. The metering data shows the energy consumption profile for Hepworth House throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. There is no electrical consumption data available vie the C3ntinel portal.

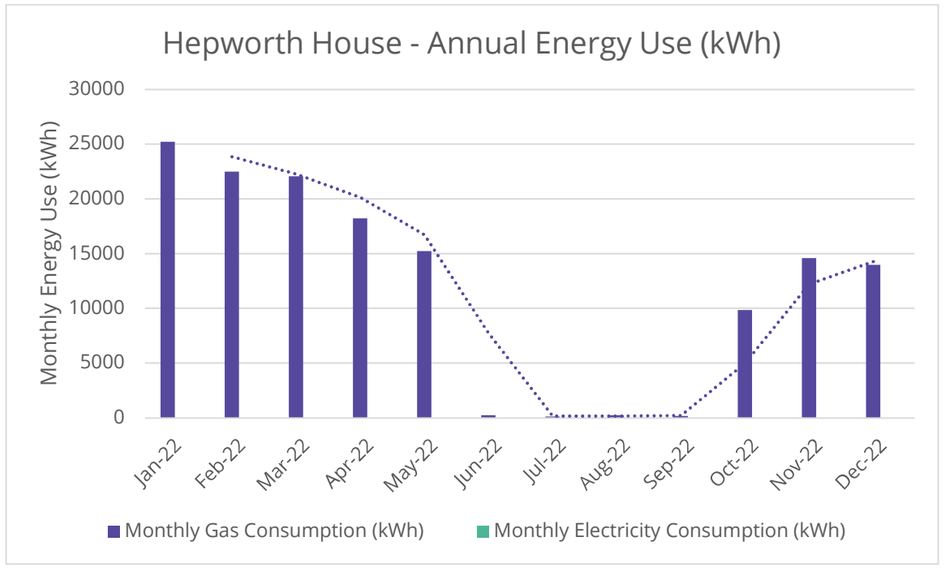


Fig. 15.2 Hepworth House annual energy usage profile

15.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.692 which suggests a relatively weak correlation between degree days and heat consumption, and this value suggests there is significant inefficiency in the system. This is likely explained by the age of the building and its construction properties.

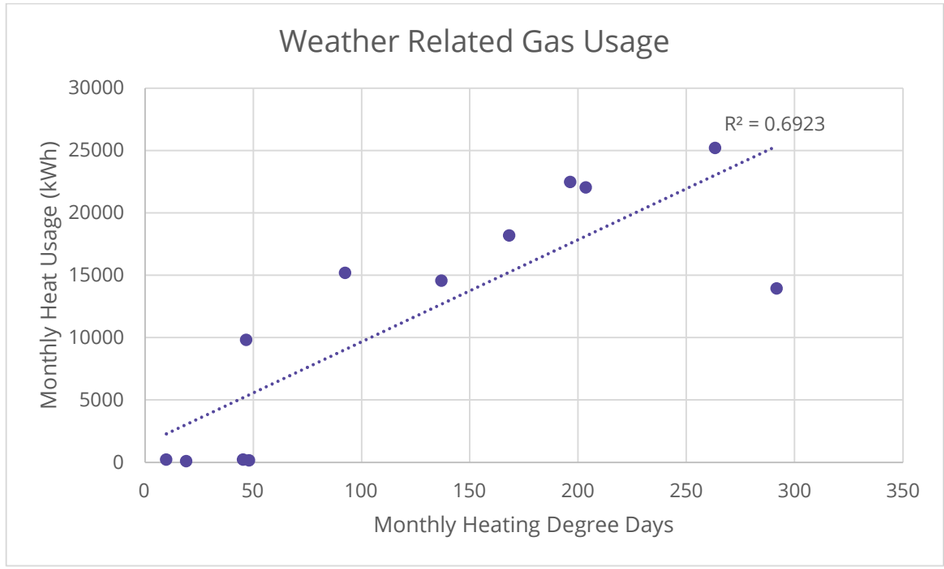


Fig. 15.3 Weather related heat usage compared to degree days

15.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

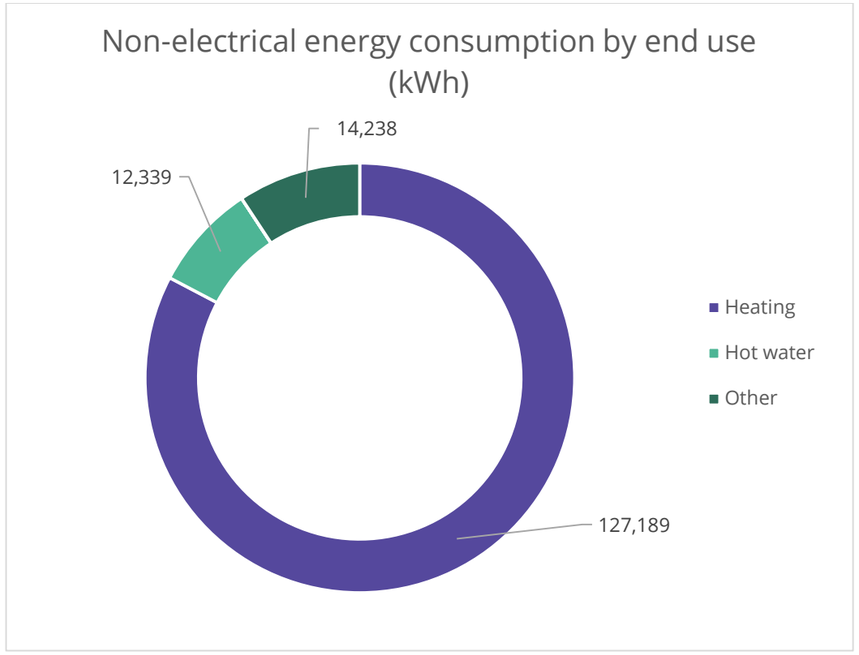


Fig. 15.4 Non-electrical energy consumption breakdown by end use

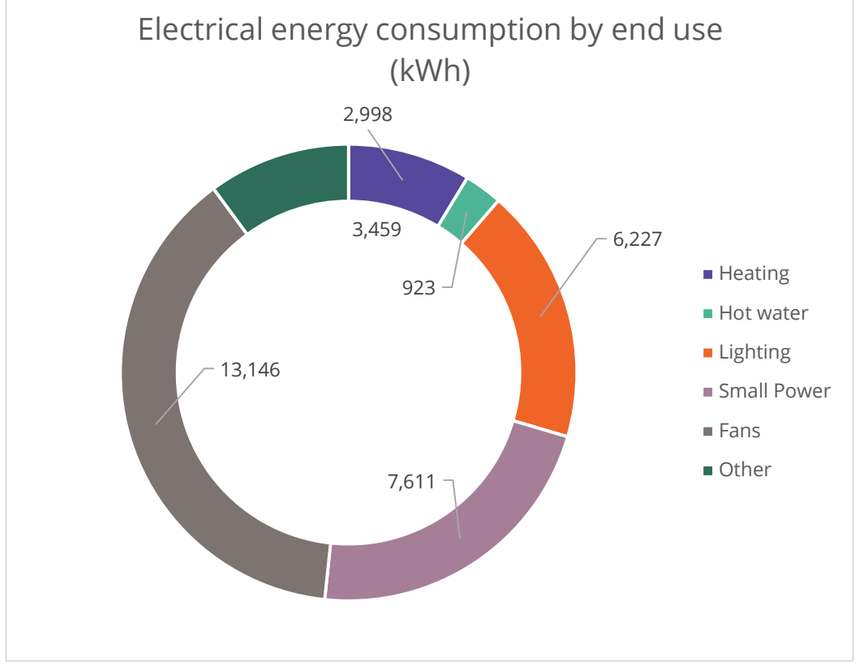


Fig. 15.5 Electrical energy consumption breakdown by end use

15.3 Technical Solution

15.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Hepworth House is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management records there being no insulation to walls. The options would be to either retrospectively install external or internal to the entirety of the masonry elevations or a multiple of the two. The agreed insulation would be fitted internally by way of adhesive to existing walls or battens with insulation quilt/plasterboard, rigid insulation board or a mixture of the two. External insulation generally, comprises of rigid insulation board either mechanically fixed to the existing walls or within a steel cage system but often having an applied render coat to either option or being of a prefinished insulation board/panel. However, these options may be subject/limited by existing listed building and planning restrictions.

Option F2: The installation of new or additional roof insulation

The assumption is the existing roofs are of a timber construction. Therefore, the anticipated works would comprise of upgrade of existing glass rock/mineral wool insulation with the similar product, rigid insulation boards or installation of a foam insulation. All would be subject to confirmation of the existing and the desired U Value to be achieved.

Option F3: Installation of replacement windows

The above-mentioned report records the existing windows as be in poor condition. The recommendation would be to replace all windows with new double-glazed windows. This would be subject to confirmation of the desired U Value to be achieved and there being no planning restrictions. This scope of works would include the replacement of existing doors with composite and glazed doors to meet requirements.

15.3.2. Building Services Solution

Option S1: Replace existing LTHW boilers with new high temperature water-water heat pumps with ambient water loop and dry air coolers.

This system will remove the existing gas fired boiler plant and remove any requirement for fossil fuel consumption on site in connection with Endsleigh Place. The proposal of a water-water heat pump and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump units would be mounted internally with the dry air coolers located externally subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the current services are less than 10 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S3: Renewal/replacement of lighting and controls with automated LED technology

The existing lighting is generally provided via fluorescent luminaires. The lighting should be upgraded to LED to reduce energy consumption and provide a better visual environment for the building users.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Hepworth House we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

15.4 Energy & Carbon Savings – Hepworth House

Table 15.3 – Carbon savings summary – Hepworth House

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	14.68	£28,725	30	440	£65	£2,668	10.8
F2	Addition/replacement of roof insulation	14.86	£28,674	30	446	£64	£2,804	10.2
F3	Replacement of glazing to improve thermal performance	13.98	£204,293	20	280	£731	£2,124	96.2
F4		11.25	£0		0	£0	£0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	16.68	£244,605	25	417	£587	-£12,092	-20.2
S2	Installation of new centralised domestic hot water generation, pipework and controls	11.60	£16,307	25	290	£56	-£11,211	-1.5
S3	Replacement of existing lighting with LED technology and upgraded controls	11.48	£130,456	10	115	£1,137	£570	228.9
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	12.24	£20,384	20	245	£83	£2,460	8.3
S5	Addition of high efficiency fans, pumps and drives	11.32	£16,307	25	283	£58	£172	94.9
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0

S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	15	0	£0	£0	0.0

15.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 122kW (based on a rule of thumb of 75W/m²) with the peak cooling demand of 117kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 26kW and 29kW for heating and cooling respectively.

15.6 Key Risks & Challenges

Key challenges include finding suitable external plant space for dry air coolers and completing building improvements/modifications within planning restrictions and conservation requirements.

It is likely that the available electrical capacity for Hepworth House will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

16. John Bull Building

16.1 Description of Building

16.1.1. General

The John Bull Building is Located adjacent to the Derriford Research Facility at Plymouth Science Park, next to Derriford Hospital. The building houses the University's Peninsula Schools of Medicine and Dentistry and contains laboratories and research facilities, teaching and administration spaces and a restaurant/café.



Fig. 16.1 John Bull Building

16.1.2. Building Fabric

The John Bull Building is a three-storey building constructed circa 2005 comprising of a steel frame construction enclosed with a combination of powder coated aluminium framed units and walling incorporating sealed double-glazed opening lights and stone, timber and concrete cladding.

The roofs were not inspected however, from our review of 'Google Maps' the roofs are understood to be flat and pitched roofs covered with a single-ply membrane and profiled metal roof sheets. The upper 'monitor' type roof incorporates aluminium framed units sealed double-glazed lights.

Powder coated aluminium framed doors incorporating double glazed units are provided to the main entrance and exit to the building. Flush faced steel framed doors are observed to means of escape and plantrooms.

During our inspection of John Bull Building, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe the external wall insulation, rigid roof insulation boards and double-glazing units to be in good condition, having been recently upgraded.

For the consideration of potential upgrade, we recommend a thermographic survey to identify/substantiate in detail where improvements could be made to the thermal performance of the building envelope.

Any potential areas for enhancement of the building fabric would be subject to the review of as-built data, liaison with consultants and building control.

16.1.3. Mechanical Services

The John Bull Building is supplied with LTHW via 2No gas fired boilers located in the main plantroom. The boilers feed Constant Temperature (CT) circuits for AHUs and hot water generation and Variable Temperature (VT) circuits for space heating via radiators.

Mechanical ventilation is provided via a series of packaged AHUs located in the main plant areas. The AHUs are complete with heat exchangers, heating and cooling coils, fans, dampers and controls to Health Technical Memoranda (HTM) specification for healthcare applications. The AHUs are also supplied with humidification plant to serve the laboratory areas.

The building is provided with comfort cooling via 2No. roof mounted packaged air-cooled chillers generating chilled water. Local cooling is provided to key areas (comms rooms etc.) via DX cooling systems.

Domestic Hot water is generated by gas fired water heaters.

The building is provided with comfort cooling via roof mounted packaged air-cooled chillers generating chilled water for AHUs. Local cooling for comms rooms etc. is provided via via DX cooling systems.

16.1.4. Electrical Services

Nick this is not one of the buildings I inspected

Power is distributed throughout from the main LV switch panel on the ground floor via vertical risers located throughout the building. The LV distribution system feeds local metered distribution boards on each level.

Lighting is generally provided via LED with occupancy sensing controls.

16.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides data for the electrical system, however there is no dedicated sub-metering data for John Bull Building in respect of the heat network therefore we have relied on data provided by the estates team for analysis.

16.1.6. BMS/Controls

The BMS serving the John Bull building is based on obsolete Trend IQ2 controllers. We understand that the building is currently transitioning to a Trend IQvision-based system.

16.1.7. Condition & Operation

We understand that the cooling system is unreliable and is subject to failures during the summer months.

We also understand that the boiler plant and heating system are scheduled for replacement in the short term.

We understand that the building was constructed in 2004 meaning the engineering services are circa 20 years old. The engineering services generally appear to be in good condition however according to CIBSE Guide M the systems should have a remaining serviceable life of 5-10 years, subject to appropriate maintenance.

16.1.8. Planned Future CAPEX Works

We understand that a programme of capex works had recently been completed to renew ventilation plant and install the chillers. It is expected that the LTHW system will be disconnected from the campus DHN with dedicated heating plant installed, likely to be heat pump based. We understand that this has been scheduled for 2022/23 and this report will form the basis of the options appraisal to determine the best solution for the new heating system.

16.1.9. Opportunities for Heat Networks

The building is currently served with LTHW from the existing boilers and there is potentially spare plant space available. The building is remote from the main city centre campus however it is located adjacent to the Derriford Hospital site which is located within an opportunity area for heat networks as identified by Plymouth Council.

If suitable technology is installed as part of the planned HCDP works along with appropriate future-proofing measures it would potentially be feasible to connect the John Bull Building to a new heat network when it becomes operational.

Typical future-proofing measures to consider could be:

- Ensure the heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
- Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

16.2 Energy & Carbon Emissions

16.2.1. The following table identifies the energy consumption and carbon emissions from the John Bull Building building based on the energy consumption figures provided from site.

Table 16.1 – Energy Consumption & Carbon Emissions – John Bull Building

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	554,109 kWh	0.184 $kgCO_2e/kWh$	101.96 TCO_2e
Grid Electricity	678,417 kWh	0.105 $kgCO_2e/kWh$	71.23 TCO_2e
Total	1,232,526 kWh	N/A	173.19 TCO_2e

16.2.2. Table 4 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 5,178.8m². The performance of John Bull Building is very good with overall energy usage and carbon emissions around half the current benchmark. The figures correspond closely with those stated on the current DEC.

Table 16.2 – Energy Consumption & Carbon Emissions Benchmarking – John Bull Building

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	107.00	19.69	240	44.16	114.02
Grid Electricity	131.00	13.75	80	8.40	81.44
Total	237.99	33.44	320	52.56	195.46

16.2.3. The building would have been constructed to 2000/2006 building regulations therefore the thermal performance and energy efficiency standards should be reasonable when compared against typical University Campus building stock.

16.2.4. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2021 as the most recent full year. The metering data shows the energy consumption profile for John Bull Building throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. The data shows an increase in electrical consumption through the winter when there is an increased demand for lighting however this is tempered by an increased demand for cooling in the summer which is provided via the roof mounted chiller plant.

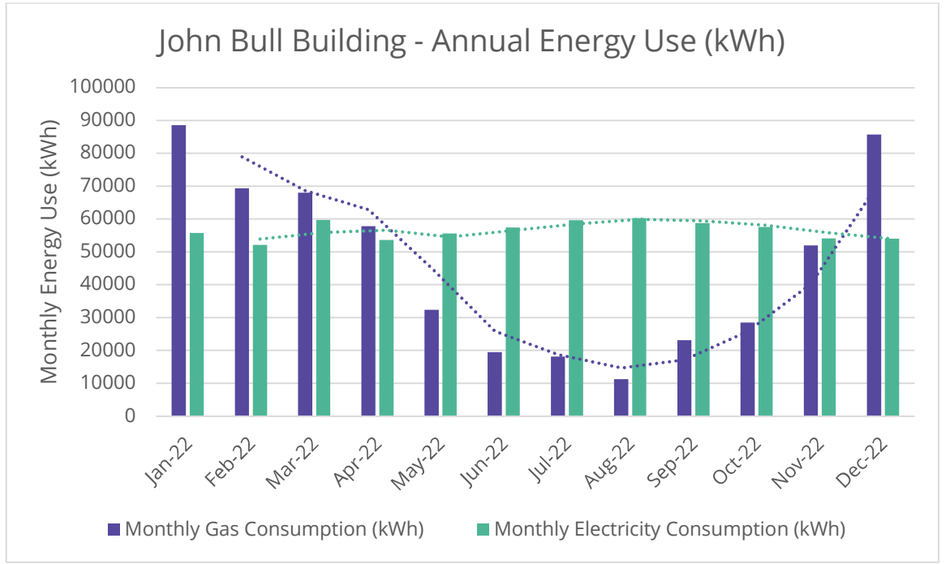


Fig. 16.2 John Bull Building annual energy usage profile

16.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.877 which suggests a relatively strong correlation between degree days and heat consumption, however this value suggests there is some inherent inefficiency in the system.

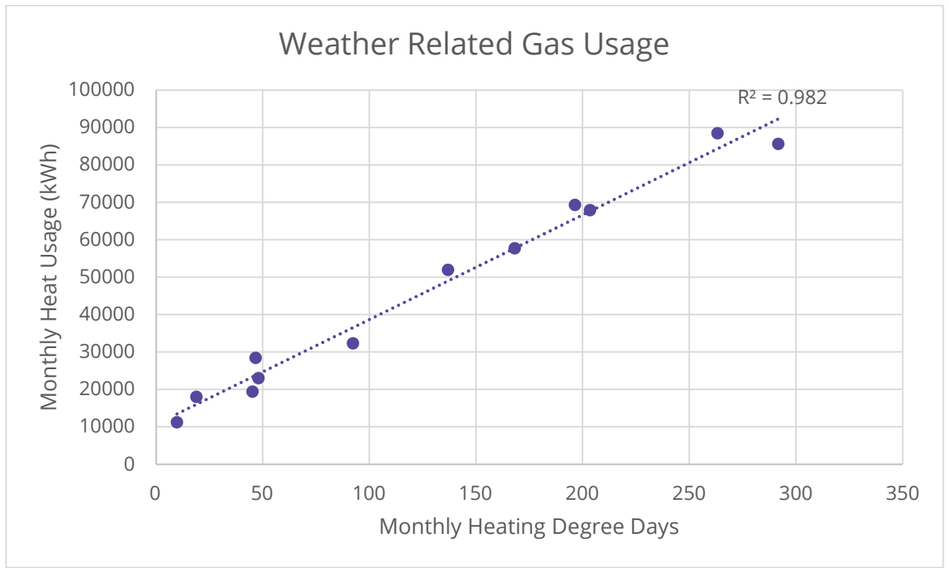


Fig. 16.3 Weather related heat usage compared to degree days

16.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

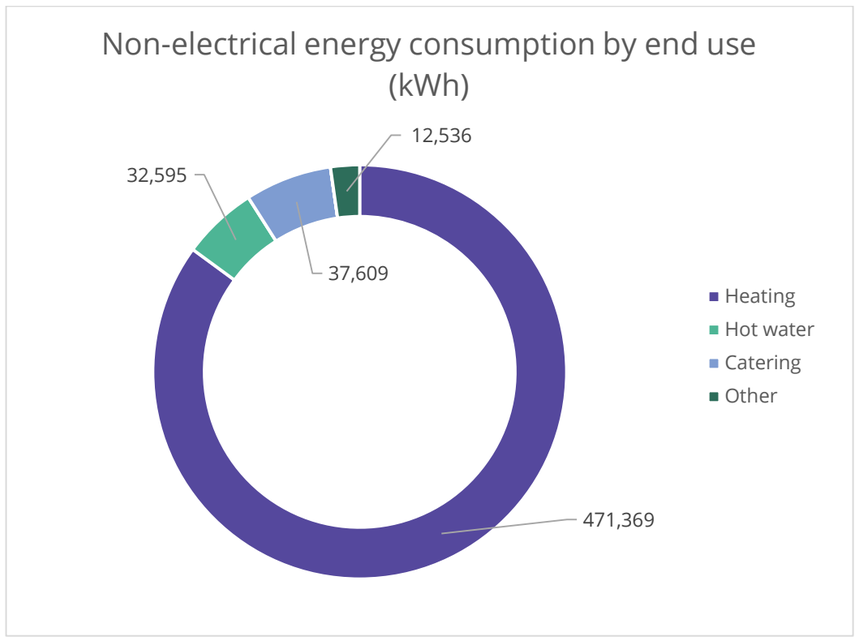


Fig. 16.4 Non-electrical energy consumption breakdown by end use

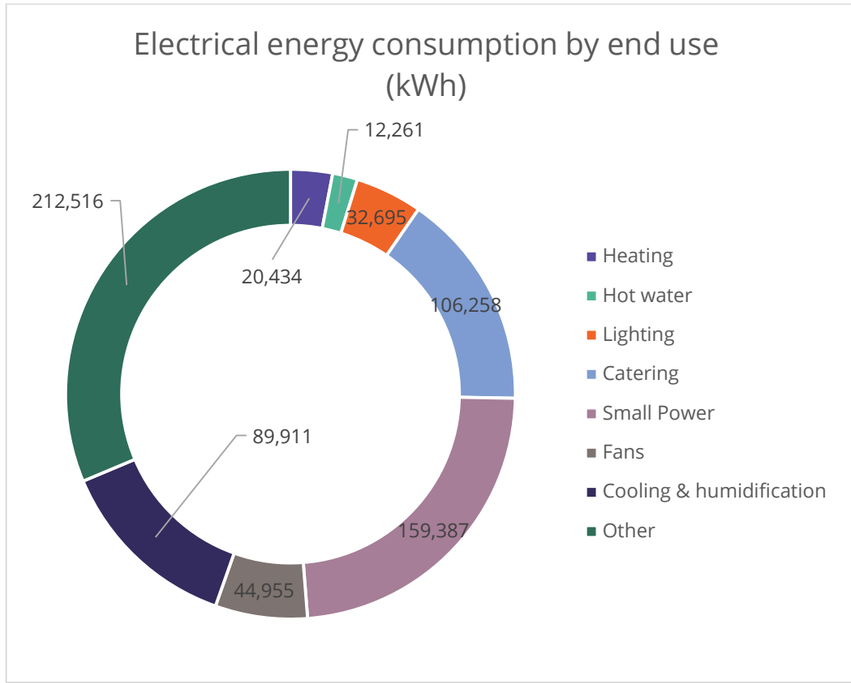


Fig. 16.5 Electrical energy consumption breakdown by end use

16.3 Technical Solution

16.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for John Bull Building is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management states the existing wall insulation as being in good condition, having been recently upgraded. However, we do recommend a thermographic survey to identify in detail the areas where meaningful improvements could be made to the thermal performance of the building envelope.

Option F2: The installation of new or additional roof insulation

The above-mentioned report states the existing roof insulation as being in good condition, having been recently upgraded. 'Refer to above comment for recommended thermographic survey'.

Option F3: Installation of reflective/ absorptive film on curtain glazing system to reduce heat gain

The above-mentioned report states the existing double windows as being in good condition, having been recently upgraded. 'Refer to above comment for a recommend a thermographic survey'.

16.3.2. Building Services Solution

Option S1: Replace existing LTHW plant with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Derriford Research Facility. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop as the facility is within a heat network opportunity area.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would be mounted in the ground floor plantroom with the dry air coolers located on the roof or at ground level, subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is only circa 10 years old, we do not anticipate that the heating system will require lifecycle renewal in the medium term.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S3: Renewal/replacement of lighting and controls with automated LED technology

The existing lighting is generally provided via fluorescent luminaires. The lighting should be upgraded to LED to reduce energy consumption and provide a better visual environment for the building users.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

For the John Bull Building we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

Option S7: Expansion of roof mounted solar PV installation.

With an available roof area of approximately 1,600m² we anticipate that an additional 960m² of solar PV cells could be installed, subject to detailed design and structural feasibility assessment. This would also need to be considered within the design of the additional roof insulation and potential location of plant on the roof.

16.4 Energy & Carbon Savings – John Bull Building

Table 16.3 – Carbon savings summary – John Bull Building

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	117.33	£39,502	30	3,520	£11	£7,014	5.6
F2	Addition/replacement of roof insulation	118.18	£102,452	30	3,545	£29	£7,638	13.4
F3	Replacement of glazing to improve thermal performance	117.91	£743,829	20	2,358	£315	£7,439	100.0
F4					0	£0	£0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	237.81	£776,820	25	5,945	£131	£109,943	7.1

S2	Installation of new centralised domestic hot water generation, pipework and controls	113.30	£207,152	25	2,832	£73	£115,595	1.8
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£5,217	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	118.35	£155,364	20	2,367	£66	£26,257	5.9
S5	Addition of high efficiency fans, pumps and drives	108.21	£51,788	25	2,705	£19	£1,025	50.5
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£21,862	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	111.21	£152,000	15	1,668	£91	£8,435	18.0

16.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 388kW (based on a rule of thumb of 75W/m²) with the peak cooling demand of 373kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 97kW and 99kW for heating and cooling respectively.

16.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is plant installed within the roof plantrooms of the John Bull Building which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for John Bull Building will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

17. Kirkby Lodge

17.1 Description of Building

17.1.1. General

Kirkby Lodge is located to the north of the main campus. The building houses the University's sustainability hub. The building contains collaborative space for sustainability research, education and partnership working. Home to the Sustainable Earth Institute and Centre for Sustainable Futures, the Sustainability Hub provides space for students, staff, and partners to host group work, meetings, workshops and events.

The Hub supports the ongoing work of the University in sustainability across teaching and learning, research, and operations.

The building was recently refurbished to achieve Ska Gold accreditation.



Fig. 17.1 Kirkby Lodge

17.1.2. Building Fabric

Kirkby Lodge is a two-storey building constructed circa 1980's comprising of a masonry and steel frame construction enclosed with a combination of powder coated aluminium framed units incorporating sealed double-glazed opening lights, faced stone, faced brickwork, timber cladding and concrete render.

The roofs were not inspected however, from street level and our review of 'Google Maps' the roofs are understood to comprise mainly tiled pitched roofs incorporating roofs lights, dormer windows and areas of flat roof.

Powder coated aluminium framed doors incorporating double glazed units are provided to the main entrance and exit to the building.

During our inspection of Kirkby Lodge, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe the thermal wall/roof insulation and double-glazed windows to be in good condition having been subject to recent upgrade. However, the detailed specification has not been provided.

No upgrade works are anticipated for the building although, as a caveat this would be subject to review of the specification associated with the recent refurbishment to corroborate this statement. Subject to the findings of the health and safety file associated with refurbishment works you may wish to consider a thermographic survey to identify in detail where improvements could be made to the thermal performance of the building envelope.

17.1.3. Mechanical Services

Kirkby Lodge is supplied with LTHW via a single wall mounted gas fired condensing combi boiler in the main plantroom. The boiler feeds an LTHW heating system comprising radiators and direct fed domestic hot water system.

The building is not provided with any mechanical cooling.

The building is generally naturally ventilated via opening windows to atmosphere with CO_2 monitoring to inform occupants when there are issues with air quality.

A rainwater harvesting system is in operation for irrigation purposes.

17.1.4. Electrical Services

The electricity supply to Kirkby Lodge (Sustainability Hub) is served with a metered Low Voltage (LV) three phase electricity supply derived from the electricity supply network operated by the local district network operator.

Power is distributed throughout from the main LV main switch gear and local distribution board on the ground floor via final circuits to sockets and lighting installation.

Lighting is generally provided via a variety of LED luminaires with occupancy sensing controls serving communal and training spaces.

The building is provided with a roof mounted solar PV array comprising 14No. panels.

17.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides data for the gas, electrical system, solar PV and water system.

17.1.6. BMS/Controls

The building is provided with a Schneider Electric BMS control panel which contains an enable/fault interface with the main boiler, monitoring of system pressurisation and emergency shutdown of the plant and gas supply on activation of the fire alarm. The boiler operates via an onboard control panel.

17.1.7. Condition & Operation

We understand that the building suffers from overheating in some areas during periods of hot weather. We have also received reports that the metal-framed glazing system induces cold draughts in cold weather which are not alleviated by the heating system.

We understand that the boiler plant in the Mary Newman building which serves the heating and hot water requirement is ageing and is generally unreliable which results in frequent periods of downtime due to failure and a regular requirement for temporary boilers to be deployed. We understand that the boilers have subsequently suffered a catastrophic failure following our inspection.

We understand that the building was constructed in the 1980s however underwent a significant refurbishment in 2017 meaning the engineering services are circa 5 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 15-20 years, subject to appropriate maintenance.

The engineering services generally appear to be in good condition and we have not been advised of any ongoing/recurring issues.

17.1.8. Planned Future CAPEX Works

We understand that a programme of capex works is planned to replace all lighting with LED luminaires.

17.1.9. Opportunities for Heat Networks

The building is currently served via standalone heating and hot water plant.

The University is investigating the feasibility of providing a 5th Generation Heating & Cooling (5DHC) network which could potentially serve the Kirkby Lodge building. If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Kirkby Lodge to the 5DHC network when it becomes operational.

Typical future-proofing measures to consider could be:

- Ensure the heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
  Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

17.2 Energy & Carbon Emissions

17.2.1. The following table identifies the energy consumption and carbon emissions from the Kirkby Lodge building based on the energy consumption figures provided from site.

Table 17.1 – Energy Consumption & Carbon Emissions – Kirkby Lodge

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	30,878 kWh	0.184 $kgCO_2e/kWh$	5.68 TCO_2e
Grid Electricity	12,396 kWh	0.105 $kgCO_2e/kWh$	1.30 TCO_2e
Total	43,273 kWh	N/A	6.98 TCO_2e

17.2.2. Table 4 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 377.8m^2. The performance of Kirkby Lodge is very good with overall energy usage and carbon emissions around half the current benchmark. The figures correspond closely with those stated on the current DEC.

Table 17.2 – Energy Consumption & Carbon Emissions Benchmarking – Kirkby Lodge

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m^2)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m^2)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m^2)
Fossil Fuel	81.75	15.04	240	44.16	-
Grid Electricity	32.82	3.45	80	8.40	-
Total	114.57	18.79	320	52.56	-

17.2.3. The building would have originally been constructed to 1985 building regulations however the building underwent a significant refurbishment in 2017 therefore the thermal performance and energy efficiency standards should be reasonable when compared against typical University Campus building stock.

17.2.4. Electricity and gas meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2022 as the most recent full year. The metering data shows the energy consumption profile for Kirkby Lodge throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. The data shows a fairly stable electrical consumption across the year.

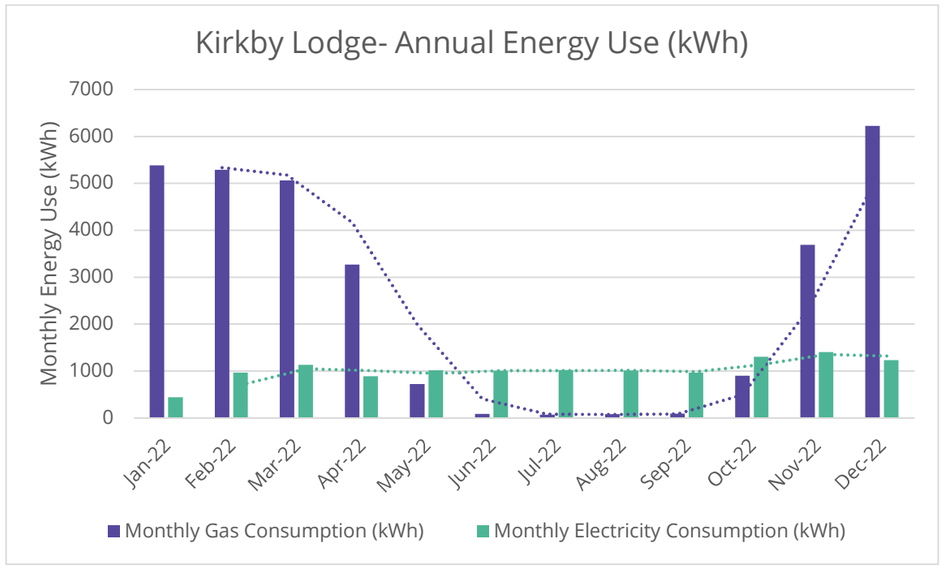


Fig. 17.2 Kirkby Lodge annual energy usage profile

17.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.934 which suggests a strong correlation between degree days and heat consumption, however this value suggests there is some inherent inefficiency in the system. This can be explained by the fact that the building fabric, although improved is still based on 1980's construction standards.

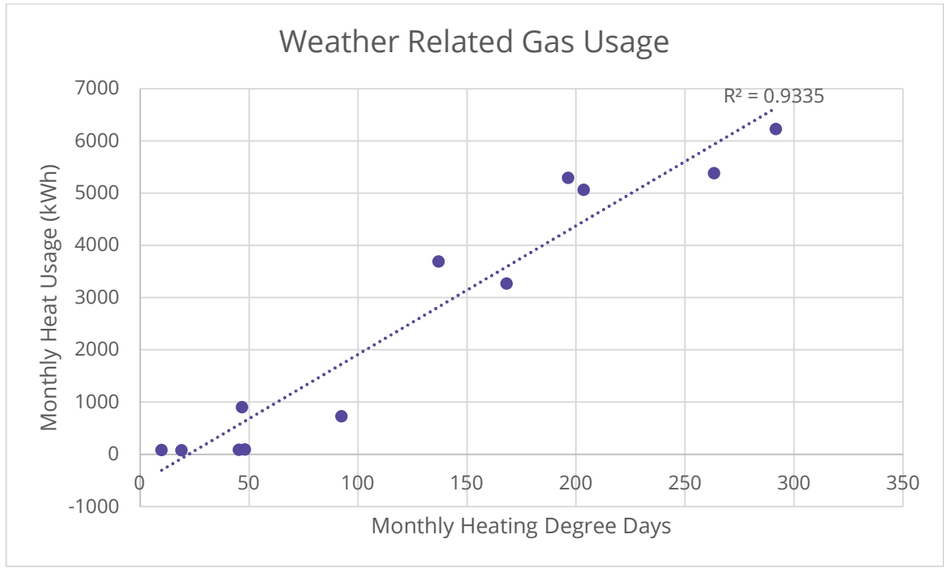


Fig. 17.3 Weather related heat usage compared to degree days

17.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

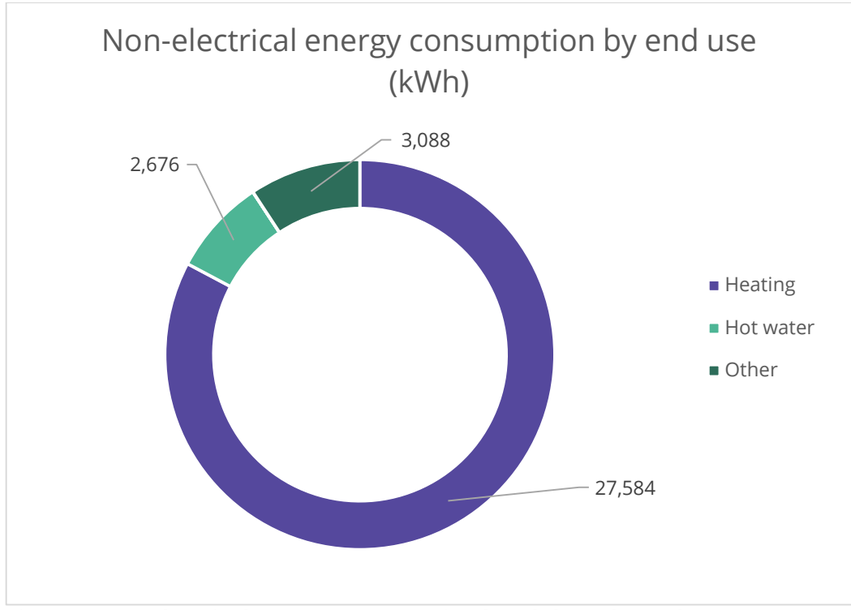


Fig. 17.4 Non-electrical energy consumption breakdown by end use

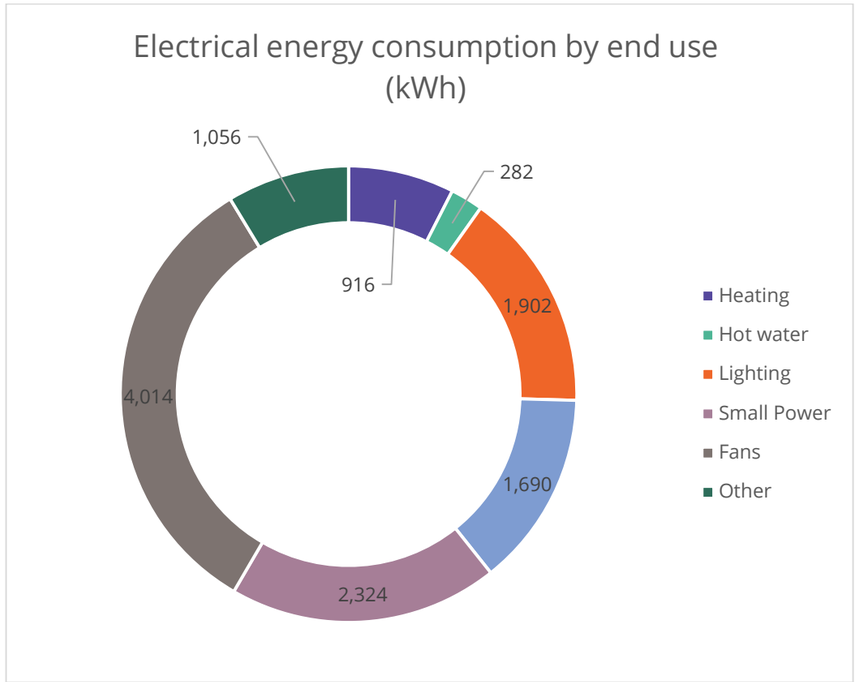


Fig. 17.5 Electrical energy consumption breakdown by end use

17.3 Technical Solution

17.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Kirkby Lodge is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management records the insulation to walls as being in good condition, having been recently upgraded.

Option F2: The installation of new or additional roof insulation

The above-mentioned report states the existing roof insulation as being in good condition, having been recently upgraded.

Option F3: Installation of replacement windows

The above-mentioned report states the existing double windows as being in good condition, having been recently upgraded. 'Refer to above comment for a recommend a thermographic survey'.

However, we do recommend a thermographic survey is undertaken to identify in detail the areas where meaningful improvements could be made to the thermal performance of the building envelope.

17.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Kirkby Lodge. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Kirkby Lodge we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

17.4 Energy & Carbon Savings – Kirkby Lodge

Table 17.3 – Carbon savings summary – Kirkby Lodge

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	2.67	£6,653	30	80	£83	£179	37.1
F2	Addition/replacement of roof insulation	2.69	£6,641	30	81	£82	£195	34.0
F3	Replacement of glazing to improve thermal performance	2.68	£47,318	20	54	£881	£190	248.8
F4		0	£0		0	£0	£0	0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	5.60	£56,655	25	140	£405	£2,316	24.5
S2	Installation of new centralised domestic hot water generation, pipework and controls	2.52	£3,777	25	63	£60	£2,512	1.5
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£174	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	2.67	£4,721	20	53	£88	£573	8.2
S5	Addition of high efficiency fans, pumps and drives	2.46	£3,777	25	62	£61	£52	72.0
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£564	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	15	0	£0	£0	0.0

17.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 28kW (based on a rule of thumb of 75W/m²). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 6kW for heating.

17.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Kirkby Lodge which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Kirkby Lodge will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

Retain or upgrade Solar PV installations

Consideration could be given to the application of battery technologies to harness the kWp energy from the Solar PV installation. In addition, the private HV ring main could be extended to service the power requirements for those metered LV power supplies across the West Campus.

LED lighting technologies has seen a significant improvement in lighting with increased lumen efficacies per luminaire circuit watts. These should be considered for the initial replacement of fluorescent lamped lighting installations and phased improvement plan for all existing LED lighting installations.

18. Kirkby Place (Nos. 1-12)

18.1 Description of Building

18.1.1. General

Kirkby Place is a series of 12 terraced properties located to the north of the main campus. The building house the faculties of Mathematical Sciences and Health, as well as the International Office, estates and facilities and the Doctoral College. The buildings primarily contain office accommodation and storage.



Fig. 18.1 Kirkby Place

18.1.2. Building Fabric

Kirkby Place is a three-storey terrace constructed between 1800 and 1900 comprising of a masonry construction, powder coated aluminium framed units incorporating sealed double-glazed opening lights and a mixture of stucco and concrete render finishes. Single and two storey extensions are observed to the south elevation and are aesthetically in keeping with the main building.

The roofs were not inspected however, from street level and our review of 'Google Maps' these are understood to comprise pitched roofs covered with roof tiles. Chimney stacks were observed although some appear to have been capped off and reduced from their original height.

A mixture of timber and powder coated aluminium framed doors, some incorporating double glazed units are provided to the building.

During our inspection of Kirkby Place, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe there is no thermal wall insulation. Glass rock/ mineral wool roof insulation and the double-glazed windows are recorded as being in poor condition. However, the detailed specification has not been provided.

It is recommended to consider a thermographic survey to identify/substantiate in detail where improvements could be made to the thermal performance of the building envelope.

We would anticipate enhancement works to include provision and upgrade of insulation to walls and roofs respectively and the replacement of windows. Any potential upgrade would be subject to review of a thermographic survey, liaison with consultants and building control.

18.1.3. Mechanical Services

Kirkby Place was formerly a series of terraced dwellings and is still arranged as such. Each individual property is provided with a wall mounted gas fired boiler to generate LTHW which feeds a central heating system comprising radiators. Hot water is generally provided via local unvented electric water heaters.

Local extract ventilation is provided to toilet areas and kitchens with ventilation generally via opening windows.

18.1.4. Electrical Services

The electricity supplies to Kirkby Place are served via a series of metered Low Voltage (LV) single phase electricity supply derived from the electricity supply network operated by the local district network operator.

Power is distributed throughout from the main LV main switch gear and local distribution board on the ground floor via final circuits to sockets and lighting installation.

Lighting is generally provided via a variety of fluorescent lamped luminaires, with some evidence of failed luminaires replaced for LED equivalents with manually switched lighting controls serving communal and offices spaces.

18.1.5. Metering

The C3ntinel metering system provides data in respect of electricity and gas consumption. Each property is provided with individual utility gas and electricity meters. There are no sub-meters currently installed.

18.1.6. BMS/Controls

Each individual building is provided with an Andover Continuum-based system which is now obsolete and scheduled for replacement.

18.1.7. Condition & Operation

We understand that the building has not been subject to significant refurbishment for circa 25 years meaning the engineering services are obsolete/end of life.

The engineering services generally appear to be in fair condition however we understand that the controls/BMS are obsolete and require renewal/refurbishment which is scheduled to be undertaken as soon as possible.

18.1.8. Planned Future CAPEX Works

We understand that a programme of light refurbishment is planned for No.1 in the short/medium term.

18.1.9. Opportunities for Heat Networks

The location and arrangement of the building/properties would allow for individual connections to a heat network. The building is located on the main campus site and is well positioned for connection to any proposed ambient loop.

The University is investigating the feasibility of providing a 5th Generation Heating & Cooling (5DHC) network which could potentially serve the Endsleigh Place building. If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Endsleigh Place to the 5DHC network when it becomes operational.

Typical future-proofing measures to consider could be:

- Ensure heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
- Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

18.2 Energy & Carbon Emissions

18.2.1. The following table identifies the energy consumption and carbon emissions from Kirkby Place based on the energy consumption figures provided from site. For clarity and ease of analysis, we have assessed all Kirkby Place buildings as a single entity.

Table 18.1 – Energy Consumption & Carbon Emissions – Kirkby Place (Nos. 2 - 11)

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	124,301 kWh	0.184 $kgCO_2e/kWh$	22.87 TCO_2e
Grid Electricity	92,465 kWh	0.105 $kgCO_2e/kWh$	9.71 TCO_2e
Total	216,766 kWh	N/A	32.58 TCO_2e

18.2.2. Table 4 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 2,499m². The performance of Kirkby Place is very good with overall energy usage and carbon emissions around half the current benchmark. There is no current DEC available

Table 18.2 – Energy Consumption & Carbon Emissions Benchmarking – Kirkby Place

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	49.74	9.15	240	44.16	N/A
Grid Electricity	37.00	3.89	80	8.40	N/A
Total	86.74	13.04	320	52.56	N/A

18.2.3. The building would have been constructed to 2000/2006 building regulations therefore the thermal performance and energy efficiency standards should be reasonable when compared against typical University Campus building stock.

18.2.4. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2021 as the most recent full year. The metering data shows the energy consumption profile for Kirkby Place throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. The data shows an increase in electrical consumption through the winter when there is an increased demand for lighting however this is tempered by an increased demand for cooling in the summer which is provided via the roof mounted chiller plant.

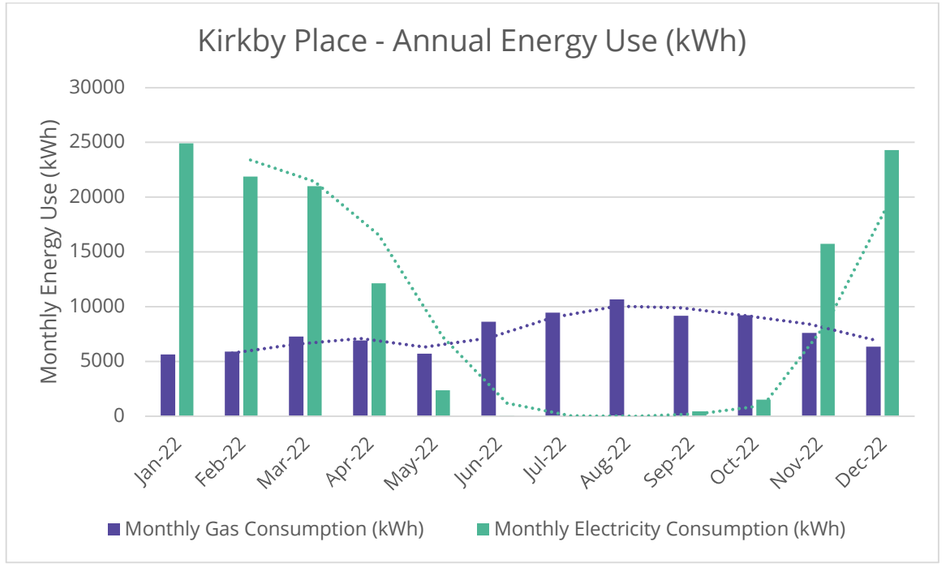


Fig. 18.2 Kirkby Place annual energy usage profile

18.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.669 which suggests a relatively strong correlation between degree days and heat consumption, however this value suggests there is some inherent inefficiency in the system. This can be explained by the fact that the heat network is metered within the Mary Newman building and that there are likely to be significant pipework heat losses between the heat source and the emitters.

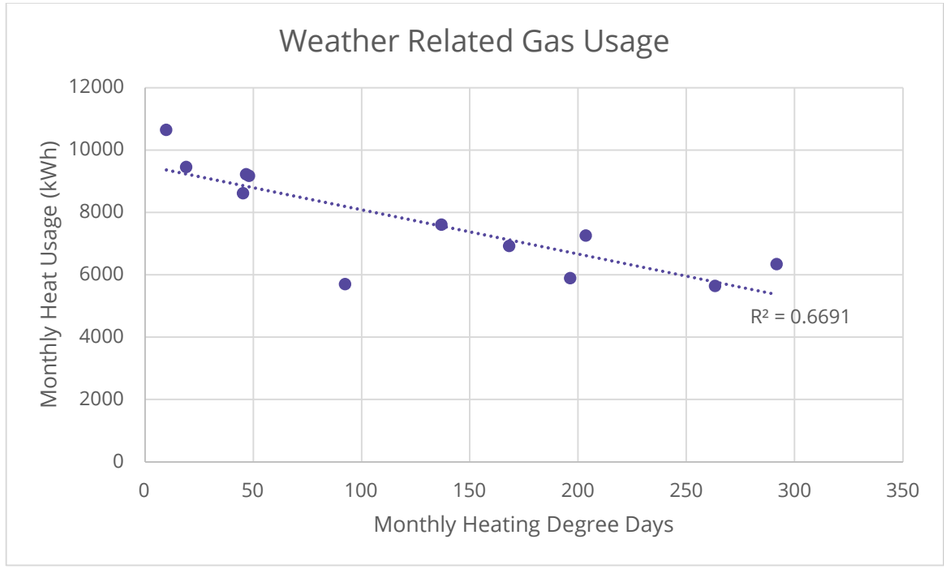


Fig. 18.3 Weather related heat usage compared to degree days

18.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

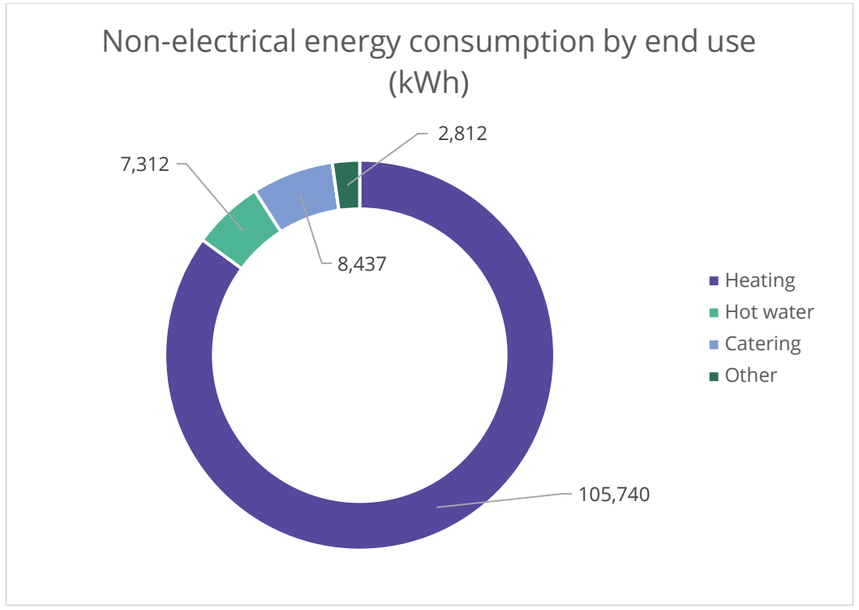


Fig. 18.4 Non-electrical energy consumption breakdown by end use

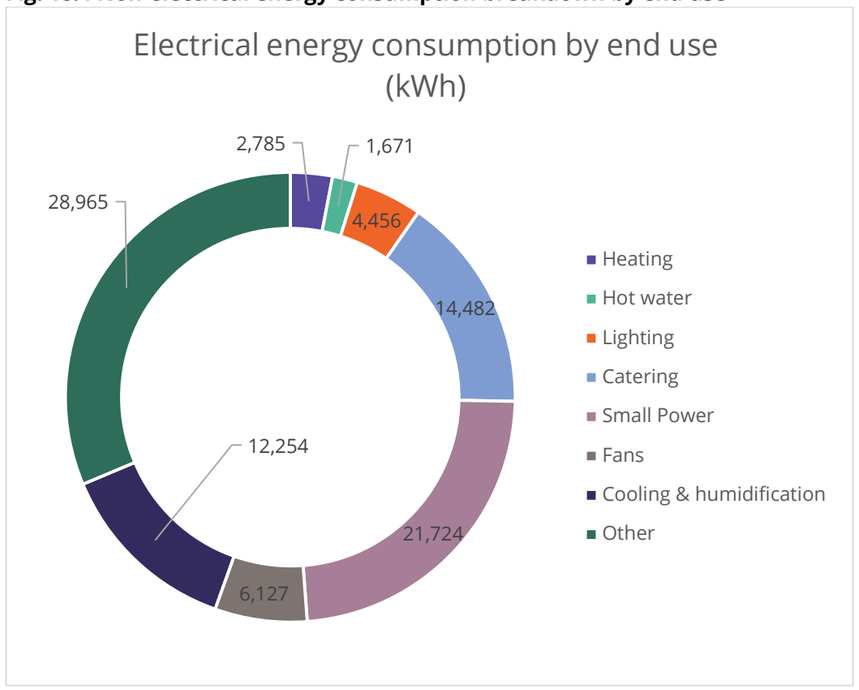


Fig. 18.5 Electrical energy consumption breakdown by end use

18.3 Technical Solution

18.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Kirkby Place is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management records there being no insulation to walls. The options would be to either retrospectively install external or internal to the entirety of the masonry elevations or a multiple of the two. The agreed insulation would be fitted internally by way of adhesive to existing walls or battens with insulation quilt/plasterboard, rigid insulation board or a mixture of the two. External insulation generally, comprises of rigid insulation board either mechanically fixed to the existing walls or within a steel cage system but often having an applied render coat to either option or being of a prefinished insulation board/panel. However, these options may be subject/limited by existing listed building and planning restrictions.

Option F2: The installation of new or additional roof insulation

It is assumed the existing roofs are of a timber construction. Therefore, the anticipated works would comprise of upgrade of existing glass rock/mineral wool insulation with the similar product, rigid insulation boards or installation of a foam insulation. All would be subject to confirmation of the existing and the desired U Value to be achieved.

Option F3: Installation of replacement of windows

The above-mentioned report records the existing windows as be in poor condition. The recommendation would be to replace all windows with new double-glazed windows. This would be subject to confirmation of the desired U Value to be achieved and there being no planning restrictions. This recommendation would include the replacement of existing doors with composite and glazed doors to meet requirements.

18.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Kirkby Place. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Kirkby Place we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

18.4 Energy & Carbon Savings – Kirkby Place

Table 18.3 – Carbon savings summary – Kirkby Place

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	13.01	£53,390	30	390	£137	£2,475	21.6
F2	Addition/replacement of roof insulation	13.17	£73,613	30	395	£186	£2,601	28.3
F3	Replacement of glazing to improve thermal performance	12.36	£296,003	20	247	£1,198	£1,970	150.2
F4		9.88	£0		0	£0	£50	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	14.77	£374,850	25	369	£1,015	-£10,040	-37.3
S2	Installation of new decentralised domestic hot water generation, pipework and controls	10.06	£37,485	25	251	£149	-£9,444	-4.0
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	10.84	£74,970	20	217	£346	£2,534	29.6
S5	Addition of high efficiency fans, pumps and drives	9.85	£24,990	25	246	£101	£80	311.9
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0

S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	15	0	£0	£0	0.0

18.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 187kW (based on a rule of thumb of 75W/m²). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 39kW for heating and cooling respectively.

18.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Kirkby Place which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Kirkby Place will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

19. Kirkby Terrace (Nos. 1-16)

19.1 Description of Building

19.1.1. General

Kirkby Terrace is located to the north of the main campus. The building houses the University's Pastoral and Spiritual Support Centre, the Design and Print Centre, the Post Room and the Estates and Facilities department. The buildings contain primarily office accommodation and storage.



Fig. 19.1 Kirkby Terrace

19.1.2. Building Fabric

Kirkby Terrace is a mixture of three, two and single-storey buildings constructed between 1901 and 1950. the buildings comprise of single-storey steel frame workshops and two and three-storey masonry constructions. Generally, the buildings are enclosed with a combination of powder coated aluminium and UPVC framed units incorporating sealed double-glazed opening lights, stucco, cement render and faced brickwork.

The roofs were not inspected however, from street level and our review of 'Google Maps' the roofs are understood to comprise pitched roofs covered with roof tiles and profiled metal roof sheet coverings. The profiled roof sheets incorporate roof lights and are observed over the single storey buildings only. Chimney stacks are seen to the two and three storey buildings. Where seen the powder coated finishes to the profiled metal roof sheets are heavily degraded exposing to base metal.

Where seen doors are a combination of timber and powder coated aluminium framed doors. Steel roller shutter doors are incorporated to the single storey workshop elevations.

From information provided by site management we believe there is no thermal wall insulation. The glass rock/mineral wool roof insulation and double-glazed windows are recorded as in poor condition. However, detailed specification has not been provided.

It is recommended to consider a thermographic survey to identify in detail where improvements could be made to the thermal performance of the building envelope. However, it is anticipated enhancement works may include provision and upgrade to wall and roof insulation, replacement of metal roofs and the replacement of windows.

Any potential upgrade would be subject to the review of a thermographic survey, liaison with consultants and building control.

19.1.3. Mechanical Services

Nos. 1-4 and 14-16 Kirkby Terrace were formerly a series of terraced dwellings and is still arranged as such. Each individual property is provided with a wall mounted gas fired boiler to generate LTHW which feeds a central heating system comprising radiators. Hot water is generally provided via local unvented electric water heaters and instantaneous water boilers.

Local extract ventilation is provided to toilet areas and kitchens with ventilation generally via opening windows.

Nos. 5-13 are single and two storey industrial-type units containing workshop and warehouse space. These units are heated by a combination of gas fired boilers serving radiators and gas fired unit heaters.

Mechanical supply and extract ventilation is provided to the Post Room located in No.6.

The buildings are generally naturally ventilated via opening windows to atmosphere. Mechanical extract ventilation is provided to toilets and cleaners stores etc.

Domestic Hot water is generated by the DHN via a central hot water calorifier.

19.1.4. Electrical Services

The electricity supply to Kirkby Terrace – Print and Design Centre is served with a metered Low Voltage (LV) three phase electricity supply derived from the electricity supply network operated by the local district network operator.

The electricity supplies to properties along Kirkby Terrace are served via a series of metered LV single phase electricity supply derived from the electricity supply network operated by the local district network operator.

Power is distributed throughout from the main LV main switch gear and local distribution board on the ground floor via final circuits to sockets and lighting installation.

Lighting is generally provided via a variety of fluorescent lamped luminaires, with evidence of failed luminaires replaced for LED equivalents to the main print room with manually switched lighting controls serving communal, workshop and offices spaces.

19.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides data for the electrical system, however there is no dedicated sub-metering data for Kirkby Terrace in respect of the heat network therefore we have relied on data provided by the estates team for analysis

19.1.6. BMS/Controls

Each individual building is provided with either an Andover Continuum-based system, a Trend IQ3 BMS or no BMS. No. 1 is provided with a Schneider Electric Building Expert controller which is now obsolete

19.1.7. Condition & Operation

We understand that the building was constructed prior to 1950 however Nos. 14-16 were refurbished in 2017. The engineering services within Nos. 1-13 are understood to be over 10 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 5-10 years, subject to appropriate maintenance.

The engineering services generally appear to be in fair condition throughout Kirkby Terrace.

19.1.8. Planned Future CAPEX Works

We understand that a programme of capex works is planned for Nos. 5-13 to take place in 2024/25 which included renewal of the engineering services.

19.1.9. Opportunities for Heat Networks

The location and arrangement of the building/properties would allow for individual connections to a heat network. The building is located on the main campus site and is well positioned for connection to any proposed ambient loop.

If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Endsleigh Place to the 5DHC network when it becomes operational.

Typical future-proofing measures to consider could be:

- Ensure heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

19.2 Energy & Carbon Emissions

19.2.1. The following table identifies the energy consumption and carbon emissions from the Kirkby Terrace building based on the energy consumption figures provided from site. For clarity and ease of analysis, we have assessed all Kirkby Terrace buildings as a single entity.

Table 19.1 – Energy Consumption & Carbon Emissions – Kirkby Terrace

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	153,566 kWh	0.184 $kgCO_2e/kWh$	28.26 TCO_2e
Grid Electricity	122,162 kWh	0.105 $kgCO_2e/kWh$	12.83 TCO_2e
Total	275,728 kWh	N/A	41.09 TCO_2e

19.2.2. Table 4 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 1,744.5m². The performance of Kirkby Terrace is very good with overall energy usage and carbon emissions around half the current benchmark. The figures correspond closely with those stated on the current DEC.

Table 19.2 – Energy Consumption & Carbon Emissions Benchmarking – Kirkby Terrace

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	88.03	16.20	240	44.16	70.00
Grid Electricity	70.03	7.35	80	8.40	51.00
Total	158.06	23.55	320	52.56	121.00

19.2.3. The building would have been constructed before 1950 therefore the thermal performance and energy efficiency standards are likely to be poor when compared against typical University Campus building stock.

19.2.4. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2022 as the most recent full year. We have extrapolated the full energy consumption for the whole of Kirkby Terrace using the available complete sets of data.

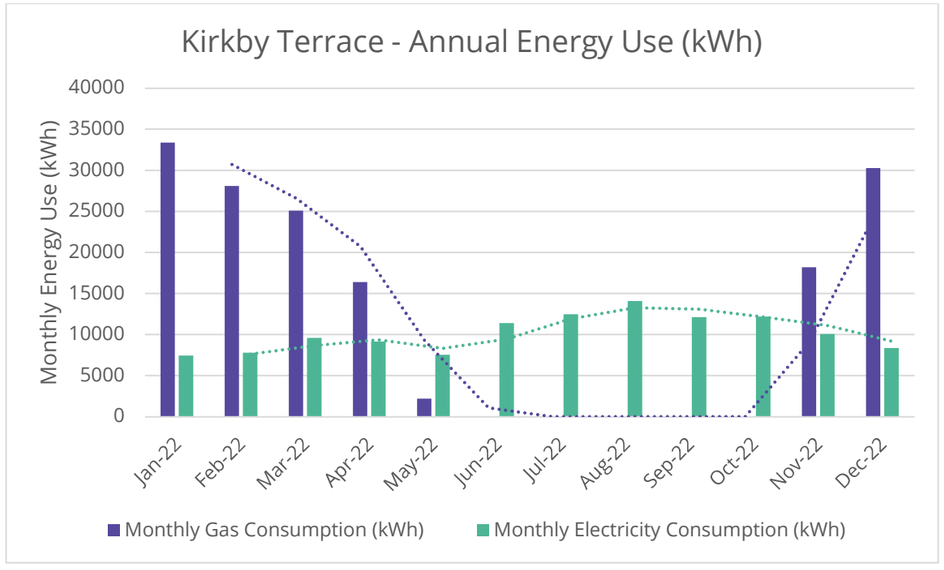


Fig. 19.2 Kirkby Terrace annual energy usage profile

19.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.930 which suggests a very strong correlation between degree days and heat consumption.

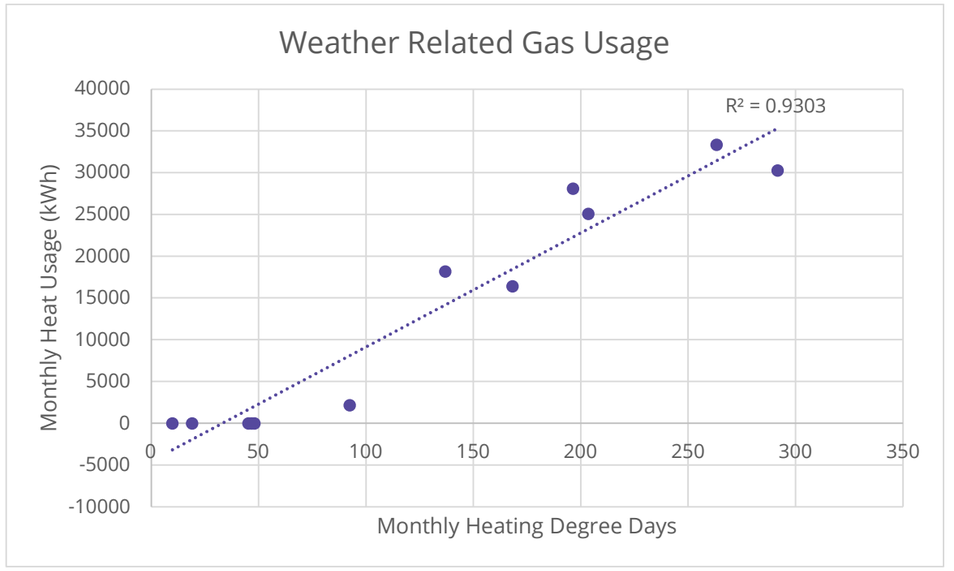


Fig. 19.3 Weather related heat usage compared to degree days

19.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

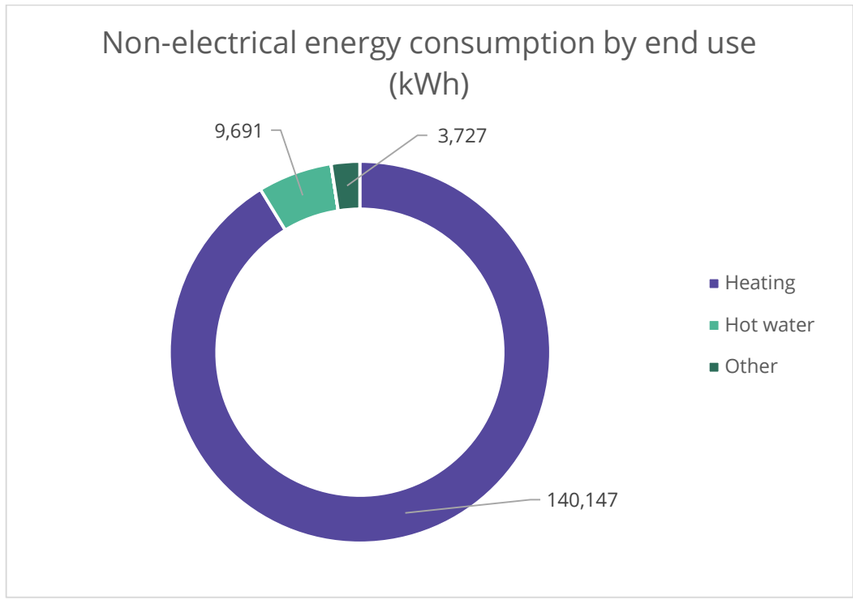


Fig. 19.4 Non-electrical energy consumption breakdown by end use

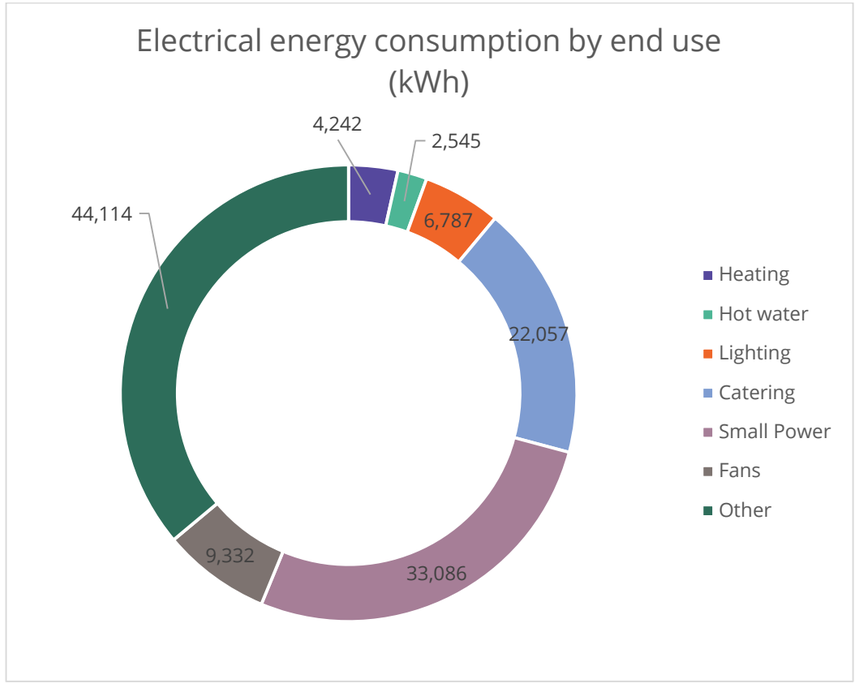


Fig. 19.5 Electrical energy consumption breakdown by end use

19.3 Technical Solution

19.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Kirkby Terrace is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management records there being no insulation to walls. The options would be to either retrospectively install external or internal to the entirety of the masonry elevations or a multiple of the two. The agreed insulation would be fitted internally by way of adhesive to existing walls or battens with insulation quilt/plasterboard, rigid insulation board or a mixture of the two. External insulation generally, comprises of rigid insulation board either mechanically fixed to the existing walls or within a steel cage system but often having an applied render coat to either option or being of a prefinished insulation board/panel. However, these options may be subject/limited by existing listed building and planning restrictions.

Option F2: The installation of new or additional roof insulation

It is assumed the majority of existing roofs are of a timber construction. Therefore, the anticipated works would comprise of upgrade of existing glass rock/mineral wool insulation with the similar product, rigid insulation boards or installation of a foam insulation.
the upgrade of insulation having profiled metal roofs sheets would comprise the provision of internal rigid insulation boards/foam insulation or the over-clad of the external roofs. A more intrusive option would be to strip and replace the entirety of the roofs with new insulated roof sheets. All would be subject to confirmation of the existing and the desired U Value to be achieved.

Option F3: Installation of replacement windows

The above-mentioned report records the existing windows as be in poor condition. The recommendation would be to replace all windows with new double-glazed windows. This would be subject to confirmation of the desired U Value to be achieved and there being no planning restrictions. This recommendation would include the replacement of existing doors with composite and glazed doors to meet requirements.

19.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Kirkby Terrace. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Kirkby Terrace we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

19.4 Energy & Carbon Savings – Kirkby Terrace

Table 19.3 – Carbon savings summary – Kirkby Terrace

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	15.94	£37,271	30	478	78	£2,959	12.6
F2	Addition/replacement of roof insulation	16.13	£51,388	30	484	106	£3,109	16.5
F3	Replacement of glazing to improve thermal performance	15.16	£206,633	20	303	681	£2,356	87.7
F4		12.13	£0		0	0	£0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	18.15	£261,675	25	454	577	-£12,629	-20.7
S2	Installation of new centralised domestic hot water generation, pipework and controls	12.46	£26,168	25	311	84	-£11,817	-2.2
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	0	£621	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	13.46	£52,335	20	269	194	£3,317	15.8
S5	Addition of high efficiency fans, pumps and drives	12.18	£17,445	25	305	57	£122	143.0
S6	Installation of heat recovery on air systems	0.00	£0	0	0	0	0	0.0

S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	15	0	0	0	0.0

19.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 131kW (based on a rule of thumb of 55W/m²). Assuming system efficiencies in line with Table 4.1 (4.00 heating) provides an indicative increase in electrical load of circa 28kW for heating.

19.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Kirkby Terrace which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Kirkby Terrace will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

20. Library

20.1 Description of Building

20.1.1. General

The Charles Seale-Hayne Library houses the University's main library facility and also includes the Student Services Hub, Careers, Wellbeing and other Student Services. The building is primarily used for the storage of books, journals and other media as well as providing access to IT facilities and other study environments.



Fig. 20.1 Library

20.1.2. Building Fabric

The Library is a four-storey building constructed circa 1970's comprising of a steel frame construction enclosed with a combination of powder coated aluminium framed units incorporating sealed double-glazed walling, concrete and metal cladding. Some single glazed walling is evident to the ground floor reception entrance lobby.

The roofs were not inspected however, from our review of 'Google Maps' the roofs are understood to comprise flat roofs and profiled metal roof sheets. The profiled metal roof sheets appear to cover the central roof plantroom.

Powder coated aluminium framed doors incorporating double glazed units are provided to the main entrance and exit to the building.

During our inspection of Library, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe the external wall insulation and rigid roof insulation boards to be in fair and good respectively with the roof insulation stated as being recently upgraded. However, the detailed specification has not been provided.

It is recommended to consider a thermographic survey to identify/substantiate in detail where improvements could be made to the thermal performance of the building envelope.

We would anticipate the potential upgrade to include enhancement to the wall insulation and the application of film to the existing glazing. Any potential upgrade would be subject to the liaison with consultants, building control and review of a thermographic survey.

20.1.3. Mechanical Services

Library is supplied with LTHW via dedicated gas fired boilers within the main plantroom. The LTHW system feed the central heating system comprising radiators, fan coil units and AHUs. The LTHW system generates domestic hot water via calorifiers.

The building is now provided with comfort cooling via 3No. roof mounted packaged air-cooled chillers generating chilled water which feeds the fan coil units. Local cooling is provided to key areas (comms rooms etc.) via DX cooling systems.

The building is generally mechanically ventilated via 5No. supply and extract AHUs.

20.1.4. Electrical Services

The electricity supply to Charles Seale-Hayne (Library) is served with the privately owned HV electricity supply which terminates at a 1000kVA rated substation located within the building.

Power is distributed throughout from the main LV switch panel on the ground floor via vertical risers located throughout the building. The LV distribution system feeds local metered distribution boards on each level.

Lighting is generally provided via a variety of fluorescent and LED luminaires with occupancy sensing controls serving the spaces.

20.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides data for the gas and electrical systems however there is no dedicated sub-metering data for Library in respect of water consumption. The BMS contains provision for sub-metering of the main plant items.

20.1.6. BMS/Controls

The BMS serving the Library is based on Andover Continuum controllers which are now obsolete although support is still available for this family of products via Schneider Electric.

20.1.7. Condition & Operation

We understand that the building suffers from overheating in some areas during periods of high occupancy as well as low temperatures in other areas. This is likely due to the response time of the system during rapid changes in occupancy.

We understand that the building was constructed in the 1970s meaning the engineering services are likely over 40 years old however we understand that the plant has been replaced during the last 20 years. According to CIBSE Guide M the systems should have a remaining serviceable life of 5-10 years, subject to appropriate maintenance.

The engineering services generally appear to be in fair condition however we understand that the controls/BMS are obsolete and would benefit from renewal/refurbishment. We also understand that the gas boilers are end of life and should be considered for replacement in the short term.

20.1.8. Planned Future CAPEX Works

We understand that a programme of capex works has been scheduled for 2024/25 to refresh the west end extension and provide a new entrance.

20.1.9. Opportunities for Heat Networks

The building is currently served with LTHW from dedicated boilers and Chilled water from roof mounted chiller plant.

If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Library to the 5DHC network when it becomes operational.

Typical future-proofing measures to consider could be:

- Ensure the heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
  Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

20.2 Energy & Carbon Emissions

20.2.1. The following table identifies the energy consumption and carbon emissions from the Library building based on the energy consumption figures provided from site.

Table 20.1 – Energy Consumption & Carbon Emissions – Library

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	1,177,633 kWh	0.184 $kgCO_2e/kWh$	216.69 TCO_2e
Grid Electricity	514,533 kWh	0.105 $kgCO_2e/kWh$	54.03 TCO_2e
Total	1,692,186 kWh	N/A	270.72 TCO_2e

20.2.2. Table 4 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 8471.9m². The performance of Library is good with overall energy usage and carbon emissions well below the current benchmark. The figures do not correspond closely with those stated on the current DEC however the overall EUI is below the total.

Table 20.2 – Energy Consumption & Carbon Emissions Benchmarking – Library

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	139.00	25.58	240	44.16	103.27
Grid Electricity	60.74	6.38	80	8.40	121.14
Total	199.74	31.95	320	52.56	224.41

20.2.3. The building would have been constructed to pre 1985 building regulations therefore the thermal performance and energy efficiency standards should be average when compared against typical University Campus building stock.

20.2.4. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2022 as the most recent full year. The metering data shows the energy consumption profile for Library throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. The data shows an increase in electrical consumption through the winter when there is an increased demand for lighting however this is tempered by an increased demand for cooling in the summer which is provided via the roof mounted chiller plant.

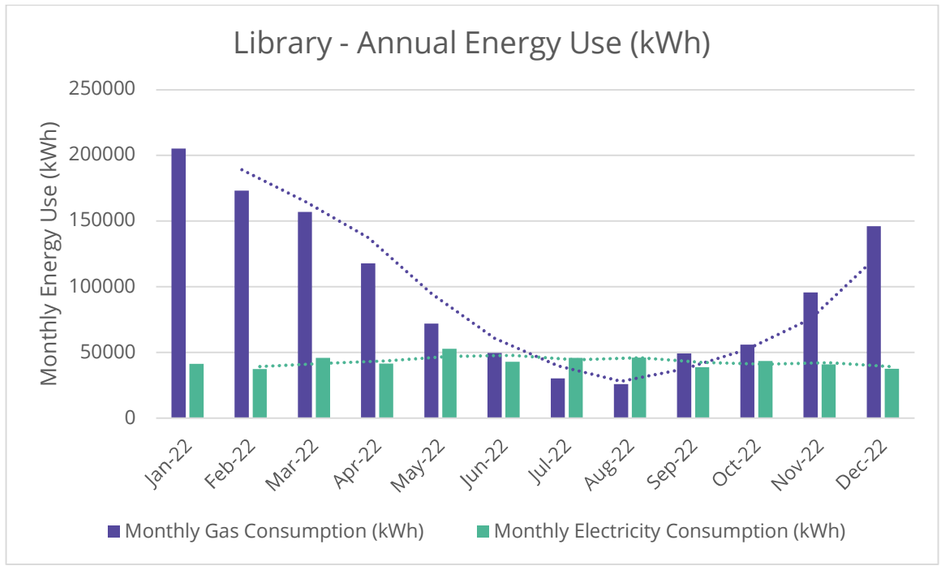


Fig. 20.2 Library annual energy usage profile

20.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.885 which suggests a relatively strong correlation between degree days and heat consumption, however this value suggests there is some inherent inefficiency in the system. This is likely due to the age of construction and the thermal characteristics of the building fabric.

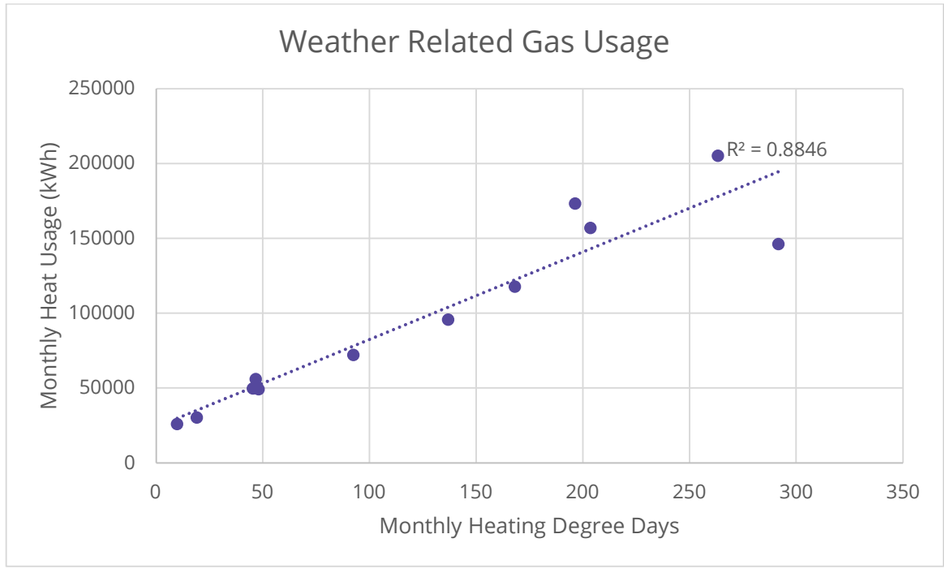


Fig. 20.3 Weather related heat usage compared to degree days

20.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

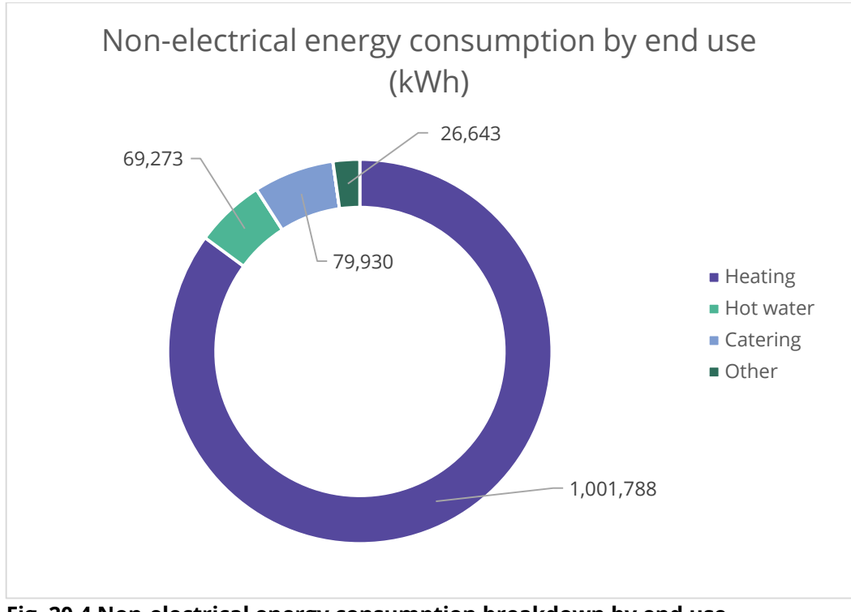


Fig. 20.4 Non-electrical energy consumption breakdown by end use

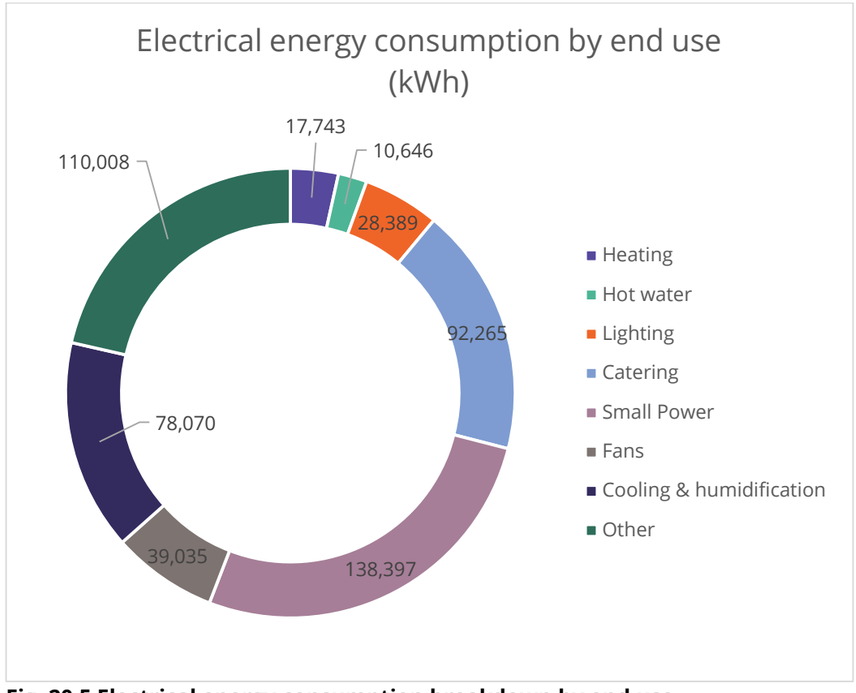


Fig. 20.5 Electrical energy consumption breakdown by end use

20.3 Technical Solution

20.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Library is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management states the existing wall insulation to be in fair condition. The options would be to enhance or replace the existing elevation cladding or retrospectively install internal wall insulation or a multiple of the two. The agreed insulation would be fitted internally by way of adhesive to existing walls or battens with insulation quilt/plasterboard, rigid insulation board or a mixture of the two. External insulation generally, comprises of rigid insulation board either mechanically fixed to the existing walls or within a steel cage system but often having an applied render coat to either option or being of a prefinished insulation board/panel. However, these options would be subject to review of as-built data.

Option F2: The installation of new or additional roof insulation

The above-mentioned report states the existing roof insulation as being in good condition, having been recently upgraded. Therefore, there is no immediate recommendation for upgrade of these areas however, a thermographic survey may provide detailed report for further consideration.

Option F3: Installation of reflective/ absorptive film on curtain glazing system to reduce heat gain

The above-mentioned report states the existing double windows as being in fair condition. Subject to further inspection and a thermographic survey, upgrade works may include the installation of reflective/absorptive window film. There is option to replace the entirety of the existing glazing however, these works would be intrusive.

20.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Library. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Library we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

20.4 Energy & Carbon Savings – Library

Table 20.3 – Carbon savings summary – Library

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	121.99	£64,621	30	3,660	£18	£22,495	2.9
F2	Addition/replacement of roof insulation	123.46	£167,599	30	3,704	£45	£23,636	7.1
F3	Replacement of glazing to improve thermal performance	116.08	£1,216,815	20	2,322	£524	£17,906	68.0
F4		0.00	£0		0	£0	£318	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	138.25	£1,270,785	25	3,456	£368	-£99,279	-12.8
S2	Installation of new centralised domestic hot water generation, pipework and controls	95.16	£211,798	25	2,379	£89	-£93,974	-2.3
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	101.01	£254,157	20	2,020	£126	£19,873	12.8
S5	Addition of high efficiency fans, pumps and drives	93.24	£84,719	25	2,331	£36	£510	166.0
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0

S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	15	0	£0	£0	0.0

20.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 847kW (based on a rule of thumb of 100W/m²) with the peak cooling demand of 610kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 178kW and 152kW for heating and cooling respectively.

20.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Library which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Library will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

21. Main Hall

21.1 Description of Building

21.1.1. General

The Main Hall is located to the east of the main campus. The building is linked to and served from the Davy building. The building houses the School of Technology and comprises teaching spaces, lecture theatres and office/administration space.



Fig. 21.1 Main Hall

21.1.2. Building Fabric

The Main Hall is a two-storey building with ground and sub-ground level constructed circa 1966 and comprising of a reinforced concrete frame construction enclosed with a combination of steel framed units incorporating single glazed opening lights and concrete cladding. Some sealed double-glazed walling is evident to ground floor reception areas.

The roofs were not inspected however, from our review of Google Maps the roofs are understood to comprise flat roofs although some profiled metal roof sheets are evident, these may cover roof plantroom.

Powder coated aluminium framed doors incorporating double glazed units are provided to the main entrance and exit to the building.

We did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe external wall insulation and rigid roof insulation boards are in fair condition. However, the detailed specification has not been provided.

It is recommended to consider a thermographic survey to identify in detail where improvements could be made to the thermal performance of the building envelope. Any potential enhancement works subject to clarification of the existing wall and roof insulation, review of a thermographic survey, liaison with consultants and building control.

Information reviewed from the management records the main windows as double glazed and in fair condition. However, from ground level inspection we believe these to be single glazed opening lights. Subject to a review of as-built data, liaison consultants and a thermographic survey the anticipation is there may be a requirement to replace the existing windows.

21.1.3. Mechanical Services

Main Hall is supplied with all primary engineering services (LTHW, CHW, DHW) via the Davy building. Heating is provided via radiators and fan convectors. Local cooling is provided to key areas (comms rooms etc.) via DX cooling systems.

The building is generally naturally ventilated via opening windows to atmosphere and to the atrium areas. Mechanical extract ventilation is provided to toilets and cleaners stores etc.

Domestic Hot water is generated by the DHN via a central hot water calorifier.

21.1.4. Electrical Services

Nick, not one recall visiting – was looking at the HV infrastructure at the time

Power is distributed throughout from the main LV switch panel on the ground floor via vertical risers located throughout the building. The LV distribution system feeds local metered distribution boards on each level.

Lighting is generally provided via LED with occupancy sensing controls.

21.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides data for the electrical system, however there is no dedicated sub-metering data for Main Hall in respect of the heat network therefore we have relied on data provided by the estates team for analysis.

21.1.6. BMS/Controls

We understand that the Main Hall has recently been upgraded to a Schneider Electric EcoStruxture Building Operation (EBO) BMS.

21.1.7. Condition & Operation

We understand that the boiler plant in the Davy building which serves the heating and hot water requirement is in good condition, having recently been replaced.

We understand that the building was constructed in the 1960s however it has been subjected to a recent refurbishment. We understand that the engineering services are generally circa 15 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 5-10 years, subject to appropriate maintenance.

The engineering services generally appear to be in good condition however we understand that the controls/BMS is in poor condition and requires renewal/refurbishment which is scheduled to be undertaken as soon as possible.

21.1.8. Planned Future CAPEX Works

We understand that a programme of capex works had recently been completed to renew ventilation plant and install the chillers. It is expected that the LTHW system will be disconnected from the campus DHN with dedicated heating plant installed, likely to be heat pump based. We understand that this has been scheduled for 2022/23 and this report will form the basis of the options appraisal to determine the best solution for the new heating system.

21.1.9. Opportunities for Heat Networks

The building is currently served with LTHW from the Davy building therefore any changes to the campus DHN will be reflected in changes to the Main Hall.

The Davy energy centre is likely to undergo a refit to include 5DHC heat pump technology.

21.2 Energy & Carbon Emissions

21.2.1. The following table identifies the energy consumption and carbon emissions from the Main Hall building based on the energy consumption figures provided from site.

Table 21.1 – Energy Consumption & Carbon Emissions – Main Hall

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	648,610 kWh	0.184 $kgCO_2e/kWh$	119.34 TCO_2e
Grid Electricity	1,954,527 kWh	0.105 $kgCO_2e/kWh$	205.23 TCO_2e
Total	2,603,137 kWh	N/A	324.57 TCO_2e

21.2.2. Table 5.31 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 13260.4m². The performance of Main Hall is very good with overall energy usage and carbon emissions around half the current benchmark. The figures vary significantly against those stated on the current DEC.

Table 21.2 – Energy Consumption & Carbon Emissions Benchmarking – Main Hall

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	76.56	14.09	240	44.16	182.93
Grid Electricity	230.71	24.22	80	8.40	50.70
Total	307.27	38.31	320	52.56	233.63

21.2.3. The building would have been constructed to 2000/2006 building regulations therefore the thermal performance and energy efficiency standards should be reasonable when compared against typical University Campus building stock.

21.2.4. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2021 as the most recent full year. The metering data shows the energy consumption profile for Main Hall throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. The data shows an increase in electrical consumption through the winter when there is an increased demand for lighting however this is tempered by an increased demand for cooling in the summer which is provided via the roof mounted chiller plant.

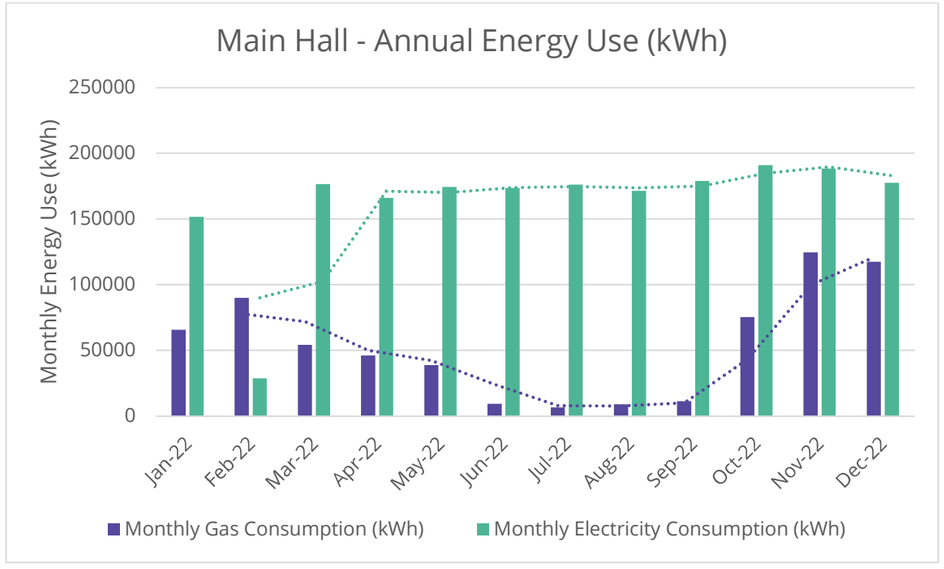


Fig. 21.2 Main Hall annual energy usage profile

21.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.877 which suggests a relatively strong correlation between degree days and heat consumption, however this value suggests there is some inherent inefficiency in the system. This can be explained by the fact that the heat network is metered within the Mary Newman building and that there are likely to be significant pipework heat losses between the heat source and the emitters.

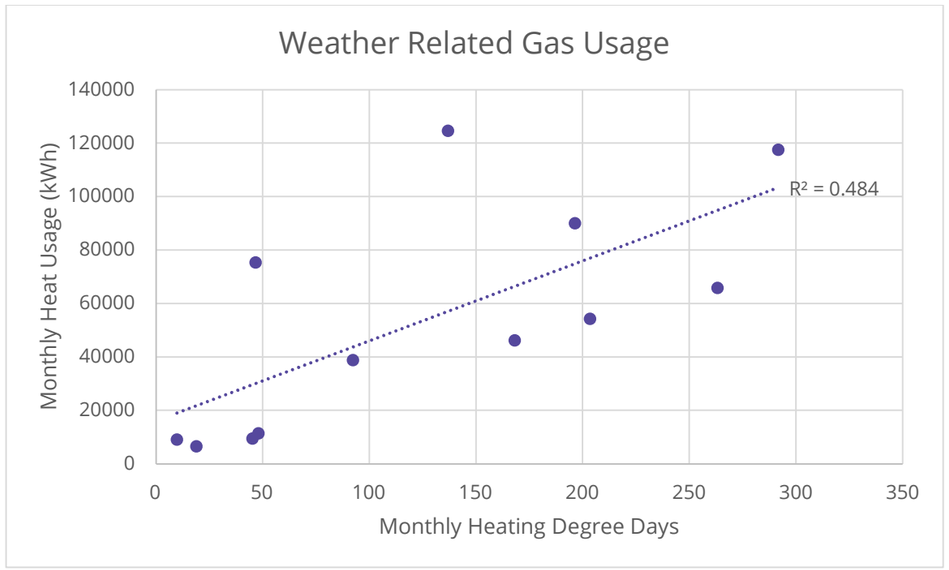


Fig. 21.3 Weather related heat usage compared to degree days

21.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

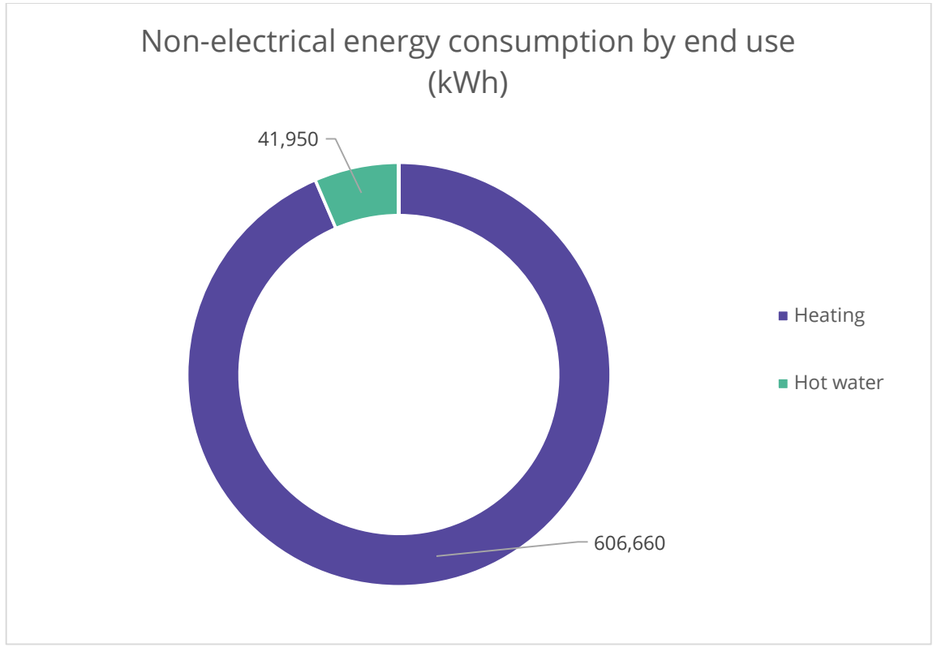


Fig. 21.4 Non-electrical energy consumption breakdown by end use

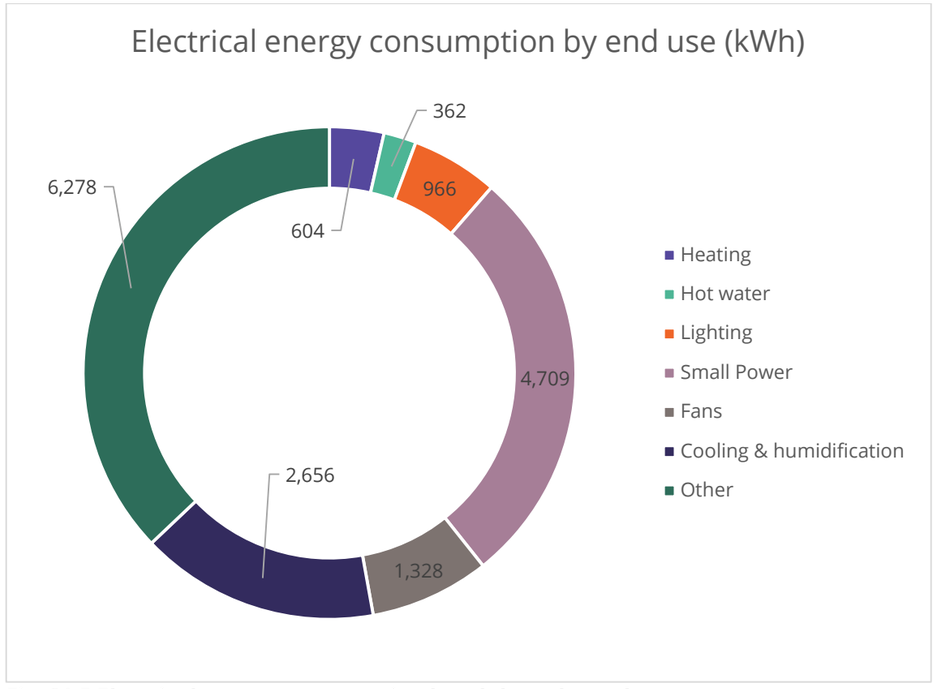


Fig. 21.5 Electrical energy consumption breakdown by end use

21.3 Technical Solution

21.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Main Hall is as follows:

Option F1: The addition of internal or external wall insulation

The recommended options would be to enhance the existing elevation cladding or retrospectively install internal wall insulation or a multiple of the two. The agreed insulation would be fitted internally by way of adhesive to existing walls or installation of battens with insulation quilt/plasterboard, rigid insulation board or a mixture of the two. External insulation generally, comprises of rigid insulation board either mechanically fixed to the existing walls or within a steel cage system but often having an applied render coat to either option or being of a prefinished insulation board/panel. There, may be option to remove the existing concrete elevation but this would be on review of as-built data/clear understanding of the buildings' construction. However, these options would be subject to review of as-built data.

Option F2: The installation of new or additional roof insulation

The majority of the roofs appear to be flat covered with a proprietary membrane. The options would be to provide internal foam insulation or rigid insulation boards. There, is an option to undertake wholesale refurbishment to the external roofs to include new rigid board insulation. These options should be subject to a thermographic survey. Where, profiled metal roofs are observed it may be possible to internally upgrade the insulation or to over-clad of the existing.

Option F3: Installation of replacement windows

The recommendation would be to replace all windows with new double-glazed windows. This would be subject to confirmation of the desired U Value to be achieved. These works would include the replacement of existing doors with composite and glazed doors to meet requirements.

21.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Main Hall. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Main Hall we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

Option S7: Expansion of roof mounted solar PV installation.

With an available roof area of approximately 510m² we anticipate that an additional 300m² of solar PV cells could be installed, subject to detailed design and structural feasibility assessment. This would also need to be considered within the design of the additional roof insulation and potential location of plant on the roof.

21.4 Energy & Carbon Savings – Main Hall

Table 21.3 – Carbon savings summary – Main Hall

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	67.33	£24,767	30	2,020	£12	£12,500	2.0
F2	Addition/replacement of roof insulation	68.15	£24,723	30	2,044	£12	£13,134	1.9
F3	Replacement of glazing to improve thermal performance	64.05	£176,143	20	1,281	£138	£9,950	17.7
F4		0.00	£0		0	£0	£11	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	76.66	£210,900	25	1,917	£110	-£53,384	-4.0
S2	Installation of new centralised domestic hot water generation, pipework and controls	52.37	£49,210	25	1,309	£38	-£50,576	-1.0
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£88	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	54.73	£17,575	20	1,095	£16	£8,701	2.0
S5	Addition of high efficiency fans, pumps and drives	51.25	£14,060	25	1,281	£11	£17	809.7
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	52.07	£390,400	15	781	£500	£2,059	189.6

21.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 141kW (based on a rule of thumb of 100W/m²) with the peak cooling demand of 101kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 30kW and 25kW for heating and cooling respectively.

21.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Main Hall which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Main Hall will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

22. Marine Station

22.1 Description of Building

22.1.1. General

The Marine Station is a sustainable teaching and research facility on the shores of Plymouth Sound, this is the University's base for marine expeditions. It includes a wet lab, seawater aquarium and academic diving centre as well as containing teaching and office space.

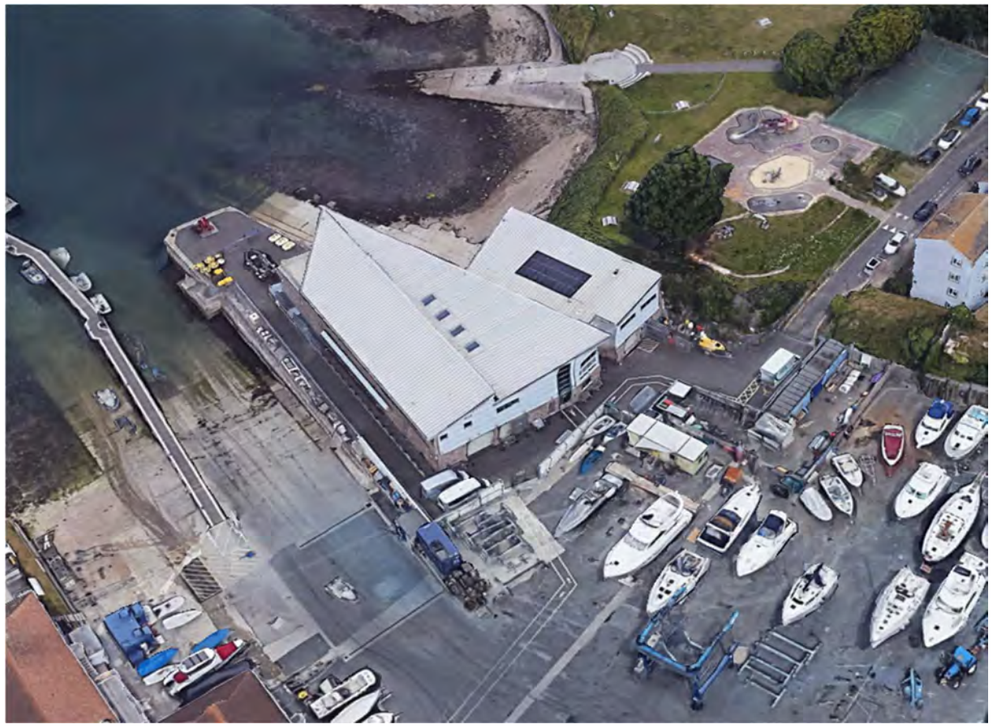


Fig. 22.1 Marine Station

22.1.2. Building Fabric

The Marine Station is a two-storey building constructed circa 2012 comprising of a concrete framed construction enclosed with a combination of powder coated aluminium framed units incorporating sealed double-glazed opening lights, faced stonework and metal cladding.

The roofs were not inspected however, from our review of 'Google Maps' the roofs are understood to comprise profiled metal roofs sheets incorporating rooflights.

Powder coated aluminium framed doors incorporating double glazed units are provided to the main entrance and exit to the building. Steel roller shutter doors provide vehicular access.

During our inspection of Marine Station, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe the external wall insulation and rigid roof insulation boards are in good condition, having been recently upgraded. However, the detailed specification has not been provided.

From the above-mentioned report the glazed windows are stated as being in good condition, also having been recently upgraded. Based on the information provided and our walk-through inspection there may be limited scope to improve on the building fabric. However, it is recommended to consider a thermographic survey to identify in detail the areas where meaningful improvements could be made to the thermal performance of the building envelope.

Notwithstanding the above and subject to a review of as-built data, liaison with consultants and review of a thermographic survey, the installation of window film may provide improvement to the building fabric.

22.1.3. Mechanical Services

Marine Station is supplied with LTHW via gas fired boilers in the main plantroom. The LTHW system provides central heating via wall mounted radiators and domestic hot water via calorifiers. A gas fired Combined Heat & Power (CHP) unit generates on site electricity and LTHW for generating hot water. A solar thermal hot water system is provided to reduce the DHW energy demand.

Local cooling is provided to key areas (comms rooms etc.) via DX cooling systems.

The building is generally naturally ventilated via opening windows to atmosphere. Mechanical extract ventilation is provided to equipment areas, toilets, showers and cleaners stores etc.

A sea water supply is provided to the labs for storage of marine animals.

22.1.4. Electrical Services

The electricity supply to the Marine Station is served with a metered Low Voltage (LV) three phase electricity supply derived from the electricity supply network operated by the local district network operator.

Power is distributed throughout from the main LV main switch gear and local distribution board on the ground floor via final circuits to sockets and lighting installation.

Lighting is generally provided via a variety of fluorescent lamped luminaires with manually switched and automatic lighting controls serving communal and offices spaces.

22.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides data for the gas, electrical system, and water consumption.

22.1.6. BMS/Controls

The BMS serving the Marine Station is based on Trend IQ3 controllers which are not integrated into the head end. The IQ3 system is considered obsolete although manufacturer support is still available.

22.1.7. Condition & Operation

We understand that the building was constructed circa 2014 meaning the engineering services are approaching 10 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 10-15 years, subject to appropriate maintenance.

The engineering services generally appear to be in good condition however we understand that the controls/BMS is in poor condition and requires renewal/refurbishment which is scheduled to be undertaken as soon as possible.

22.1.8. Planned Future CAPEX Works

We understand that there are no CAPEX works planned for Marine Station.

22.1.9. Opportunities for Heat Networks

The building is remote from the main University campus and is not situated within an opportunity area for heat networks as identified by Plymouth City Council.

The opportunity for connection to a heat network is limited unless a network is developed to serve the surrounding buildings.

22.2 Energy & Carbon Emissions

22.2.1. The following table identifies the energy consumption and carbon emissions from the Marine Station building based on the energy consumption figures provided from site.

Table 22.1 – Energy Consumption & Carbon Emissions – Marine Station

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	184,756 kWh	0.184 $kgCO_2e/kWh$	34.00 TCO_2e
Grid Electricity	29,903 kWh	0.105 $kgCO_2e/kWh$	3.14 TCO_2e
Total	214,659 kWh	N/A	37.14 TCO_2e

22.2.2. Table 5.33 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 1,687.8 m². The performance of Marine Station is very good with overall energy usage and carbon emissions around half the current benchmark. The figures compare reasonably well with those stated on the current DEC.

Table 22.2 – Energy Consumption & Carbon Emissions Benchmarking – Marine Station

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	109.47	20.14	240	44.16	93.03
Grid Electricity	17.72	1.86	80	8.40	24.10
Total	127.18	22.00	320	52.56	117.13

22.2.3. The building would have been constructed to 2010/2013 building regulations therefore the thermal performance and energy efficiency standards should be good when compared against typical University building stock.

22.2.4. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2021 as the most recent full year. The metering data shows the energy consumption profile for Marine Station throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. The data shows a consistent electrical consumption through the suggesting that there is a minimal requirement for cooling and that lighting is provided with reasonable illuminance control.

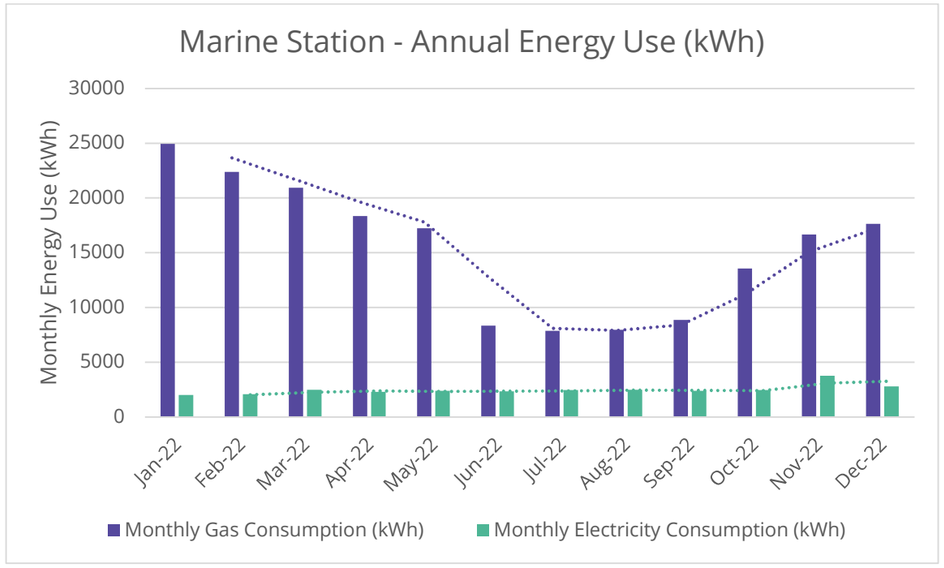


Fig. 22.2 Marine Station annual energy usage profile

22.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.751 which suggests a reasonable correlation between degree days and heat consumption, however this value suggests there is some inherent inefficiency in the system.

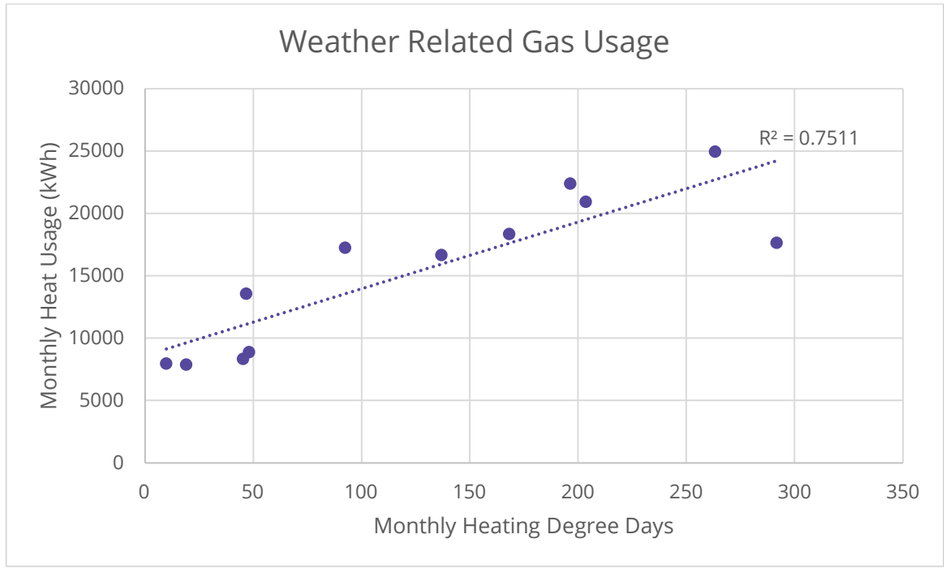


Fig. 22.3 Weather related heat usage compared to degree days

22.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

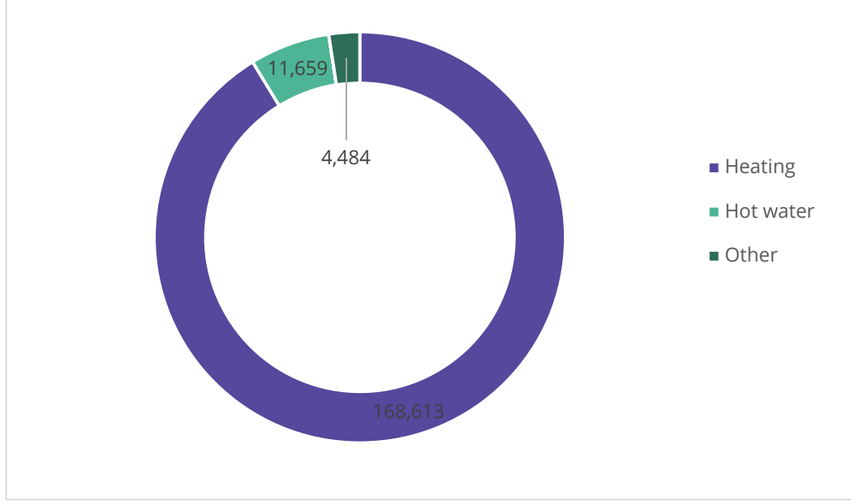


Fig. 22.4 Non-electrical energy consumption breakdown by end use

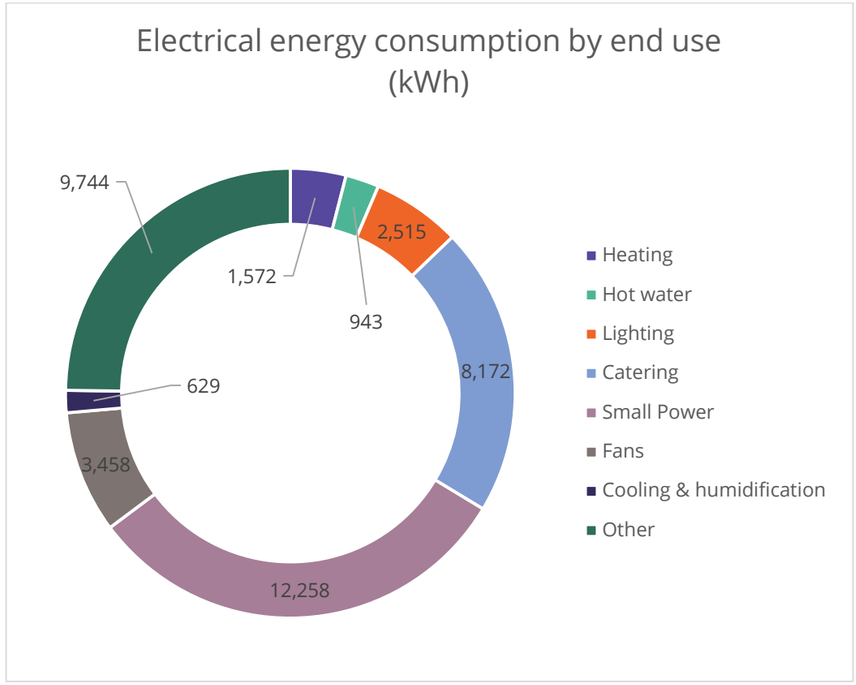


Fig. 22.5 Electrical energy consumption breakdown by end use

22.3 Technical Solution

22.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Marine Station is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management states the existing wall insulation as being in good condition, having been recently upgraded. However, we do recommend a thermographic survey to identify in detail the areas where meaningful improvements could be made to the thermal performance of the building envelope.

Option F2: The installation of new or additional roof insulation

The above-mentioned report states the existing roof insulation as being in good condition, having been recently upgraded. 'Refer to above comment for recommended thermographic survey'.

Option F3: Installation of reflective/ absorptive film on curtain glazing system to reduce heat gain

The above-mentioned report states the existing double windows as being in good condition, having been recently upgraded. 'Refer to above comment for a recommend a thermographic survey'.

22.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Marine Station. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Marine Station we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

Option S7: Expansion of roof mounted solar PV installation.

With an available roof area of approximately 890m² we anticipate that an additional 530m² of solar PV cells could be installed, subject to detailed design and structural feasibility assessment. This would also need to be considered within the design of the additional roof insulation and potential location of plant on the roof.

22.4 Energy & Carbon Savings – Marine Station

Table 22.3 – Carbon savings summary – Marine Station

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
-	Addition of external window film to reduce solar heat gain	14.60	£15,378	15	219	£70	£3	5997.8
F1	Addition of wall insulation	15.98	£29,730	30	479	£62	£1,075	27.7
F2	Addition/replacement of roof insulation	16.10	£29,678	30	483	£61	£1,170	25.4
F3	Replacement of glazing to improve thermal performance	16.06	£211,447	20	321	£658	£1,140	185.5
F4			£0		0	£0	£0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	31.93	£253,170	25	798	£317	£9,917	25.5
S2	Installation of new centralised domestic hot water generation, pipework and controls	14.93	£42,195	25	373	£113	£10,754	3.9
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	15.73	£21,098	20	315	£67	£2,822	7.5
S5	Addition of high efficiency fans,	14.61	£16,878	25	365	£46	£45	373.4

	pumps and drives							
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	16.06	£169,600	15	241	£704	£3,638	46.6

22.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 127kW (based on a rule of thumb of 75W/m²) with the peak cooling demand of 122kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 32kW and 32kW for heating and cooling respectively.

22.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Marine Station which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Marine Station will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

23. Mary Newman

23.1 Description of Building

23.1.1. General

Mary Newman Hall contains student accommodation. The plantroom within the basement contains the main heating plant for part of the University's district heat network. The student accommodation was not part of this study.



Fig. 23.1 Mary Newman

23.1.2. Building Fabric

We have not considered the building fabric in respect of the Mary Newman building.

23.1.3. Mechanical Services

The Mary Newman plantroom serves as an energy centre for the existing campus 3rd Generation heat network. We have not considered the engineering services within the main Mary Newman building.

23.1.4. Electrical Services

Suki to complete

Power is distributed throughout from the main LV switch panel on the ground floor via vertical risers located throughout the building. The LV distribution system feeds local metered distribution boards on each level.

Lighting is generally provided via LED with occupancy sensing controls.

23.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides data for the gas, electrical system and water consumption.

23.1.6. BMS/Controls

The Mary Newman plantroom is provided with a Satchwell Sigma BMS system which is now considered obsolete.

23.1.7. Condition & Operation

We understand that the boiler plant in the Mary Newman building which serves the heating and hot water requirement is ageing and is generally unreliable which results in frequent periods of downtime due to failure and a regular requirement for temporary boilers to be deployed. We understand that the boilers have subsequently suffered a catastrophic failure following our inspection.

23.1.8. Planned Future CAPEX Works

We understand that a programme of capex works had recently been completed to renew ventilation plant and install the chillers. It is expected that the LTHW system will be disconnected from the campus DHN with dedicated heating plant installed, likely to be heat pump based. We understand that this has been scheduled for 2022/23 and this report will form the basis of the options appraisal to determine the best solution for the new heating system.

23.1.9. Opportunities for Heat Networks

The University is investigating the feasibility of providing a 5th Generation Heating & Cooling (5DHC) network which could potentially serve the Mary Newman building. If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Mary Newman to the 5DHC network when it becomes operational.

Typical future-proofing measures to consider could be:

- Ensure the heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
- Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

23.1.10. We have not reviewed the Mary Newman building as only the plantroom was with the scope of the report. The gas consumption associated with Mary Newman is distributed across the buildings within scope which are served by the campus DHN fed from the Mary Newman plantroom.

23.2 Technical Solution

23.2.1. Building Fabric Solution

Option F1: The addition of internal or external wall insulation

This building is excluded from our inspection of the fabric envelope.

Option F2: The installation of new or additional roof insulation

Refer to comments within 'Option F1'

Option F3: Installation of reflective/ absorptive film on curtain glazing system to reduce heat gain

Refer to comments within 'Option F1'

24. Nancy Astor

24.1 Description of Building

24.1.1. General

The Nancy Astor Building is located to the north of the main campus and houses the University's admissions and student funding teams. The building also contains the University Sports Centre. The building generally comprises office space, with a sports hall, changing facilities and a café.

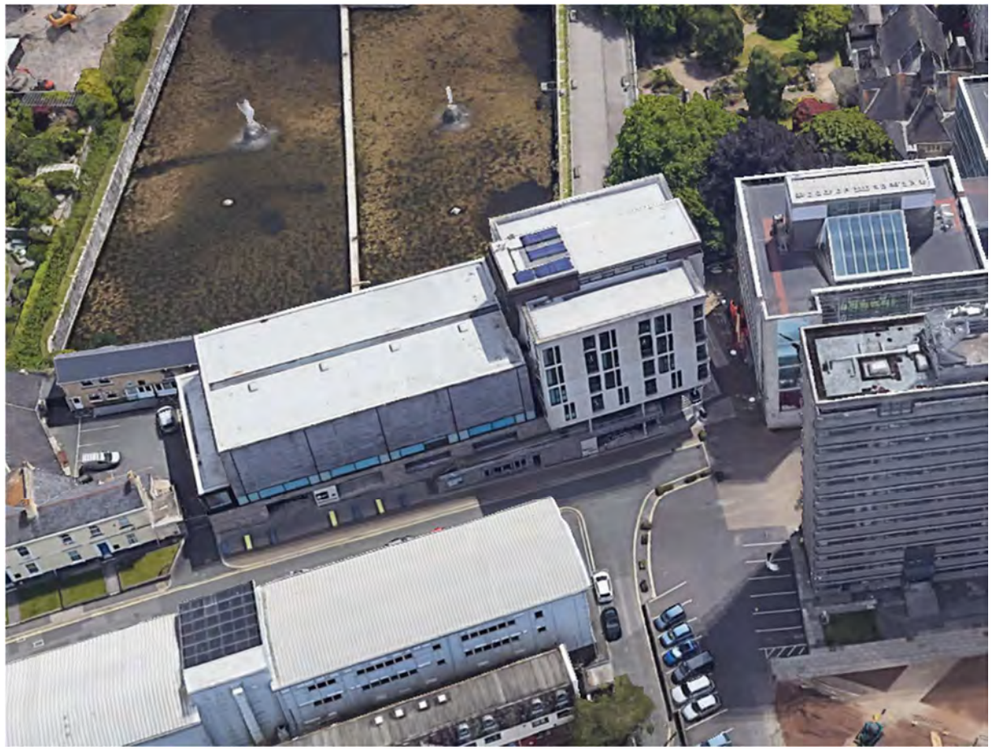


Fig. 24.1 Nancy Astor Building

24.1.2. Building Fabric

The Nancy Astor Building is a six-storey building constructed between 2001 and 2010 comprising of a reinforced concrete fame construction enclosed with a combination of powder coated aluminium framed units incorporating glazed walling and sealed double-glazed opening lights, concrete, and stone cladding.

The roofs were not inspected however, from our review of 'Google Maps' the roofs are understood to comprise flat roofs with proprietary membrane coverings.

Powder coated aluminium framed doors shop frontage incorporating double glazed units are provided to the first-floor café, main entrance and exit to the building.

During our inspection of Nancy Astor Building, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe external wall insulation and rigid roof insulation boards and double-glazed windows are in fair condition. However, the detailed specification has not been provided.

It is recommended to consider a thermographic survey to identify substantiate in detail where improvements could be made to the thermal performance of the building envelope.

We anticipate areas for potential fabric enhancement may include the upgrade to wall/roof insulation and double-glazed windows. However, this would be subject to clarification of the existing fabric specification, thermographic survey findings, liaison with consultants and building control.

24.1.3. Mechanical Services

Marine Station is supplied with LTHW via 2No. MHS UltraMax gas fired boilers in the main plantroom. The LTHW system provides central heating via wall mounted radiators and domestic hot water is generated via 2No. Andrews gas fired water heaters.

Local cooling is provided to key areas (comms rooms etc.) via DX cooling systems.

The building is generally mechanically ventilated via a series of supply and extract AHUs located in the 5th floor plantroom. Mechanical extract ventilation is provided to toilets, showers and cleaners stores etc.

24.1.4. Electrical Services

Nancy Astor is served with the privately owned HV electricity supply which terminates at a 1000kVA rated substation located within the building. The electrical installation includes connection provisions for standby power generation for supplies to services.

Power is distributed throughout from the main LV switch panel on the ground floor via vertical risers located throughout the building. The LV distribution system feeds local metered distribution boards on each level.

Lighting is generally provided via a variety of LED luminaires with occupancy sensing controls serving communal, offices and teaching spaces. Fluorescent lamped lighting to Badminton Courts and Entrance Lobby.

24.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides sub-metering data for the electrical system. The sub-meters are listed below.

- Main Incomer
- Café Servery
- Energy Centre DB EC
- Fitness Suite
- LV Switch Room ECG
- North Core Riser 1
- North Core Riser 2
- Off Vent MCCP3
- AHU5
- South Core Riser
- Sports Hall Lvl 1
- Sports Hall MCCP2

24.1.6. BMS/Controls

The BMS serving the Nancy Astor building is based on Trend IQ3 controllers which are not integrated into the head end. The IQ3 system is considered obsolete although manufacturer support is still available.

24.1.7. Condition & Operation

We understand that there are recurring issues on some levels in respect of heating system performance and water pressure.

We understand that the building was constructed in the late 2000s meaning the engineering services are circa 15 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 5-10 years, subject to appropriate maintenance.

The engineering services generally appear to be in good condition however we understand that the controls/BMS is in poor condition and requires renewal/refurbishment which is scheduled to be undertaken as soon as possible.

24.1.8. Planned Future CAPEX Works

We understand that a programme of capex works including refurbishment of the roof and additional solar PV is planned for 2024/25.

We also understand that plans are being developed to replace the gas boilers with water-to-water heat pumps fed from the adjacent reservoir.

24.1.9. Opportunities for Heat Networks

The building is currently served with LTHW from dedicated boilers. If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Library to the 5DHC network when it becomes operational.

Typical future-proofing measures to consider could be:

- Ensure the heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
- Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

24.2 Energy & Carbon Emissions

24.2.1. The following table identifies the energy consumption and carbon emissions from the Nancy Astor building based on the energy consumption figures provided from site.

Table 23.1 – Energy Consumption & Carbon Emissions – Nancy Astor

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	313,066 kWh	0.184 $kgCO_2e/kWh$	57.60 TCO_2e
Grid Electricity	289,527 kWh	0.105 $kgCO_2e/kWh$	30.40 TCO_2e
Total	602,593 kWh	N/A	88.00 TCO_2e

24.2.2. Table 5.35 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 13260.4m². The performance of Nancy Astor is very good with overall energy usage and carbon emissions around half the current benchmark. The figures compare favourably with those stated on the current DEC.

Table 23.2 – Energy Consumption & Carbon Emissions Benchmarking – Nancy Astor

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	75.92	13.97	240	44.16	91.49
Grid	70.21	7.37	80	8.40	70.73

Electricity					
Total	146.13	21.34	320	52.56	162.22

24.2.3. The building would have been constructed to 2000/2006 building regulations therefore the thermal performance and energy efficiency standards should be reasonable when compared against typical University Campus building stock.

24.2.4. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2021 as the most recent full year. The metering data shows the energy consumption profile for Nancy Astor throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. The data shows an increase in electrical consumption through the winter when there is an increased demand for lighting however this is tempered by an increased demand for cooling in the summer which is provided via the cooling plant.

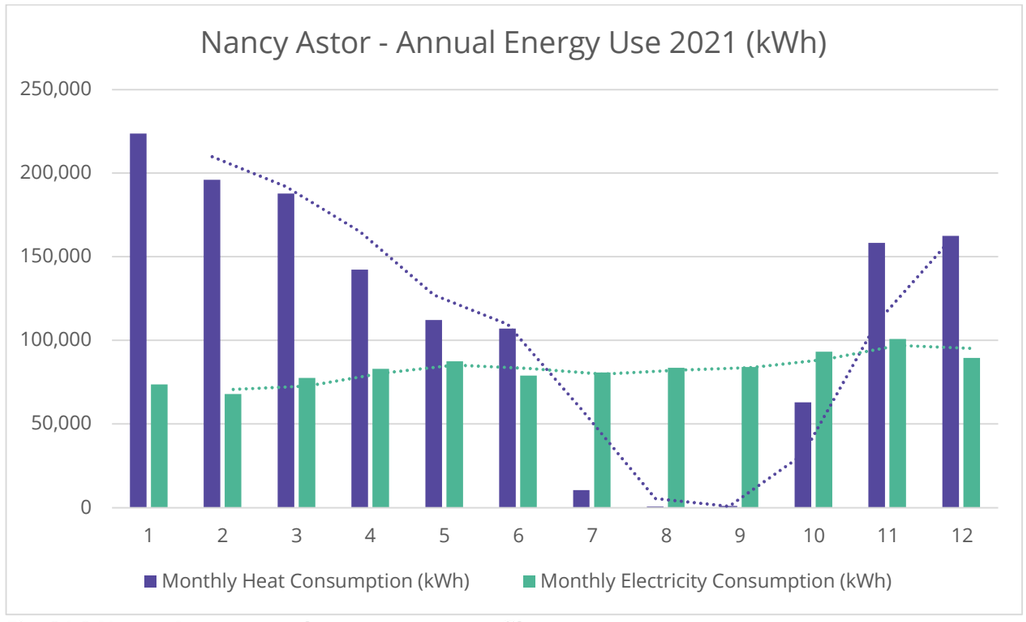


Fig. 24.2 Nancy Astor annual energy usage profile

24.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.842 which suggests a relatively strong correlation between degree days and heat consumption, however this value suggests there is some inherent inefficiency in the system.

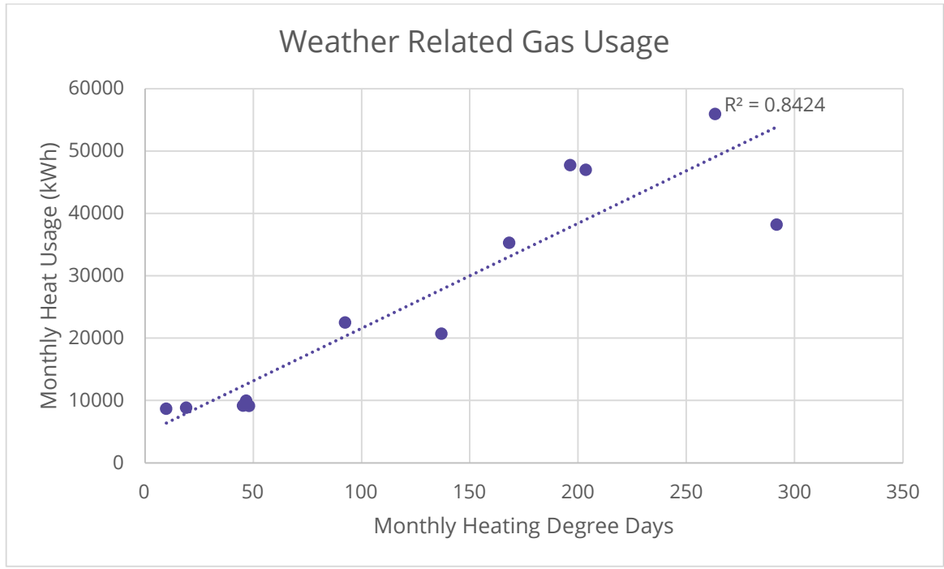


Fig. 24.3 Weather related heat usage compared to degree days

24.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

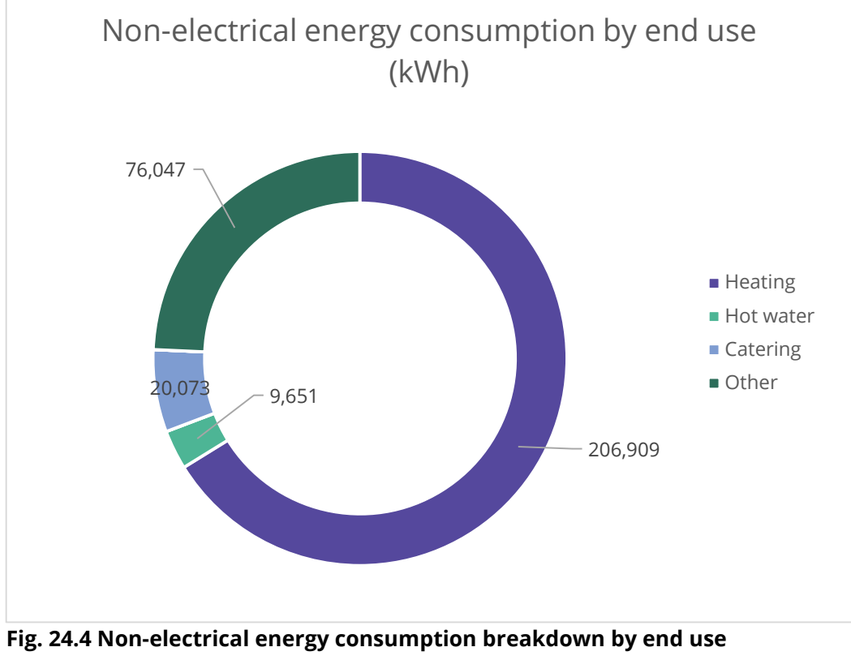


Fig. 24.4 Non-electrical energy consumption breakdown by end use

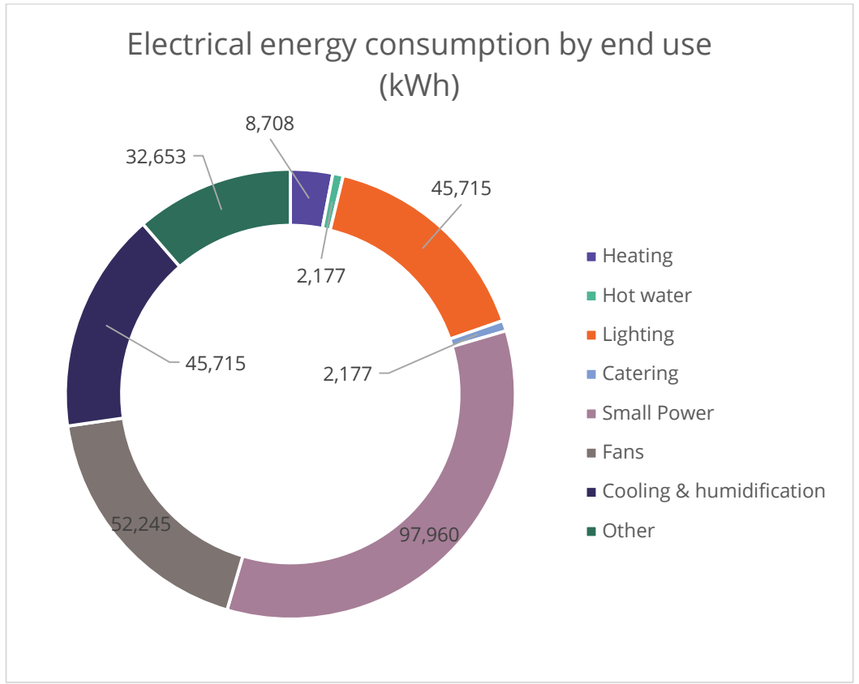


Fig. 24.5 Electrical energy consumption breakdown by end use

24.3 Technical Solution

24.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Nancy Astor Building is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management states the existing external wall insulation to be in fair condition. The options are to consider the upgrade/replacement to the existing elevation cladding or retrospectively install internal wall insulation or a multiple of the two. The agreed insulation would be fitted internally by way of adhesive to existing walls or battens with insulation quilt/plasterboard, rigid insulation board or a mixture of the two. External insulation generally, comprises of rigid insulation board either mechanically fixed to the existing walls or within a steel cage system but often having an applied render coat to either option or being of a prefinished insulation board/panel. However, these options would be subject to review of as-built data.

Option F2: The installation of new or additional roof insulation

The above-mentioned report states the existing roof insulation as being in fair condition. Consider the provision of spray foam or rigid board insulation to the internal of the flat roofs. These works would be subject to review of as-built data and thermographic survey findings. consideration.

Option F3: Installation of reflective/ absorptive film on curtain glazing system to reduce heat gain

The above-mentioned report states the existing double windows as being in fair condition. Subject to further inspection and a thermographic survey, upgrade works may include the installation of reflective/absorptive window film. The more intrusive option would be to replace the entirety of the existing glazing.

To assess the impact of installing a reflective/absorptive film we have assumed a 5% improvement in the cooling demand for the building due to reduced solar gain.

24.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Nancy Astor Building. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Nancy Astor Building we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

Option S7: Expansion of roof mounted solar PV installation.

With an available roof area of approximately 570m² we anticipate that an additional 340m² of solar PV cells could be installed, subject to detailed design and structural feasibility assessment. This would also need to be considered within the design of the additional roof insulation and potential location of plant on the roof.

24.4 Energy & Carbon Savings – Nancy Astor Building

Table 23.3 – Carbon savings summary – Nancy Astor Building

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	26.85	£31,454	30	805	£39	£1,644	19.1
F2	Addition/replacement of roof insulation	27.04	£81,577	30	811	£101	£1,791	45.6
F3	Replacement of glazing to improve thermal performance	26.98	£356,216	20	540	£660	£1,744	204.2
F4		0	£0		0	£0	£0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	53.38	£618,540	25	1,334	£464	£15,017	41.2
S2	Installation of new centralised domestic hot water generation, pipework and controls	25.05	£103,090	25	626	£165	£15,802	6.5
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	27.77	£123,708	20	555	£223	£7,554	16.4
S5	Addition of high efficiency fans, pumps and drives	25.01	£41,236	25	625	£66	£683	60.4
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0

S7	Install building mounted solar Photo-Voltaic (PV) array	25.67	£108,800	15	385	£283	£2,334	46.6

24.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 309kW (based on a rule of thumb of 75W/m²) with the peak cooling demand of 297kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 65kW and 74kW for heating and cooling respectively.

24.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Nancy Astor Building which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Nancy Astor Building will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

25. Nursery

25.1 Description of Building

25.1.1. General

The Nursery is located to the north of the main campus site and is housed within No. 3 Endsleigh Place. Nursery UCSP provides childcare to staff and students of the University of Plymouth. The building also contains a fitness suite/studio.



Fig. 25.1 Fitness Complex

25.2 Energy & Carbon Emissions

25.2.1. The following table identifies the energy consumption and carbon emissions from the Nursery building based on the energy consumption figures provided from site.

Table 24.1 – Energy Consumption & Carbon Emissions – Nursery

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	76,613 kWh	0.184 $kgCO_2e/kWh$	13.55 TCO_2e
Grid Electricity	42,201 kWh	0.105 $kgCO_2e/kWh$	4.43 TCO_2e
Total	115,814 kWh	N/A	17.98 TCO_2e

25.2.2. Table 5.37 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 1,781.5 m². The performance of Nursery is very good with overall energy usage and carbon emissions around half the current benchmark. The figures correspond closely with those stated on the current DEC.

Table 24.2 – Energy Consumption & Carbon Emissions Benchmarking – Nursery

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	41.32	7.60	240	44.16	46.46
Grid Electricity	23.69	2.49	80	8.40	26.38
Total	65.01	10.09	320	52.56	72.84

25.2.3. The building would have been constructed to 2000/2006 building regulations therefore the thermal performance and energy efficiency standards should be reasonable when compared against typical University Campus building stock.

25.2.4. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2021 as the most recent full year. The metering data shows the energy consumption profile for Nursery throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays.

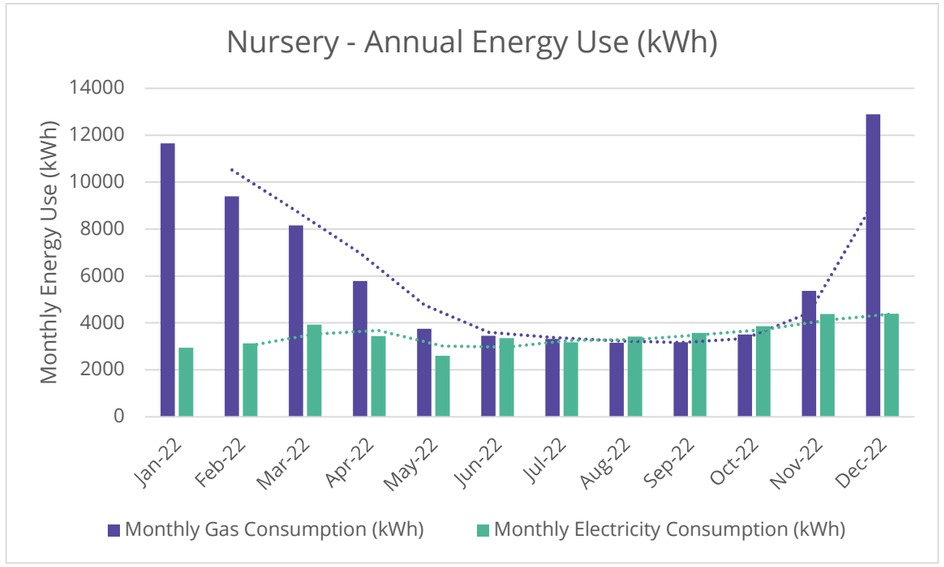


Fig. 25.2 Nursery annual energy usage profile

25.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.921 which suggests a strong correlation between degree days and heat consumption, however this value suggests there is minimal inherent inefficiency in the system.

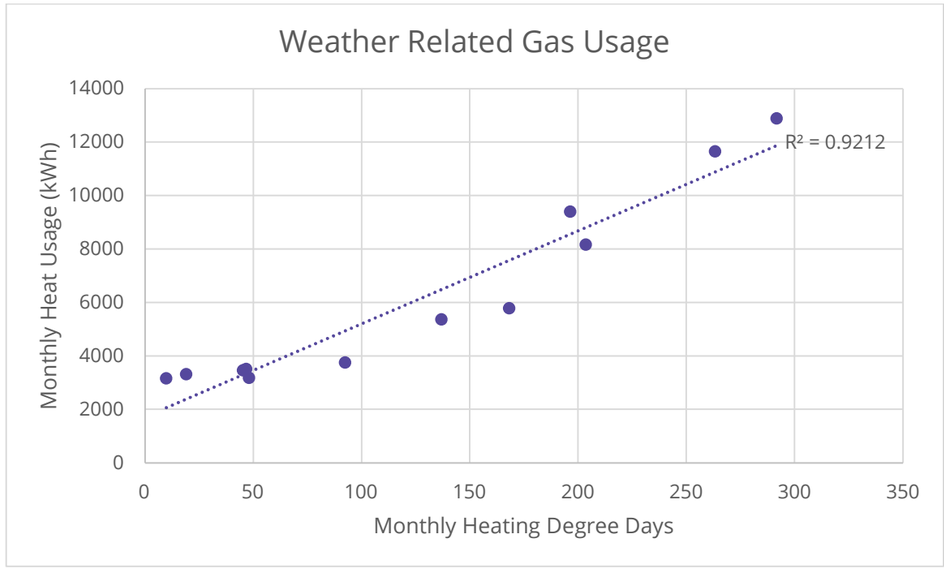


Fig. 25.3 Weather related heat usage compared to degree days

25.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

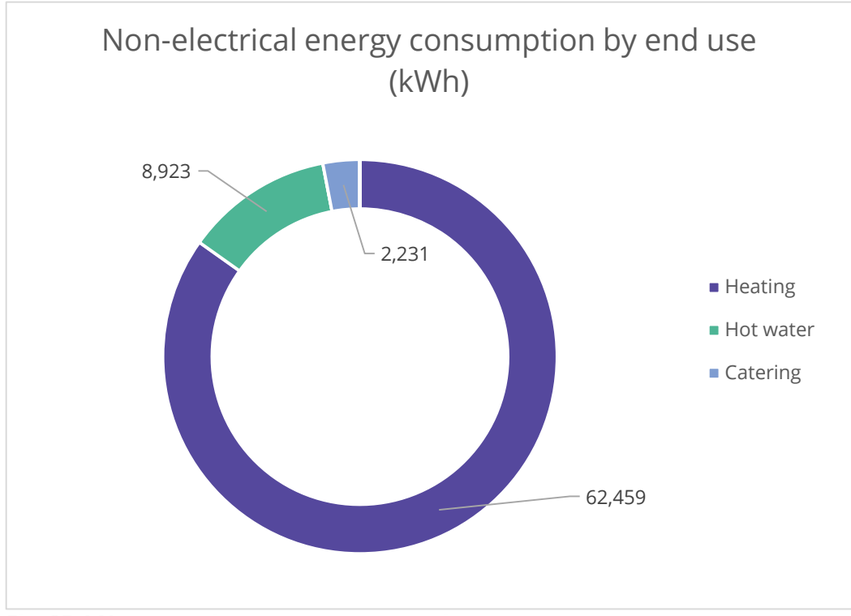


Fig. 25.4 Non-electrical energy consumption breakdown by end use

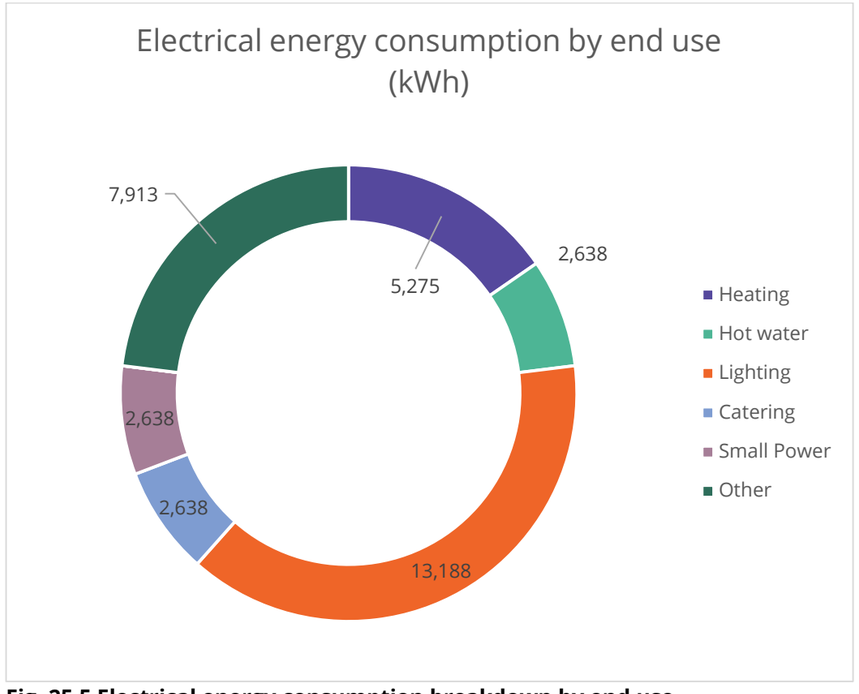


Fig. 25.5 Electrical energy consumption breakdown by end use

25.3 Nursery Building

25.3.1. Building Fabric Solution

This building is excluded from our inspection of the fabric envelope.

25.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Nursery Building. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Nursery Building we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

25.3.3. Energy & Carbon Savings – Nursery Building

Table 24.3 – Carbon savings summary – Nursery Building

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	6.72	£13,589	30	201	£67	£700	19.4
F2	Addition/replacement of roof insulation	6.85	£35,243	30	206	£171	£805	43.8
F3	Replacement of glazing to improve thermal performance	6.85	£153,894	20	137	£1,124	£802	191.9
F4		5.82	£0		0	£0	£0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	11.60	£267,225	25	290	£922	£1,149	232.5
S2	Installation of new centralised domestic hot water generation, pipework and controls	6.12	£44,538	25	153	£291	£1,916	23.2
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	6.36	£53,445	20	127	£420	£1,347	39.7
S5	Addition of high efficiency fans, pumps and drives	0.00	£0	25	0	£0	£0	0.0
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	15	0	£0	£0	0.0

25.3.4. Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 178kW (based on a rule of thumb of 100W/m²) with the peak cooling demand of 128kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 38kW and 32kW for heating and cooling respectively.

25.3.5. Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Nursery Building which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Nursery Building will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

26. Portland Mews

26.1 Portland Mews

26.1.1. General

Portland Mews is located to north of the main campus to the rear of 3 Endsleigh Place. The building houses the Hub, Advise, Counselling and Mental Health teams and Student Services Managers. The building contains mainly office space and staff welfare facilities.



Fig. 26.1 Portland Mews

26.1.2. Building Fabric

Portland Mews/Buckland House are three-storey buildings constructed in the 1980's comprising of a masonry construction with faced brick and cement render elevations and powder coated aluminium units incorporating sealed double-glazed opening lights. Timber framed double glazed windows are observed to Portland Mews only.

The roofs were seen from ground level and from our review of 'Google Maps' and are understood to comprise 'mansard' type roofs incorporating flat and sloped roofs with aluminium and timber framed double glazed openings to Portland Mews and Buckland House respectively.

Timber framed doors incorporating single glazed units are provided to the main entrance and exit to the building.

We observed general degradation to the timber framed windows and doors. Fine cracking is noted to the cement render, whilst this is believed due to weathering it should be further investigated to confirm this. From information provided by site management we believe the cavity wall insulation and glass rock/mineral wool roof insulation are in poor condition. However, the detailed specification has not been provided.

It is recommended to consider a thermographic survey to identify in detail where improvements could be made to the thermal performance of the building envelope.

We would anticipate future works to include the upgrade of insulation. Any potential insulation upgrade would be subject to review of a thermographic survey, liaison with consultants and building control.

The further investigations aside it is anticipated for the replacement of the timber framed windows.

26.1.3. Mechanical Services

Portland Mews is provided with direct electric heating via wall mounted panel heaters.

Local cooling is provided to key areas (comms rooms etc.) via DX cooling systems.

The building is generally naturally ventilated via opening windows to atmosphere and to the atrium areas. Stale air is discharged at roof level via Automatic Opening Vents (AOVs). Mechanical extract ventilation is provided to toilets and cleaners stores etc.

Domestic Hot water is generated by local unvented electric water heaters.

26.1.4. Electrical Services

The electricity supplies to Portland Mews are served via individually metered Low Voltage (LV) three phase electricity supply derived from the electricity supply network operated by the local district network operator.

Power is distributed throughout from the main LV main switch gear and local distribution board on the ground floor via final circuits to electric heating, sockets and lighting installation.

Lighting is generally provided via a variety of fluorescent lamped luminaires, with some evidence of failed luminaires replaced for LED equivalents with manually switched lighting controls serving communal and offices spaces.

26.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides data for the electrical system, however there is no dedicated sub-metering data for Portland Mews in respect of the heat network therefore we have relied on data provided by the estates team for analysis

26.1.6. BMS/Controls

There is no BMS in operation within Portland Mews.

26.1.7. Condition & Operation

The building was constructed in the 1980s however we understand that the engineering services have previously been renewed and are over 10 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 10-15 years, subject to appropriate maintenance.

The engineering services generally appear to be in fair condition however we understand that the controls/BMS is in poor condition and requires renewal/refurbishment which is scheduled to be undertaken as soon as possible.

26.1.8. Planned Future CAPEX Works

We understand that a programme of capex works including refurbishment of the windows in 2023 and the engineering services in 2024.

26.1.9. Opportunities for Heat Networks

If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Portland Mews to the 5DHC network when it becomes operational, however this would require the installation of a new wet distribution system.

Typical future-proofing measures to consider could be:

- Ensure the heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
- Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

26.2 Energy & Carbon Emissions

26.2.1. The following table identifies the energy consumption and carbon emissions from the Portland Villas building based on the energy consumption figures provided from site.

Table 25.1 – Energy Consumption & Carbon Emissions – Portland Villas

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	N/A	0.184 $kgCO_2e/kWh$	N/A
Grid Electricity	60,530 kWh	0.105 $kgCO_2e/kWh$	6.36 TCO_2e
Total	60,530 kWh	N/A	6.36 TCO_2e

26.2.2. Table 5.39 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 676.5m². The performance of Portland Mews is good with overall energy usage and carbon emissions around half the current benchmark. There is no current DEC available.

Table 25.2 – Energy Consumption & Carbon Emissions Benchmarking – Portland Villas

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	N/A	N/A	240	44.16	N/A
Grid Electricity	89.48	9.39	80	8.40	N/A
Total	89.48	9.39	320	52.56	N/A

26.2.3. The building would have been constructed to 1985 building regulations therefore the thermal performance and energy efficiency standards should be reasonable when compared against typical University Campus building stock.

26.2.4. We have been provided with bulk electrical consumption for the building by the estates team. We have not been able to extract electrical consumption information from the Portal therefore we are unable to analyse the annual energy profile or provide a degree day analysis.

26.2.5. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

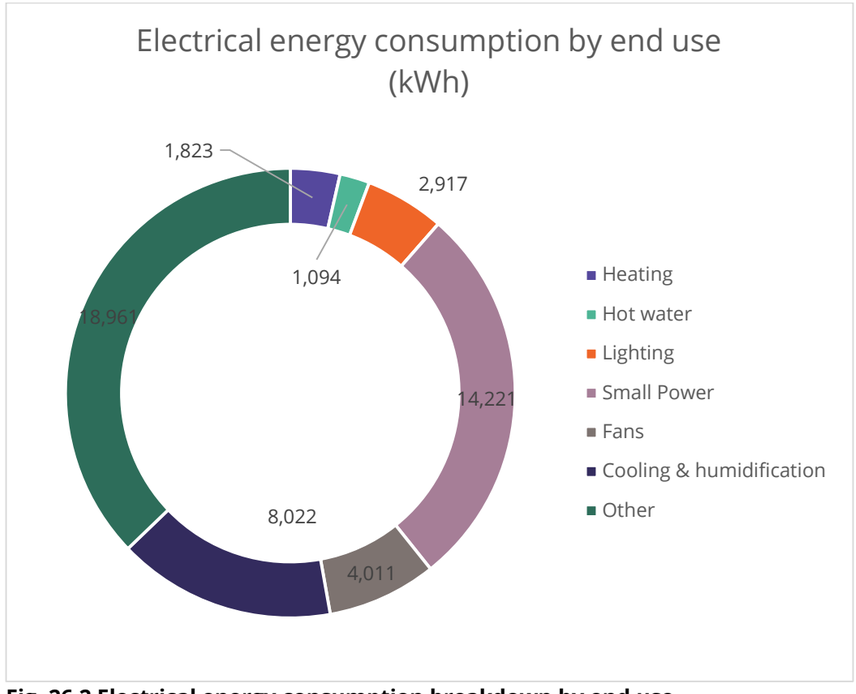


Fig. 26.2 Electrical energy consumption breakdown by end use

26.3 Portland Mews

26.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Portland Mews is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management states the cavity wall insulation to be in poor condition. The options are to consider the retrospective installation of internal/external wall insulation or a multiple of the two. The agreed insulation would be fitted internally by way of adhesive to existing walls or battens with insulation quilt/plasterboard, rigid insulation board or a mixture of the two. External insulation generally, comprises of rigid insulation board either mechanically fixed to the existing walls or within a steel cage system but often having an applied render coat to either option or being of a prefinished insulation board/panel. However, these options would be subject to review of as-built data.

Option F2: The installation of new or additional roof insulation

The above-mentioned report states the existing roof insulation as being in poor condition. Consider the provision of glass rock/rigid board insulation to the internal of the roofs. These works would be subject to review of as-built data and thermographic survey findings.

Option F3: Installation of reflective/ absorptive film on curtain glazing system to reduce heat gain

The above-mentioned report states the existing double windows as being in poor condition. Subject to further inspection and a thermographic survey, the likely recommendation would be the replacement of all existing glazing with new double-glazed windows.

26.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Portland Mews. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Portland Mews we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

26.3.3. Energy & Carbon Savings – Portland Mews

Table 25.3 – Carbon savings summary – Portland Mews

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	0.26	£14,453	30	8	£1,855	£202	71.6
F2	Addition/replacement of roof insulation	0.27	£19,928	30	8	£2,434	£212	94.0
F3	Replacement of glazing to improve thermal performance	0.21	£80,130	20	4	£19,379	£161	498.9
F4		0.04	£0		0	£0	£33	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	0.32	£101,475	25	8	£12,805	£789	128.5
S2	Installation of new centralised domestic hot water generation, pipework and controls	0.03	£10,148	25	1	£15,313	£855	11.9
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	0.27	£20,295	20	5	£3,786	£667	30.4
S5	Addition of high efficiency fans, pumps and drives	0.00	£0	25	0	£0	£0	0.0
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	15	0	£0	£0	0.0

26.3.4. Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 68kW (based on a rule of thumb of 100W/m²) with the peak cooling demand of 49kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 14kW and 12kW for heating and cooling respectively.

26.3.5. Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Portland Mews which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Portland Mews will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

27. Portland Villas (Nos. 1-14 & 15-20)

27.1 Description of Building

27.1.1. General

Portland Villas are located to the north-west of the main campus. No.16 houses the office for the University's International College which provides foundation, first year and pre-masters programmes. The remaining buildings contain various faculty buildings for departments including Health and Society and Culture. No. 17 houses the University's Human Resources department. The buildings comprise mainly office, administration and storage areas.



Fig. 27.1 Portland Villas

27.1.2. Building Fabric

Portland Villas are terraces of buildings either side of 'Portland Villas' Road. These buildings are predominately of two-storey with some having basement level and constructed between 1800 and 1900. Our inspection of some buildings was restricted due to in-progress refurbishment. Where seen the buildings comprise of masonry construction with a combination of stucco and cement render elevations finishes and timber framed units incorporating single-glazed opening lights.

The roofs were not inspected however, from our review of 'Google Maps' the roofs are understood to comprise pitched roofs covered with roof tiles. Some roofs incorporate chimneys.

Timber doors, some incorporating glazed units are provided to the main entrance and exit to the buildings.

During our inspection of Portland Villas, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe there is no thermal wall insulation, and the glass rock/mineral wool roof insulation is in poor condition. However, the detailed specification has not been provided.

The above-mentioned report records the windows as double-glazed however, where seen we observed single glazed sash type windows.

It is recommended to consider a thermographic survey to identify in detail where improvements could be made to the thermal performance of the building envelope.

Subject to review of the on-going refurbishment works we would anticipate further works being required to include the provision/upgrade of wall and roof insulation and the replacement of windows.

Any potential enhancement works would be subject to review of the thermographic survey, liaison with consultants and building control. In addition, some considered works to Portland Villas may require or be restricted by listed building/planning consent

27.1.3. Mechanical Services

Portland Villas were originally constructed as separate large dwellings. Nos. 15-20 are served by 2No. Potterton gas fired boilers located in the basement plantroom. The boilers serve wall mounted radiators.

Nos. 3-9 are provided with individual gas fired boilers serving radiator circuits.

The buildings are generally naturally ventilated via opening windows to atmosphere and mechanical extract ventilation is provided to toilets and cleaners stores etc.

Domestic Hot water is generated via local unvented electric water heaters.

27.1.4. Electrical Services

The electricity supplies to Portland Villas are served via a series metered Low Voltage (LV) single phase electricity supply derived from the electricity supply network operated by the local district network operator.

Power is distributed throughout from the main LV distribution board on the ground floor via final circuits to sockets and lighting installation.

Lighting is generally provided via a variety of fluorescent lamped luminaires, with evidence of failed luminaires replaced for LED equivalents with manually switched lighting controls serving communal and offices spaces.

27.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides data for the gas consumption, however there is no dedicated sub-metering data for Portland Villas in respect of the electrical consumption therefore we have relied on data provided by the estates team for analysis.

27.1.6. BMS/Controls

The heating controls comprise an obsolete Satchwell Climatronic CXC controller alongside a Satchwell CRC optimiser.

27.1.7. Condition & Operation

Nos. 3-9 have been undergoing refurbishment which has recently completed however the heating systems were not renewed.

We understand that the buildings were constructed in the 1800s meaning the buildings are over 120 years old. The engineering services are circa 15-20 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 5-10 years, subject to appropriate maintenance.

The engineering services generally appear to be in fair condition however we understand that the controls/BMS are obsolete and require renewal/refurbishment which is scheduled to be undertaken as soon as possible.

27.1.8. Planned Future CAPEX Works

We understand that a programme of capex works including refurbishment of the remaining building is scheduled for the next 2 years.

27.1.9. Opportunities for Heat Networks

If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Portland Villas to the 5DHC network when it becomes operational. However, due to the historic nature of the building and listing status, further detailed investigation would be necessary to determine the feasibility of this opportunity.

Typical future-proofing measures to consider could be:

- Ensure the heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
  Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

27.2 Energy & Carbon Emissions

27.2.1. The following table identifies the energy consumption and carbon emissions from the Portland Villas building based on the energy consumption figures provided from site. For clarity and ease of analysis we have assessed all Portland Villas as a single entity.

Table 26.1 – Energy Consumption & Carbon Emissions – Portland Villas

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	299,171 kWh	0.184 $kgCO_2e/kWh$	55.05 TCO_2e
Grid Electricity	814,382 kWh	0.105 $kgCO_2e/kWh$	85.51 TCO_2e
Total	1,113,553 kWh	N/A	140.558 TCO_2e

27.2.2. Table 5.39 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 6173.9m². The performance of Portland Villas is very good with overall energy usage and carbon emissions around half the current benchmark. The figures vary significantly against those stated on the current DEC.

Table 26.2 – Energy Consumption & Carbon Emissions Benchmarking – Portland Villas

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	48.46	8.92	240	44.16	101.39
Grid Electricity	131.91	13.85	80	8.40	80.21
Total	180.36	22.77	320	52.56	181.60

27.2.3. The building would have been constructed to 2000/2006 building regulations therefore the thermal performance and energy efficiency standards should be reasonable when compared against typical University Campus building stock.

27.2.4. Gas meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2022 as the most recent full year. The metering data shows the energy consumption profile for Portland Villas throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. We have not been able to extract electrical consumption information from the Portal therefore we are unable to analyse the electrical energy profile.

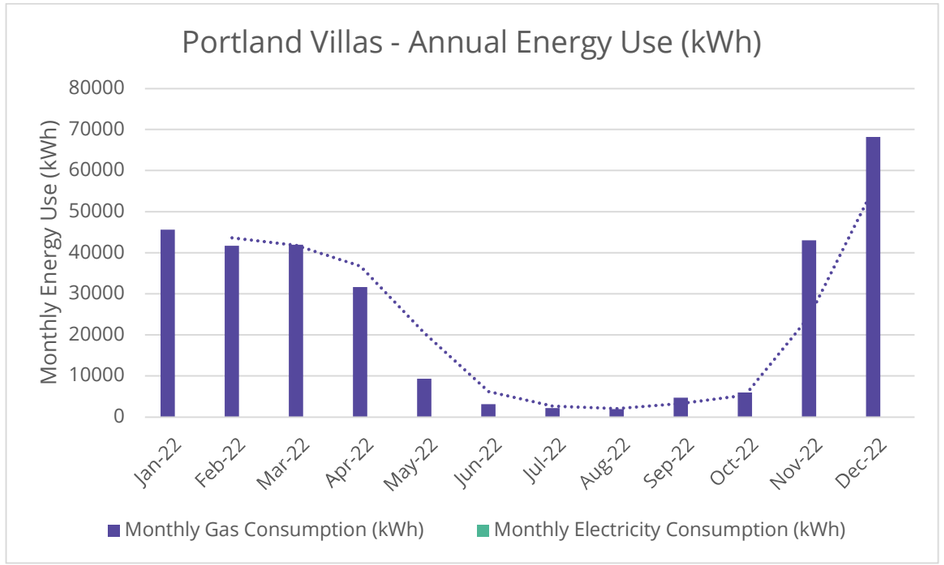


Fig. 27.2 Portland Villas annual energy usage profile

27.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.915 which suggests a strong correlation between degree days and heat consumption.

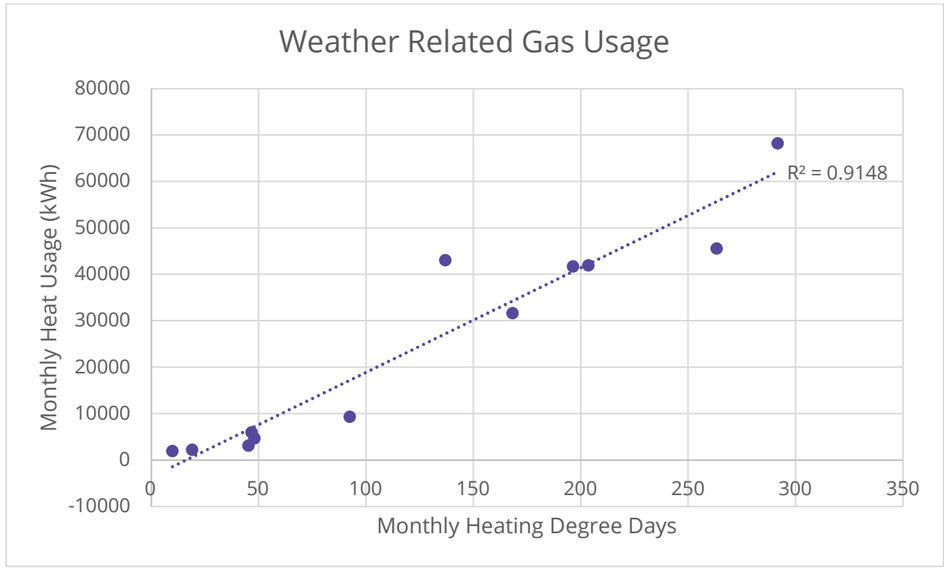


Fig. 27.3 Weather related heat usage compared to degree days

27.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

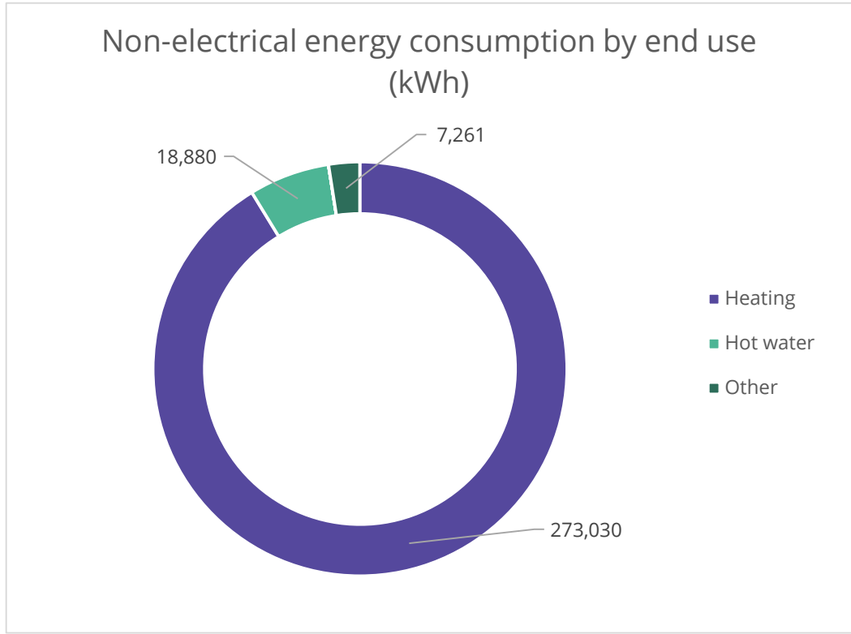


Fig. 27.4 Non-electrical energy consumption breakdown by end use

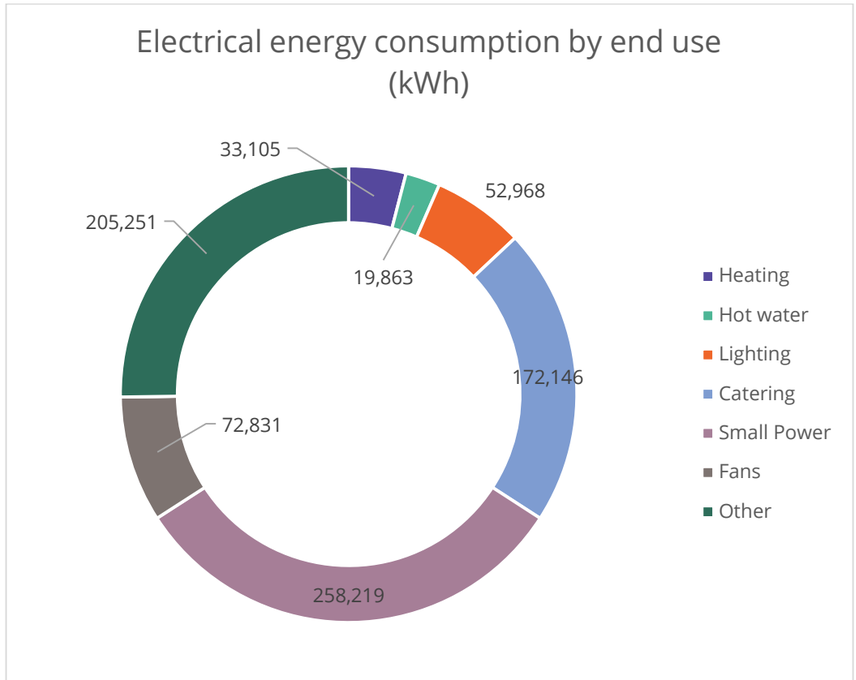


Fig. 27.5 Electrical energy consumption breakdown by end use

27.3 Technical Solution

27.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Portland Villas is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management records there being no thermal wall insulation. The options would be to either retrospectively install external or internal to the entirety of the masonry elevations or a multiple of the two. The agreed insulation would be fitted internally by way of adhesive to existing walls or battens with insulation quilt/plasterboard, rigid insulation board or a mixture of the two. External insulation generally, comprises of rigid insulation board either mechanically fixed to the existing walls or within a steel cage system but often having an applied render coat to either option or being of a prefinished insulation board/panel. However, these options may be subject/limited by existing listed building and planning restrictions.

Option F2: The installation of new or additional roof insulation

The assumption is the existing roofs are of a timber construction. The existing roof insulation is recorded as being in poor condition. Therefore, the anticipated works would comprise of upgrade of existing glass rock/mineral wool insulation with the similar product, rigid insulation boards or installation of a spray foam insulation. All would be subject to confirmation of the existing and the desired U Value to be achieved.

Option F3: Installation of replacement windows

The above-mentioned report records the existing windows as be in fair condition. The recommendation would be to replace all windows with new double-glazed units. These works would be subject to the U Value to be achieved and there being no planning restrictions. This recommendation would include the replacement of existing doors with composite and glazed doors to meet requirements.

27.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Portland Villas. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Portland Villas we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

Option S7: Expansion of roof mounted solar PV installation.

We anticipate that an circa 400m² of solar PV cells could be installed, subject to detailed design and structural feasibility assessment. This would also need to be considered within the design of the additional roof insulation and potential location of plant on the roof.

27.4 Energy & Carbon Savings – Portland Villas

Table 26.3 – Carbon savings summary – Portland Villas

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	31.71	£131,903	30	951	£139	£6,274	21.0
F2	Addition/replacement of roof insulation	32.12	£181,865	30	964	£189	£6,592	27.6
F3	Replacement of glazing to improve thermal performance	30.06	£731,289	20	601	£1,216	£4,994	146.4
F4		0.00	£0		0	£0	£0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	36.40	£926,085	25	910	£1,018	-£22,024	-42.0
S2	Installation of new centralised domestic hot water generation, pipework and controls	24.67	£92,609	25	617	£150	-£19,452	-4.8
S3	Replacement of existing lighting with LED technology and upgraded	0.00	£0	0	0	£0	£4,848	0.0

	controls							
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	28.58	£185,217	20	572	£324	£12,308	15.0
S5	Addition of high efficiency fans, pumps and drives	24.02	£61,739	25	600	£103	£952	64.8
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£2,279	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	15	0	£0	£0	0.0

27.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 463kW (based on a rule of thumb of 75W/m²) with the peak cooling demand of 445kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 97kW and 111kW for heating and cooling respectively.

27.6 Key Risks & Challenges

Portland Villas are noted by Historic England as having listed status. This will need to be considered during the planning and design stages for the proposed solution.

It is likely that the available electrical capacity for Portland Villas will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

The Structural integrity of existing roofs and access thereto will need to be carefully considered when developing any solar PV scheme.

28. Reynolds

28.1 Description of Building

28.1.1. General

The Reynolds building is located to the south-west of the main campus site. The building houses the School of Engineering, Computing and Mathematics. The building mainly comprises offices, meeting rooms and welfare facilities.

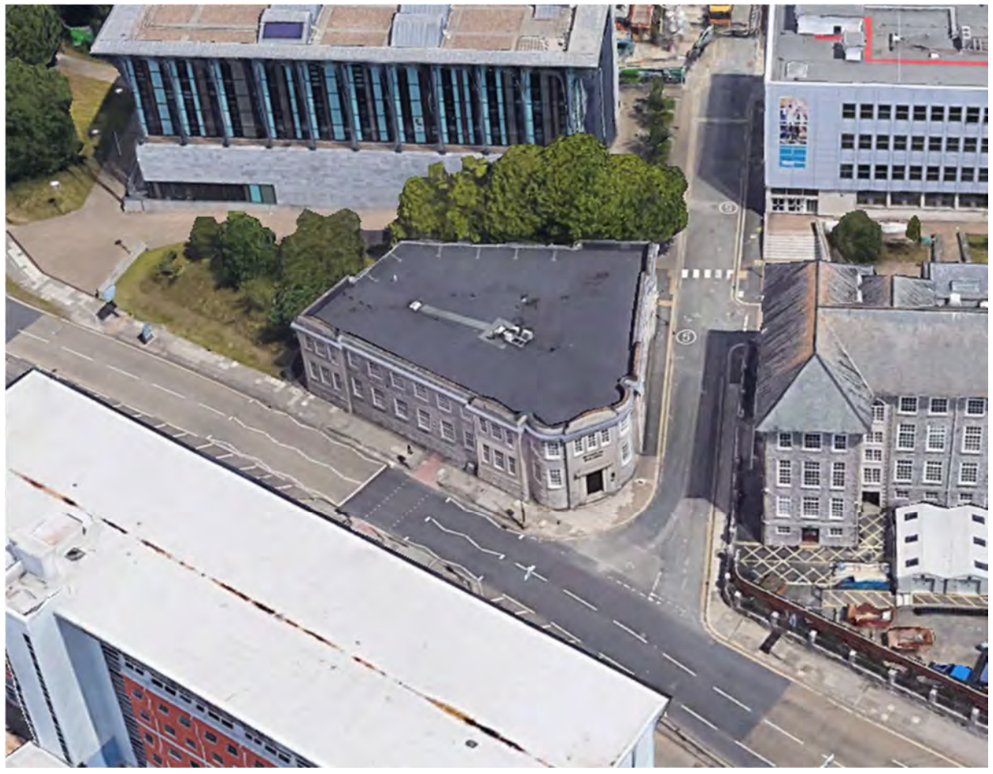


Fig. 28.1 Reynolds Building

28.1.2. Building Fabric

The Reynolds Building is a two-storey building constructed circa 1920's comprising of a masonry construction with a combination of faced stonework and cement render elevation finishes and timber framed units incorporating single-glazed opening lights.

The roofs were not inspected however, from our review of 'Google Maps' the roofs are understood to comprise flat roofs.

Timber framed doors are provided to the main entrance and exit to the building.

Generally, we observed degradation to the single glazed sash windows. From information provided by site management we believe there is no thermal wall insulation. Glass rock and mineral wool insulation is installed to the roofs is recorded as in poor condition. However, the detailed specification has not been provided.

We would recommend consideration is given to the provision and upgrade of insulation to the walls and roofs respectively, subject to intrusive investigation. Any potential insulation upgrade would be subject to liaison with consultants and potential listed building/planning consents.

The timber framed single glazed windows and doors should be replaced subject to listed building requirements/restrictions, and liaison with building control and consultants.

It is further recommended to consider a thermographic survey to identify in detail where improvements could be made to the thermal performance of the building envelope.

28.1.3. Mechanical Services

Reynolds Building is supplied with LTHW gas fired boilers located in the main plantroom. The LTHW system feeds wall mounted radiators.

Local cooling is provided to key areas (comms rooms etc.) via DX cooling systems via roof mounted condensers.

The building is generally naturally ventilated via opening windows to atmosphere and to the atrium areas. Stale air is discharged at roof level via Automatic Opening Vents (AOVs). Mechanical extract ventilation is provided to toilets and cleaners stores etc.

Domestic Hot water is generated by local unvented electric water heaters.

28.1.4. Electrical Services

The electricity supply to Reynolds Building is served with a metered Low Voltage (LV) three phase electricity supply derived from the electricity supply network operated by the local district network operator.

Power is distributed throughout from the main LV main switch gear and local distribution board on the ground floor via final circuits to sockets and lighting installation.

Lighting is generally provided via a variety of LED luminaires, with some evidence of failed fluorescent luminaires are replaced for LED equivalents with manually switched and automatic lighting controls serving communal and offices spaces.

28.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides data for the gas, electrical system and water consumption. The building is provided with an electrical sub-meter for the mechanical services.

28.1.6. BMS/Controls

We understand that the Rolle Building operates via a Schneider Electric EcoStruxture Building Operation (EBO) BMS.

28.1.7. Condition & Operation

We understand that the building was constructed in the 1800s therefore the building is over 120 years old. The engineering services are circa 15-20 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 5-10 years, subject to appropriate maintenance.

The engineering services generally appear to be in good condition however we understand that the controls/BMS is in poor condition and requires renewal/refurbishment which is scheduled to be undertaken as soon as possible.

28.1.8. Planned Future CAPEX Works

We understand that a programme of capex works to repair the windows is scheduled for 2022/23.

28.1.9. Opportunities for Heat Networks

If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Reynolds Building to the 5DHC network when it becomes operational.

Typical future-proofing measures to consider could be:

- Ensure the heat pumps can operate on ambient loops served by both dry air coolers and borehole installations.
- Modular arrangement of system so that dry air coolers can be easily replaced with heat exchangers.

28.2 Energy & Carbon Emissions

28.2.1. The following table identifies the energy consumption and carbon emissions from the Reynolds building based on the energy consumption figures provided from site.

Table 27.1 – Energy Consumption & Carbon Emissions – Reynolds

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	67,858 kWh	0.184 $kgCO_2e/kWh$	12.49 TCO_2e
Grid Electricity	40,761 kWh	0.105 $kgCO_2e/kWh$	4.28 TCO_2e
Total	108,619 kWh	N/A	16.77 TCO_2e

28.2.2. Table 5.41 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 1,330.9m². The performance of Reynolds is very good with overall energy usage and carbon emissions well below the current benchmark. The figures correspond closely with those stated on the current DEC.

Table 27.2 – Energy Consumption & Carbon Emissions Benchmarking – Reynolds

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	50.99	9.38	240	44.16	57.51
Grid Electricity	30.63	3.22	80	8.40	31.17
Total	81.61	12.60	320	52.56	88.68

28.2.3. The building was constructed prior to 1900 therefore the thermal performance and energy efficiency standards is likely to be poor when compared against typical University Campus building stock.

28.2.4. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2021 as the most recent full year. The metering data shows the energy consumption profile for Reynolds throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays.

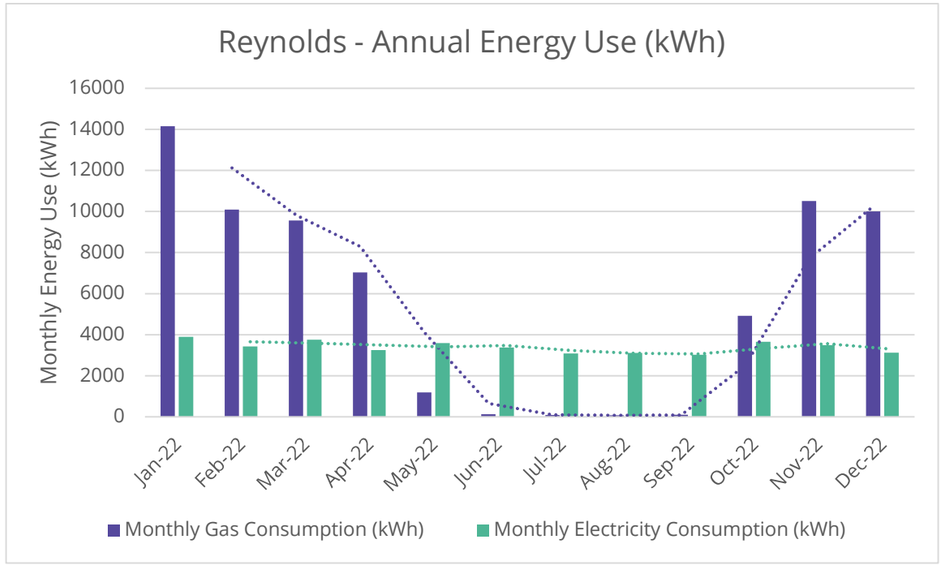


Fig. 28.2 Reynolds annual energy usage profile

28.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.794 which suggests a reasonable correlation between degree days and heat consumption, however this value suggests there is some inherent inefficiency in the system. This can be explained by the fact that the age of the building and potential issues with optimisation of controls.

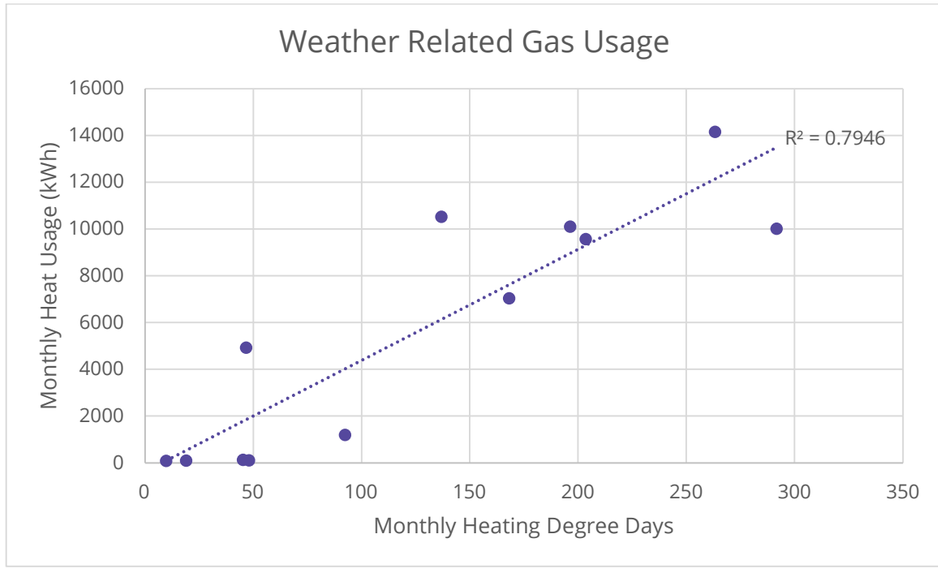


Fig. 28.3 Weather related heat usage compared to degree days

28.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

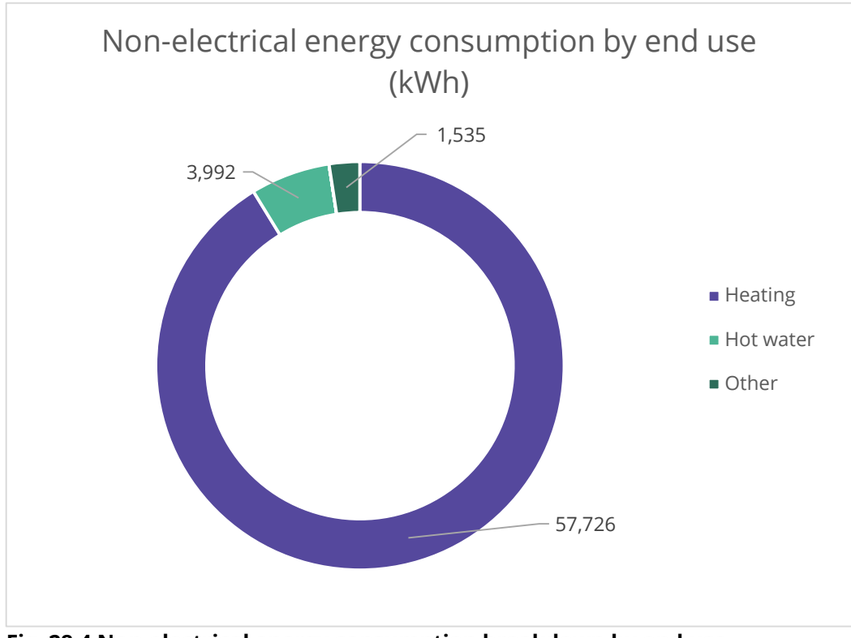


Fig. 28.4 Non-electrical energy consumption breakdown by end use

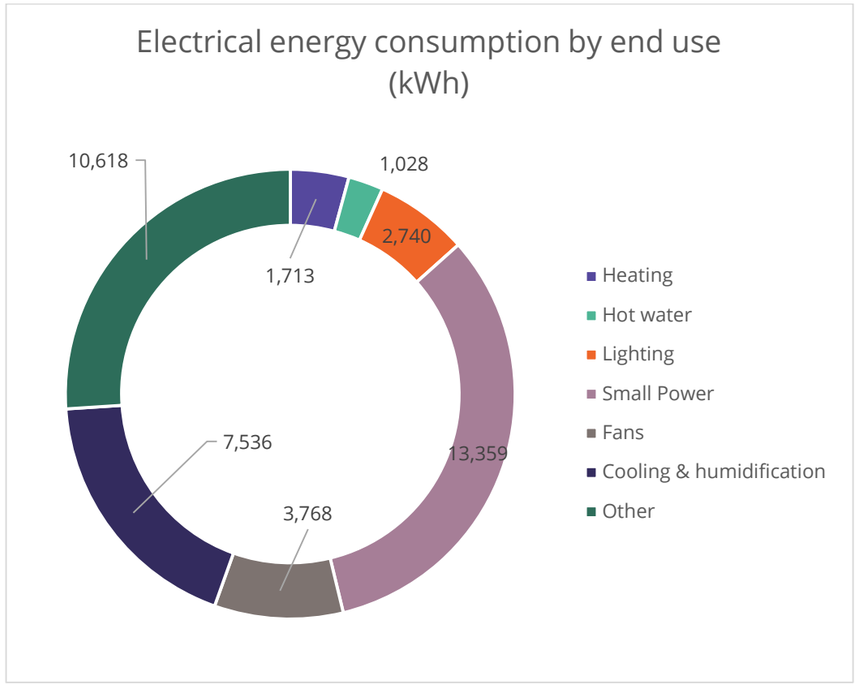


Fig. 28.5 Electrical energy consumption breakdown by end use

28.3 Technical Solution

28.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Reynolds Building is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management records there being no thermal wall insulation. The options would be to either retrospectively install external or internal to the entirety of the masonry elevations or a multiple of the two. The agreed insulation would be fitted internally by way of adhesive to existing walls or battens with insulation quilt/plasterboard, rigid insulation board or a mixture of the two. External insulation generally, comprises of rigid insulation board either mechanically fixed to the existing walls or within a steel cage system but often having an applied render coat to either option or being of a prefinished insulation board/panel. However, the existing stonework elevations and anticipated listed building and planning restrictions, may preclude the option to provide external wall insulation.

Option F2: The installation of new or additional roof insulation

From review of 'Google Maps' the roofs are believed to be flat with a proprietary membrane. The existing roof insulation is recorded as being in poor condition. Therefore, the anticipated works would comprise of upgrade of existing glass rock/mineral wool insulation with the similar product, rigid insulation boards or installation of a spray foam insulation. Alternatively, the refurbishment of the entirety of the roofs may be considered which would include upgrade of insulation. All would be subject to confirmation of the existing and the desired U Value to be achieved.

Option F3: Installation of replacement windows

Where seen the timber framed single-glazed windows are in poor condition. The recommendation would be to replace all windows with new double-glazed units. These works would be subject to the U Value to be achieved and compliance with local planning authority. This recommendation would include the replacement of existing doors with composite and glazed doors to meet requirements.

28.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Reynolds Building. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Reynolds Building we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

Option S7: Expansion of roof mounted solar PV installation.

With an available roof area of approximately 840m² we anticipate that an additional 400m² of solar PV cells could be installed, subject to detailed design and structural feasibility assessment. This would also need to be considered within the design of the additional roof insulation and potential location of plant on the roof.

28.4 Energy & Carbon Savings – Reynolds Building

Table 27.3 – Carbon savings summary – Reynolds Building

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	7.13	£10,152	30	214	£47	£1,373	7.4
F2	Addition/replacement of roof insulation	7.22	£26,329	30	217	£122	£1,442	18.3
F3	Replacement of glazing to improve thermal performance	6.77	£191,157	20	135	£1,412	£1,093	175.0
F4		0.00	£0		0	£0	£0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	8.10	£199,635	25	202	£986	-£5,389	-37.0
S2	Installation of new centralised domestic hot water generation, pipework and controls	5.49	£19,964	25	137	£145	-£5,056	-3.9
S3	Replacement of existing lighting with LED technology and upgraded controls	5.46	£0	0	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	5.91	£39,927	20	118	£338	£1,360	29.4
S5	Addition of high efficiency fans, pumps and drives	5.38	£13,309	25	135	£99	£49	270.2
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0

S7	Install building mounted solar Photo-Voltaic (PV) array	6.46	£128,000	15	97	£1,320	£2,746	46.6

28.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 100kW (based on a rule of thumb of 75W/m²) with the peak cooling demand of 96kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 21kW and 24kW for heating and cooling respectively.

28.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Reynolds Building which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Reynolds Building will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

29. Robbins Conference Centre

29.1 Description of Building

29.1.1. General

The Robbins Conference Centre is located approximately 200m to the east of the main University campus, adjacent to the Robbins halls of residence. The building is generally sub-terranean and primarily houses lecture theatres and conference facilities.



Fig. 29.1 Robbins Conference Centre

29.1.2. Building Fabric

The Robbins Conference Centre is a two-storey building constructed between 1991 and 2000. The building is predominately structured below pavement level and believed to comprise of a reinforced concrete frame construction. At pavement level powder coated aluminium framed units incorporating sealed double-glazed walling and roof lanterns provide lift/stair lobbies and natural daylight. The elevations forming the lift/stair lobbies also include pitched tile covered roofs and faced blockwork.

Powder coated aluminium framed doors incorporating double glazed units provide entrance and exit to the building.

During our inspection of Robbins Conference Centre, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe cavity wall insulation and rigid insulation boards are present to the perimeter walls and roofs respectively. The wall and roof insulation are recorded as fair and poor respectively however, the detailed specification has not been provided.

Conditional on the confirmation of existing insulation to walls and roofs we anticipate the enhancement of the wall insulation and replacement of roof insulation. Any potential insulation upgrade would be subject to liaison with consultants and building control.

Subject to the review of as-built data and consultants, consideration may be given for the installation of window film to glazed walls and roof lantern.

29.1.3. Mechanical Services

Robbins Conference Centre is supplied with LTHW via dedicated gas fired boiler plant located in a plantroom within the basement car park area. The LTHW system feeds fan convectors and recessed fan coil units.

The building is generally mechanically ventilated via AHU plant located in the basement. Stale air is discharged at roof level via Automatic Opening Vents (AOVs). Mechanical extract ventilation is provided to toilets and cleaners stores etc.

Domestic Hot water is generated by local unvented electric water heaters.

29.1.4. Electrical Services

The electricity supply to Robbins Conference Centre is served with the privately owned HV electricity supply to the East Campus which terminates at 2no. 500kVA rated transformers and substation located within the basement to the building.

Power is distributed throughout from the main LV main switch gear and local distribution board on the ground floor via final circuits to electric heating, sockets and lighting installation.

Lighting is generally provided via a variety of fluorescent lamped luminaires, with some evidence of failed luminaires replaced for LED equivalents with manually switched lighting controls serving communal and offices spaces.

29.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides data for the electrical system, however there is no dedicated sub-metering data for Robbins Conference Centre in respect of the gas consumption therefore we have relied on data provided by the estates team for analysis

29.1.6. BMS/Controls

The Robbins Conference Centre services operate via an obsolete Andover Continuum BMS.

29.1.7. Condition & Operation

We understand that the building was constructed in the 1990s meaning the engineering services are circa 25-30 years old. According to CIBSE Guide M the systems operating beyond end of life.

The engineering services generally appear to be in fair condition however much of the equipment requires renewal/refurbishment in the short term.

29.1.8. Planned Future CAPEX Works

We understand that there are currently no CAPEX works scheduled for the Robbins Conference Centre.

29.1.9. Opportunities for Heat Networks

The building is remote from the main campus however is within the PCC area of opportunity for heat networks. If suitable technology is installed as part of any planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Reynolds Building to a future heat network if and when it becomes operational

29.2 Energy & Carbon Emissions

29.2.1. The following table identifies the energy consumption and carbon emissions from the Robbins Conference Centre based on the energy consumption figures provided from site.

Table 28.1 – Energy Consumption & Carbon Emissions – Robbins Conference Centre

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	39,563 kWh	0.184 $kgCO_2e/kWh$	7.28 TCO_2e
Grid Electricity	245,703 kWh	0.105 $kgCO_2e/kWh$	25.80 TCO_2e
Total	285,266 kWh	N/A	33.08 TCO_2e

29.2.2. Table 5.43 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 3,149m². The performance of Robbins Conference Centre is very good with overall energy usage and carbon emissions around half the current benchmark. The figures correspond closely with those stated on the current DEC.

Table 28.2 – Energy Consumption & Carbon Emissions Benchmarking – Robbins Conference Centre

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	12.56	2.31	240	44.16	15.19
Grid Electricity	78.03	8.19	80	8.40	94.32
Total	90.59	10.50	320	52.56	109.51

29.2.3. The building would have been constructed to 2000/2006 building regulations therefore the thermal performance and energy efficiency standards should be reasonable when compared against typical University Campus building stock.

29.2.4. We have not been able to extract hourly/monthly data from the C3ntinel metering system for the Robbins Conference Centre so we are unable to analyse the annual energy profile or carry out a degree day analysis. However, we can observe that the fossil fuel usage is very low compared to a typical building which can be explained by the sub-terranean construction. The high total electrical consumption is likely due to the increased requirement for artificial lighting.

29.2.5. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

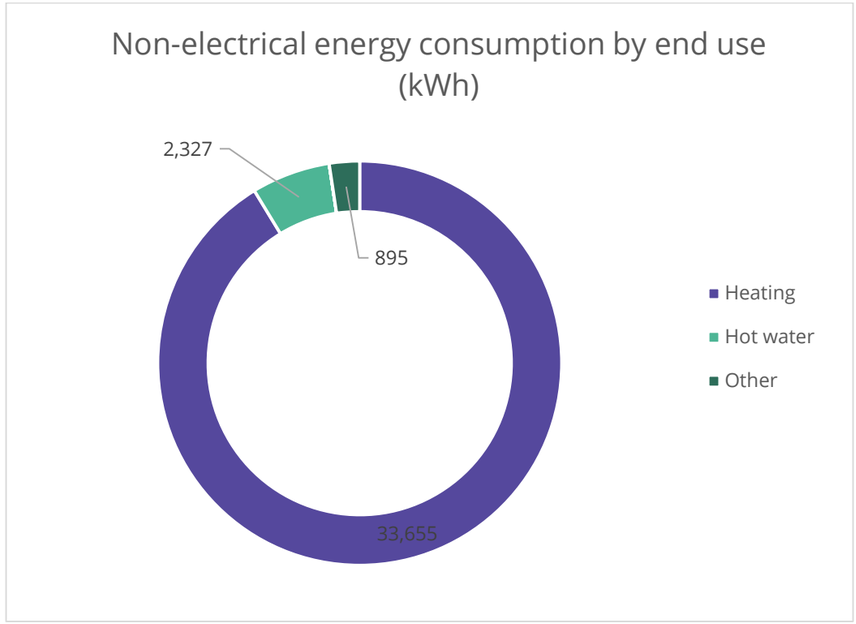


Fig. 29.2 Non-electrical energy consumption breakdown by end use

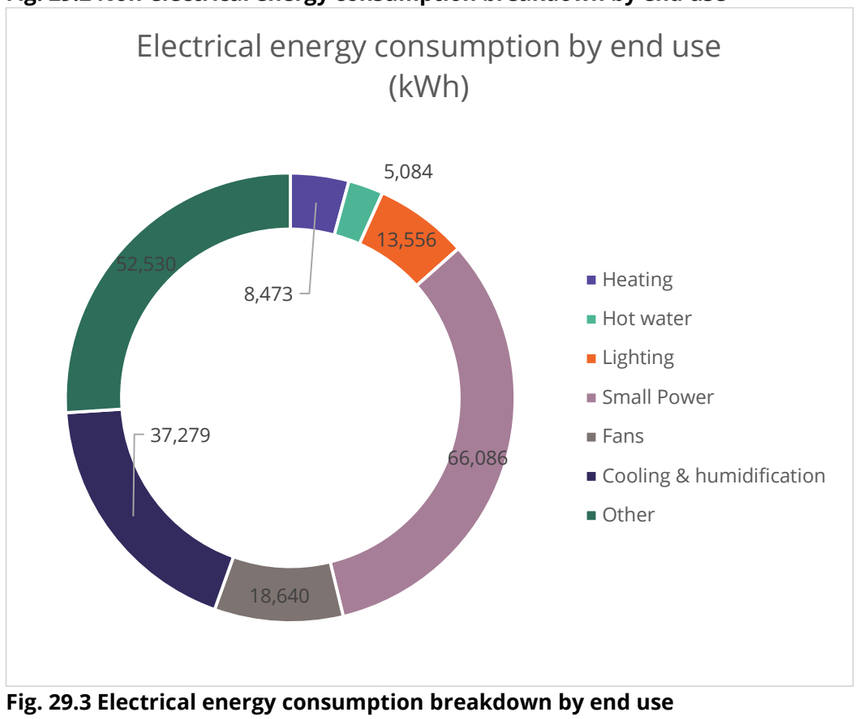


Fig. 29.3 Electrical energy consumption breakdown by end use

29.3 Technical Solution

29.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Robbins Conference Centre is as follows:

Option F1: The addition of internal or external wall insulation

From our inspection the building is essentially constructed below ground level and incorporating ground lift and stair lobbies. The report provided site management records the cavity wall insulation as being in fair condition. At this stage the option would appear limited to the provision/upgrade to internal thermal insulation. The agreed insulation would be fitted internally by way of adhesive to existing walls or battens with insulation quilt/plasterboard, rigid insulation board or a mixture of the two.

Option F2: The installation of new or additional roof insulation

The above-mentioned report records the rigid roof insulation boards as being in poor condition. Given the limited roofs having insulation the options for consideration would be strip the external roof finishes and upgrade the insulation or to upgrade the insulation internally.

Installation of reflective/ absorptive film on curtain glazing system to reduce heat gain

The recommendation would be to consider the overhaul of existing glazing to correct damaged/failed seals and blown glazing units. In addition, the provision of reflective/absorptive window film may be a beneficial improvement.

The works to be considered under Options F1, F2 and F3 of the above would be subject to review via a thermographic survey report.

29.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Robbins Conference Centre. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Robbins Conference Centre we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

29.3.3. Energy & Carbon Savings – Robbins Conference Centre

Table 28.3 – Carbon savings summary – Robbins Conference Centre

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
-	Addition of external window film to reduce solar heat gain	3.32	£28,691	15	50	£576	£152	188.7
F1	Addition of wall insulation	4.54	£55,469	30	136	£407	£1,101	50.4
F2	Addition/replacement of roof insulation	4.50	£55,371	30	135	£410	£1,069	51.8
F3	Replacement of glazing to improve thermal performance	4.79	£394,505	20	96	£4,115	£1,295	304.5
F4			£0		0	£0	£0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	7.83	£472,350	25	196	£2,414	£4,586	103.0
S2	Installation of new centralised domestic hot water generation, pipework and controls	3.32	£31,490	25	83	£379	£5,078	6.2
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	4.38	£39,363	20	88	£450	£3,119	12.6
S5	Addition of high efficiency fans,	3.22	£31,490	25	81	£391	£244	129.2

	pumps and drives							
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£917	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	15	0	£0	£0	0.0

29.4 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 315kW (based on a rule of thumb of 100W/m²) with the peak cooling demand of 227kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 79kW and 60kW for heating and cooling respectively.

29.5 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Robbins Conference Centre which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Robbins Conference Centre will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

30. Roland Levinsky building

30.1 Description of Building

30.1.1. General

The Roland Levinsky Building is located to the south-east of the main University campus and houses the faculty of Arts, Humanities and Business. The building contains teaching and offices/administration areas as well as lecture theatres, gallery, restaurant, café and studios for art, design and architecture.



Fig. 30.1 Roland Levinsky Building

30.1.2. Building Fabric

The Roland Levinsky Building was constructed between 2001 and 2010 comprising of a steel frame construction of three to nine-storeys enclosed with a combination of powder coated aluminium framed units incorporating sealed double-glazed walling and metal and stone cladding.

The roofs were not inspected however, from our review of 'Google Maps' the roofs are understood to comprise sloped roofs covered with metal roof sheeting and incorporating rooflights.

Powder coated aluminium framed doors incorporating double glazed units are provided to the main entrance and exit to the building.

During our inspection of Roland Levinsky Building, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe the fabric includes external wall insulation and rigid roof insulation boards. These insulations are recorded as in fair condition however, the detailed specification has not been provided.

It is recommended to consider a thermographic survey to identify in detail where improvements could be made to the thermal performance of the building envelope.

It is anticipated the considered enhancement works would include upgrade of wall insulation. Any potential insulation upgrade would be subject to review of the thermographic survey report, liaison with consultants and building control.

The above-mentioned report records the double-glazing as in good condition, having been recently upgraded. Subject to a review of the recommended thermographic survey these windows may benefit from the installation of window film.

30.1.3. Mechanical Services

Roland Levinsky Building is supplied with LTHW via 3No. Remeha floor standing gas fired condensing boilers located in the main plantroom. The boilers provide LTHW to VT circuits for central heating and CT circuits for AHUs.

The building is provided with comfort cooling via roof mounted packaged air-cooled chillers generating chilled water which feed the supply AHUs and fan coil units. Local cooling is provided to key areas (comms rooms etc.) via DX cooling systems.

The building is generally mechanically ventilated via a series of AHUs located in the roof plantroom. Mechanical extract ventilation is provided to toilets and cleaners stores etc.

Domestic Hot water is generated by 2No. Lochinvar gas fired water heaters and 2No. storage vessels.

30.1.4. Electrical Services

The electricity supply to Roland Levinsky is served with the privately owned HV electricity supply which terminates at a 1000kVA rated substation located within the building.

Power is distributed throughout from the main LV switch panel on the ground floor via vertical risers located throughout the building. The LV distribution system feeds local metered distribution boards on each level.

Lighting is generally provided via a variety of predominately fluorescent lamped luminaires with some LED luminaires, with manual switching and occupancy sensing controls serving communal, offices and teaching spaces.

30.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and water network consumption. The BMS records temperature data for the AHUs but does not record sub-metering data for the major items of plant and equipment.

30.1.6. BMS/Controls

We understand that the Roland Levinsky building operates via a Schneider Electric EcoStruxture Building Operation (EBO) BMS.

30.1.7. Condition & Operation

We understand that the building suffers from overheating in some areas during periods of hot weather and that heating performance is poor in some areas during cold weather.

The building was constructed in 2009 meaning the engineering services are approaching 15 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 5-10 years, subject to appropriate maintenance.

The engineering services generally appear to be in good condition.

30.1.8. Planned Future CAPEX Works

We understand that there are no CAPEX works planned for the Roland Levinsky Building.

30.1.9. Opportunities for Heat Networks

If suitable technology were installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Roland Levinsky Building to the 5DHC network when it becomes operational.

There is significant plant space available for additional equipment required to facilitate a heat pump installation as well as existing chiller plant located on the roof.

30.2 Energy & Carbon Emissions

30.2.1. The following table identifies the energy consumption and carbon emissions from the Roland Levinsky building based on the energy consumption figures provided from site.

Table 29.1 – Energy Consumption & Carbon Emissions – Roland Levinsky building

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	998,947 kWh	0.184 $kgCO_2e/kWh$	183.81 TCO_2e
Grid Electricity	1,065,231 kWh	0.105 $kgCO_2e/kWh$	111.85 TCO_2e
Total	2,064,178 kWh	N/A	295.66 TCO_2e

30.2.2. Table 5.45 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 13464.4m². The performance of Roland Levinsky building is very good with overall energy usage and carbon emissions around half the current benchmark. The figures correspond closely with those stated on the current DEC.

Table 29.2 – Energy Consumption & Carbon Emissions Benchmarking – Roland Levinsky building

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	74.19	13.65	240	44.16	86.26
Grid Electricity	79.11	8.31	80	8.40	81.52
Total	153.31	21.96	320	52.56	167.78

30.2.3. The building would have been constructed to 2013 building regulations therefore the thermal performance and energy efficiency standards should be very good when compared against typical University Campus building stock. The building was also constructed to achieve a BREEAM "Excellent" rating which would further enhance the energy performance of the building.

30.2.4. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2021 as the most recent full year. The metering data shows the energy consumption profile for Roland Levinsky building throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. The data shows an increase in electrical consumption through the winter when there is an increased demand for lighting however this is tempered by an increased demand for cooling in the summer which is provided via the cooling plant.

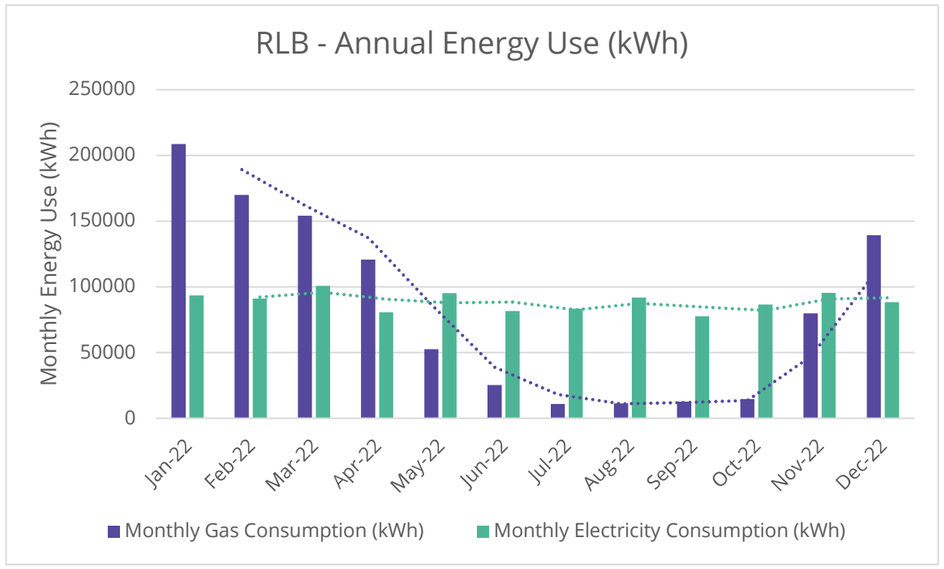


Fig. 30.2 Roland Levinsky building annual energy usage profile

30.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.880 which suggests a relatively strong correlation between degree days and heat consumption, however this value suggests there is some inherent inefficiency in the system or a lack of optimisation within the controls.

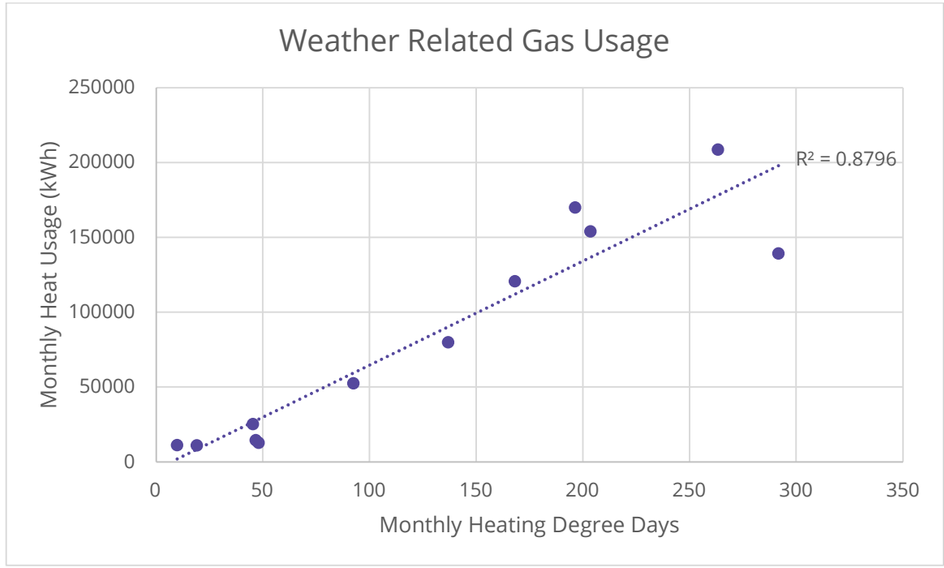


Fig. 30.3 Weather related heat usage compared to degree days

30.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

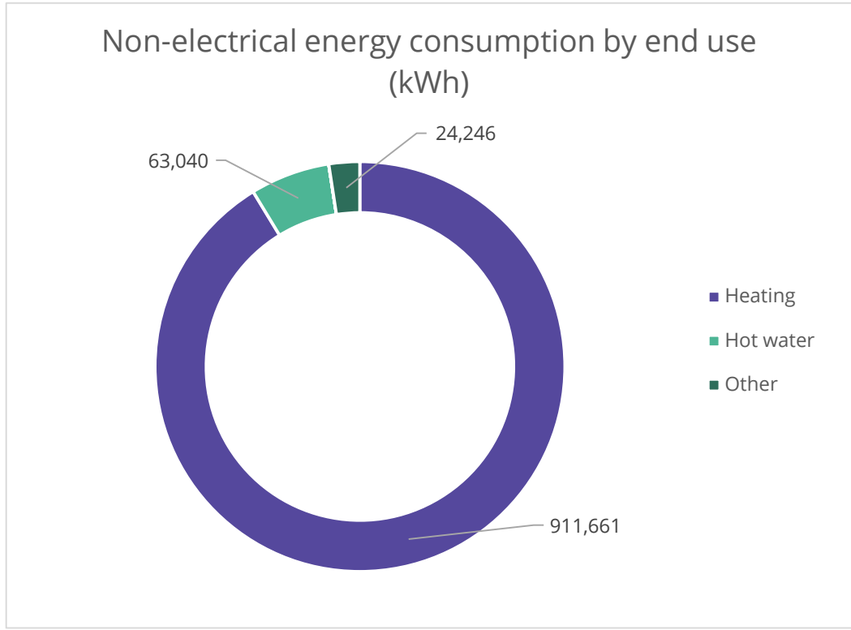


Fig. 30.4 Non-electrical energy consumption breakdown by end use

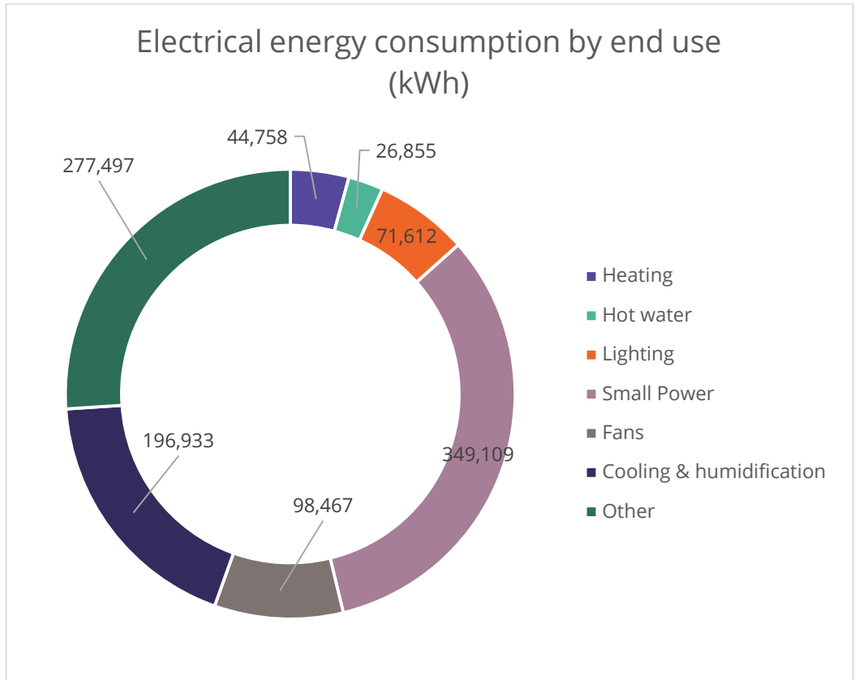


Fig. 30.5 Electrical energy consumption breakdown by end use

30.3 Technical Solution

30.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Roland Levinsky Building is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management states the existing wall insulation as being in fair condition therefore, these walls may benefit from internal and or external thermal insulation. However, we do recommend a thermographic survey to identify in detail the areas where meaningful improvements could be made to the thermal performance of the building envelope.

Option F2: The installation of new or additional roof insulation

The above-mentioned report states the existing roof insulation as being in fair condition. 'Refer to above comment for recommended thermographic survey'.

Option F3: Installation of reflective/ absorptive film on curtain glazing system to reduce heat gain

The above-mentioned report states the existing double windows as being in good condition, having been recently upgraded. 'Refer to above comment for a recommend a thermographic survey'. Subject to the findings of a thermographic survey, an additional option may be the installation of reflective/absorptive window film.

To assess the impact of installing a reflective/absorptive film we have assumed a 5% improvement in the cooling demand for the building due to reduced solar gain.

30.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Roland Levinsky Building. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Roland Levinsky Building we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

Option S7: Expansion of roof mounted solar PV installation.

With an available roof area of approximately 3000m² we anticipate that an additional 1,800m² of solar PV cells could be installed, subject to detailed design and structural feasibility assessment. This would also need to be considered within the design of the additional roof insulation and potential location of plant on the roof.

30.4 Energy & Carbon Savings – Roland Levinsky Building

Table 29.3 – Carbon savings summary – Roland Levinsky Building

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	88.26	£237,174	30	2,648	£90	£7,258	32.7
F2	Addition/replacement of roof insulation	89.09	£236,754	30	2,673	£89	£7,903	30.0
F3	Replacement of glazing to improve thermal performance	88.83	£0	20	1,777	£0	£7,697	0.0
F4		79.95	£0		0	£0	£803	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	205.39	£2,019,660	25	5,135	£393	£135,224	14.9
S2	Installation of new centralised domestic hot water generation, pipework and controls	81.31	£471,254	25	2,033	£232	£141,191	3.3
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	89.75	£168,305	20	1,795	£94	£26,988	6.2
S5	Addition of high efficiency fans, pumps and drives	79.43	£134,644	25	1,986	£68	£1,287	104.6
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£22,574	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	83.88	£576,000	15	1,258	£458	£12,355	46.6

30.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 1,000kW (based on a rule of thumb of 75W/m²) with the peak cooling demand of 970kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 213kW and 242kW for heating and cooling respectively.

30.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Roland Levinsky Building which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Roland Levinsky Building will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

31. Rolle building

31.1 Description of Building

31.1.1. General

The Rolle building is located to the west of the main campus site and houses the Plymouth Institute of Education. This building contains office and academic spaces with adjacent student accommodation and a pavilion-style refectory.



Fig. 31.1 Rolle Building

31.1.2. Building Fabric

The Rolle Building is a seven-storey building constructed 2008 comprising of a steel frame construction enclosed with a combination of powder coated aluminium framed units incorporating sealed double-glazed opening lights and stone and concrete cladding.

The roofs were not inspected however, from our review of 'Google Maps' the roofs are understood to comprise flat roofs covered with a proprietary membrane.

Powder coated aluminium framed doors incorporating double glazed units are provided to the main entrance and exit to the building.

During our inspection of Rolle Building, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe the condition of the double glazed-windows, wall insulation and rigid roof insulation boards to be fair. However, the detailed specification has not been provided.

It is recommended to consider a thermographic survey to identify in detail where improvements could be made to the thermal performance of the building envelope.

The anticipated works may include the upgrade of insulation to the walls and roofs. However, any potential works would be subject to a thermographic survey, review of as-built data, liaison with consultants and building control.

Subject to a review of liaison with consultants and a thermographic survey, the installation of window film may provide an area for the reduction in energy consumption.

31.1.3. Mechanical Services

The Rolle building is supplied with LTHW gas fired boilers located in the main plantroom. The LTHW system feeds wall mounted radiators and generates domestic hot water.

Local cooling is provided to key areas (comms rooms etc.) via DX cooling systems via roof mounted condensers.

The building is mechanically ventilated via roof mounted packaged AHUs fed via DX units however the majority of occupied areas are naturally ventilated via automatic opening windows. Mechanical extract ventilation is provided to toilets and cleaners stores etc.

31.1.4. Electrical Services

The electricity supply to Rolle is served with the privately owned HV electricity supply which terminates at a 1500kVA rated substation located within Francis Drake Building substation. The local network of LV submains cabling serves the Rolle Building.

Power is distributed throughout from the main LV switch panel on the ground floor via vertical risers located throughout the building. The LV distribution system feeds local metered distribution boards on each level.

Lighting is generally provided via a variety of fluorescent lamped luminaires with LED replacement luminaires to the theatre and occupancy sensing controls serving the spaces.

31.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and water consumption. The BMS provides sub-metering data for the electrical distribution system and major plant items. The full list of electrical sub-meters is included below:

- DB Lecture Theatre 1
- DB01
- Essential Services DB ES
- Riser 1
- Riser 2
- Riser 3
- Roof Plant AHU
- Roof Plant Mechanical Services

31.1.6. BMS/Controls

We understand that the Rolle Building services operate via an obsolete Andover Continuum BMS.

31.1.7. Condition & Operation

We understand that the building was constructed in 2007 meaning the engineering services are circa 15 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 5-10 years, subject to appropriate maintenance. We understand the window actuators are approaching end of life and that one of the boilers has been recently replaced.

The engineering services generally appear to be in good condition.

31.1.8. Planned Future CAPEX Works

We understand that a programme of capex works have been scheduled including the replacement of window actuators and new taps.

31.1.9. Opportunities for Heat Networks

If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Rolle Building to the 5DHC network when it becomes operational.

31.2 Energy & Carbon Analysis

31.2.1. The following table identifies the energy consumption and carbon emissions from the Rolle building based on the energy consumption figures provided from site.

Table 30.1 – Energy Consumption & Carbon Emissions – Rolle building

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	220,117 kWh	0.184 $kgCO_2e/kWh$	40.50 TCO_2e
Grid Electricity	321,596 kWh	0.105 $kgCO_2e/kWh$	33.77 TCO_2e
Total	541,713 kWh	N/A	74.27 TCO_2e

31.2.2. Table 5.47 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 6754.1m². The performance of Rolle building is very good with overall energy usage and carbon emissions around half the current benchmark. The figures correspond closely with those stated on the current DEC.

Table 30.2 – Energy Consumption & Carbon Emissions Benchmarking – Rolle building

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	32.59	6.00	240	44.16	38.30
Grid Electricity	47.61	5.00	80	8.40	51.13
Total	80.21	11.00	320	52.56	89.43

31.2.3. The building would have been constructed to 2000/2006 building regulations therefore the thermal performance and energy efficiency standards should be reasonable when compared against typical University Campus building stock.

31.2.4. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2022 as the most recent full year. The metering data shows the energy consumption profile for Rolle building throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays.

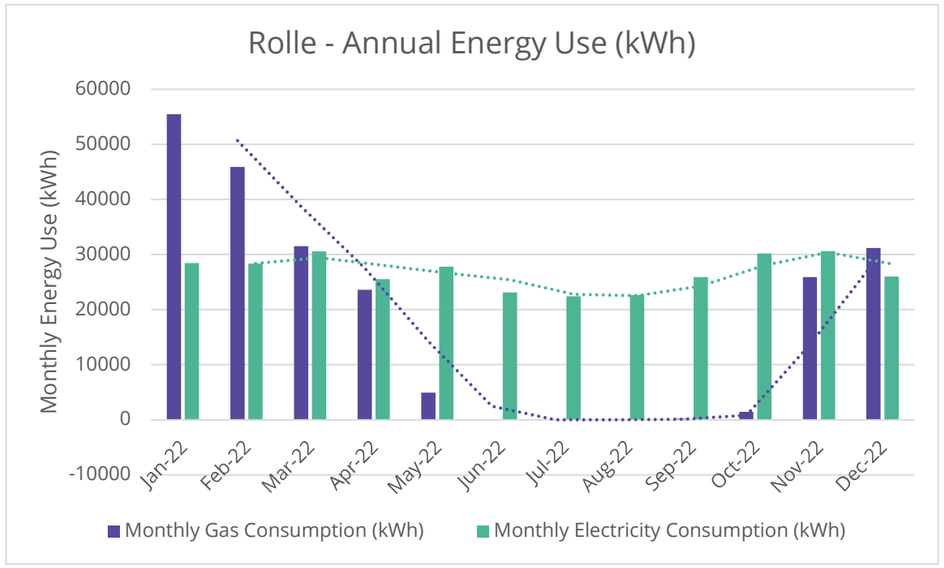


Fig. 31.2 Rolle building annual energy usage profile

31.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.817 which suggests a reasonable correlation between degree days and heat consumption, however this value suggests there is some inherent inefficiency in the system.

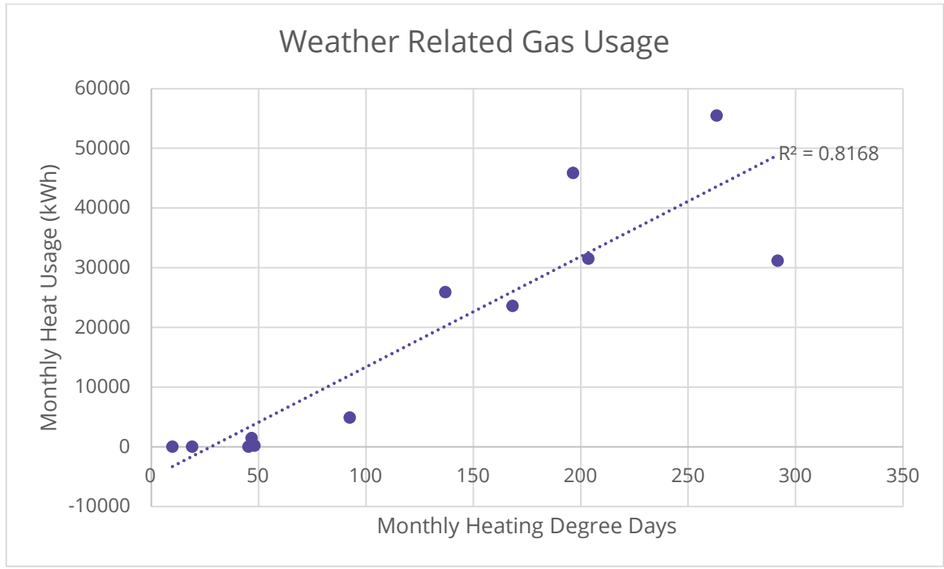


Fig. 31.3 Weather related heat usage compared to degree days

31.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

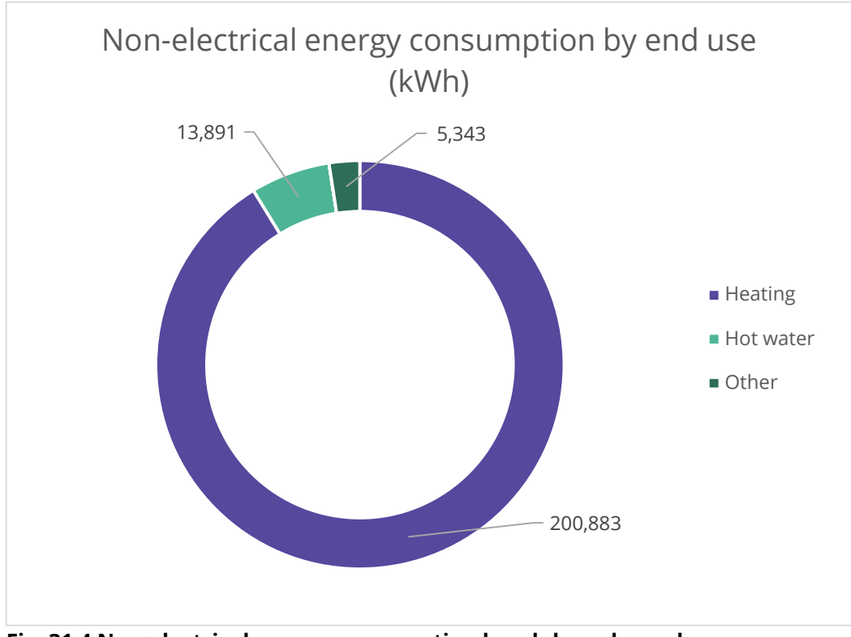


Fig. 31.4 Non-electrical energy consumption breakdown by end use

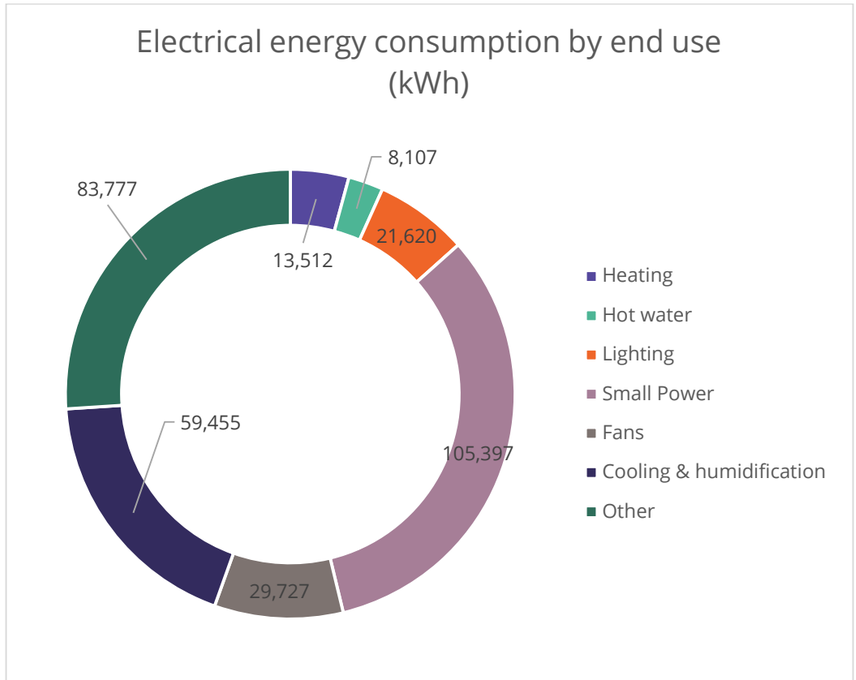


Fig. 31.5 Electrical energy consumption breakdown by end use

31.3 Technical Solution

31.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Rolle Academic Building is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management states the external wall insulation as being in fair condition therefore, these walls may benefit from internal and or external thermal insulation. However, we do recommend a thermographic survey to identify in detail the areas where meaningful improvements could be made to the thermal performance of the building envelope.

Option F2: The installation of new or additional roof insulation

The above-mentioned report states the existing roof insulation as being in fair condition. 'Refer to above comment for recommended thermographic survey'.

Option F3: Installation of reflective/ absorptive film on curtain glazing system to reduce heat gain

The above-mentioned report states the existing double windows as being in good condition. 'Refer to above comment for a recommend a thermographic survey'. Subject to the findings of a thermographic survey, an additional option may be the installation of reflective/absorptive window film.

To assess the impact of installing a reflective/absorptive film we have assumed a 5% improvement in the cooling demand for the building due to reduced solar gain.

31.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Rolle Academic Building. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Rolle Academic Building we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

31.4 Energy & Carbon Savings – Rolle Academic Building

Table 30.3 – Carbon savings summary – Rolle Academic Building

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	19.61	£51,518	30	588	£88	£1,723	29.9
F2	Addition/replacement of roof insulation	19.80	£133,616	30	594	£225	£1,876	71.2
F3	Replacement of glazing to improve thermal performance	19.74	£583,451	20	395	£1,478	£1,828	319.2
F4		0.00	£0		0	£0	£0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	47.32	£1,013,115	25	1,183	£856	£34,947	29.0
S2	Installation of new centralised domestic hot water generation, pipework and controls	17.98	£168,853	25	449	£376	£36,408	4.6
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	20.23	£202,623	20	405	£501	£7,083	28.6
S5	Addition of high efficiency fans, pumps and drives	17.55	£67,541	25	439	£154	£389	173.8
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	15	0	£0	£0	0.0

31.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 507kW (based on a rule of thumb of 75W/m²) with the peak cooling demand of 486kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 107kW and 122kW for heating and cooling respectively.

31.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Rolle Academic Building which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Rolle Academic Building will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

32. Sherwell Centre (Lecture Theatre)

32.1 Description of Building

32.1.1. General

The Sherwell Centre is a converted church building located to the east of the main campus site containing two large lecture theatres and exhibition space for both internal and external parties.



Fig. 32.1 Sherwell Centre (Lecture Theatre)

32.1.2. Building Fabric

The Sherwell Centre (Lecture Theatre) is originally a building of worship. The 'gothic' style building was constructed circa 1860's comprising of masonry construction with faced stonework elevations, stone mullions to openings, lead-glazed windows. More recent refurbishment has added powder coated aluminium framed ground floor entrance and metal rain screen cladding to localised areas.

The roofs were not inspected however, from street level and our review of 'Google Maps' the roofs are understood to comprise pitched roofs covered with roof tiles.

During our inspection of Sherwell Centre (Lecture Theatre), we observe general weathering to mortar bed joints and moss/lichen covered roofs. From information provided by site management we believe there is no wall insulation. The condition of the glass rock and mineral wool insulation to the roofs is recorded as poor. The detailed specification has not been provided.

We would recommend consideration is given to the provision and upgrade of insulation to the walls and roofs respectively. Any potential insulation installation/upgrade would be subject to liaison with consultants and listed building/planning consent.

We assume the potential works would require listed building consent therefore, greater thought is required as to how best to enhance existing windows and openings to attain the desired reduction in energy consumption.

Given the type of construction, it is recommended to consider a thermographic survey to identify in detail where improvements could be made to the thermal performance of the building envelope.

32.1.3. Mechanical Services

The Sherwell Centre (Lecture Theatre) is supplied with LTHW via domestic type gas fired condensing combi boilers which generate instantaneous domestic hot water. The LTHW system feeds fan coil units.

There are no cooling systems present.

The building is generally naturally ventilated however the central atrium area is provided with supply and extract ventilation via an AHU located in the roof space. Mechanical extract ventilation is provided to toilets and cleaners stores etc.

32.1.4. Electrical Services

The electricity supply to Sherwell Centre is served with a metered Low Voltage (LV) three phase electricity supply derived from the electricity supply network operated by the local district network operator.

Power is distributed throughout from the main LV main switch gear and local distribution board on the ground floor via final circuits to sockets and lighting installation.

Lighting is generally provided via a variety of fluorescent lamped luminaires and replacement LED lighting with manually switched lighting controls serving communal and training spaces.

32.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and water consumption. The BMS also records gas consumption data.

32.1.6. BMS/Controls

We understand that the Sherwell Centre services operate via a Schneider Electric EcoStruxture Building Operation (EBO) BMS.

32.1.7. Condition & Operation

We understand that the building was constructed in 1800s however it was subjected to a significant refurbishment in 2018 meaning the engineering services are circa 5 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 15-20 years, subject to appropriate maintenance.

The engineering services generally appear to be in good condition.

32.1.8. Planned Future CAPEX Works

We understand that there are currently no CAPEX works planned for the Sherwell Centre.

32.1.9. Opportunities for Heat Networks

If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Sherwell Centre (Lecture Theatre) to the 5DHC network when it becomes operational.

32.2 Energy & Carbon Emissions

32.2.1. The following table identifies the energy consumption and carbon emissions from the Sherwell Centre (Lecture Theatre) based on the energy consumption figures provided from site.

Table 31.1 – Energy Consumption & Carbon Emissions – Sherwell Centre (Lecture Theatre)

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	66,316 kWh	0.184 $kgCO_2e/kWh$	12.20 TCO_2e
Grid Electricity	184,467 kWh	0.105 $kgCO_2e/kWh$	19.37 TCO_2e
Total	250,783 kWh	N/A	31.57 TCO_2e

32.2.2. Table 5.49 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 1,974.1m². The performance of Sherwell Centre (Lecture Theatre) is very good with overall energy usage and carbon emissions around half the current benchmark. The figures correspond favourably with those stated on the current DEC.

Table 31.2 – Energy Consumption & Carbon Emissions Benchmarking – Sherwell Centre

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	33.59	6.18	240	44.16	58.75
Grid Electricity	93.44	9.81	80	8.40	82.76
Total	127.04	15.99	320	52.56	141.51

32.2.3. The building is a former church constructed using predominantly stone therefore the thermal performance and energy efficiency standards should be reasonable when compared against typical University Campus building stock.

32.2.4. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2021 as the most recent full year. The metering data shows the energy consumption profile for Sherwell Centre (Lecture Theatre) throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays.

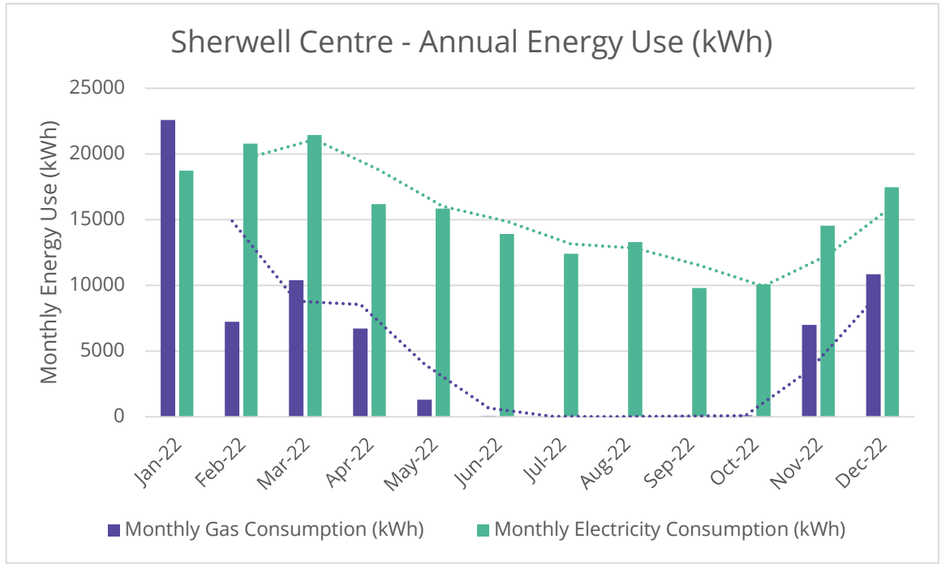


Fig. 32.2 Sherwell Centre (Lecture Theatre) annual energy usage profile

32.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.774 which suggests a reasonable correlation between degree days and heat consumption, however this value suggests there is some inherent inefficiency in the system. This can be explained by the building fabric properties.

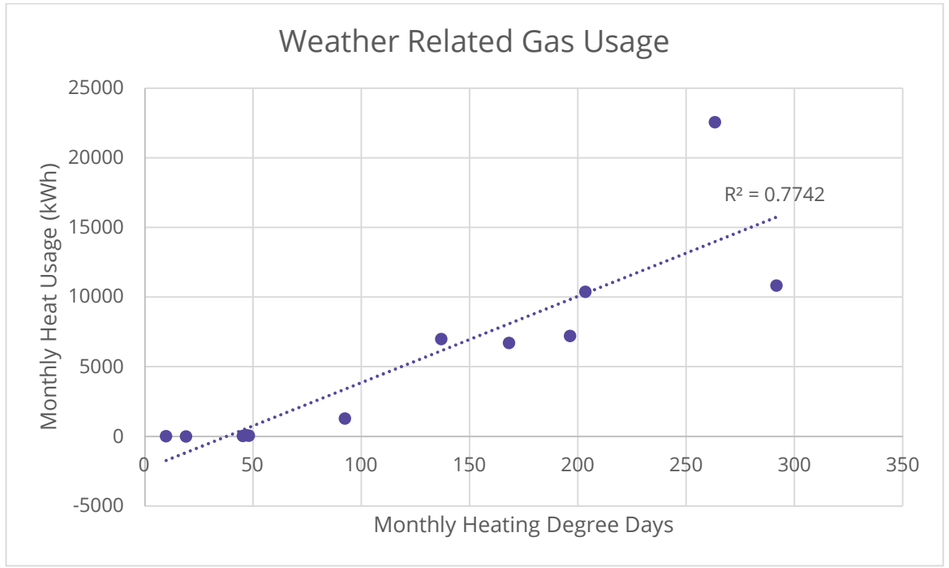


Fig. 32.2 Weather related heat usage compared to degree days

32.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

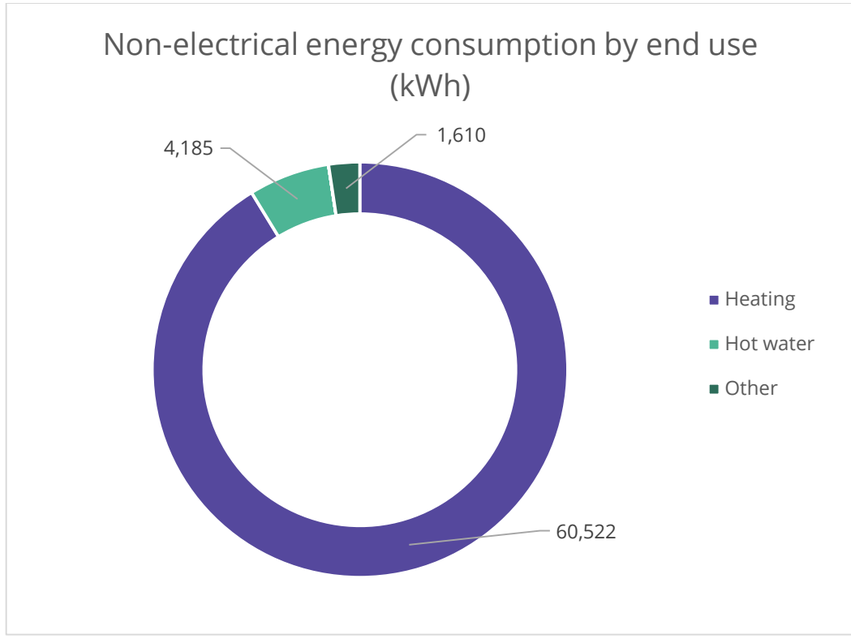


Fig. 32.4 Non-electrical energy consumption breakdown by end use

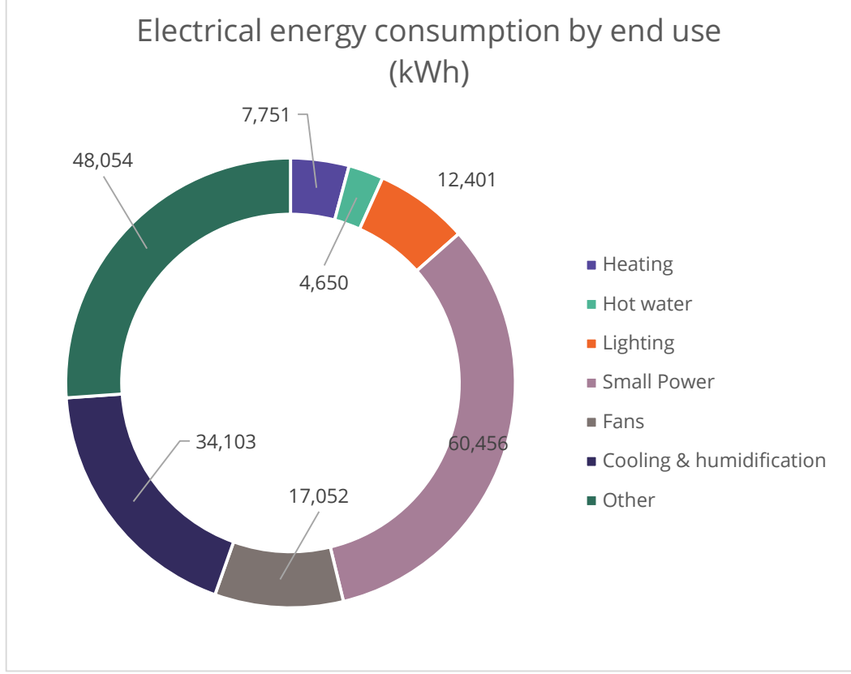


Fig. 32.5 Electrical energy consumption breakdown by end use

32.3 Technical Solution

32.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Sherwell Centre (Lecture Theatre) is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management states there is no thermal wall insulation which is typical for this type/construction date. However, we do recommend a thermographic survey to identify in detail the areas where meaningful improvements could be made to the thermal performance of the building envelope. Whilst we have observed some more recent alterations to the building, we anticipate any proposed works would be subject to local planning authority/listed building consent.

Option F2: The installation of new or additional roof insulation

The above-mentioned report states the existing roof insulation as being in poor condition. 'Refer to above comment for recommended thermographic survey'. Any anticipated works would be subject to intrusive inspection and liaison with consultants.

Option F3: Installation of replacement windows

The above-mentioned report states the existing single glazed windows as being in poor. The existing windows comprise leaded windows 'some incorporate stained glass' within stone mullions. We envisage upgrade recommendation to be limited to internal secondary type glazing/screens. 'Refer to above comment for a recommend a thermographic survey'.

32.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Sherwell Centre (Lecture Theatre). The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Sherwell Centre (Lecture Theatre) we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

32.4 Energy & Carbon Savings – Sherwell Centre

Table 31.3 – Carbon savings summary – Sherwell Centre (Lecture Theatre)

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	7.94	£34,774	30	238	£146	£2,098	16.6
F2	Addition/replacement of roof insulation	8.08	£34,712	30	242	£143	£2,205	15.7
F3	Replacement of glazing to improve thermal performance	7.39	£247,314	20	148	£1,674	£1,670	148.1
F4			£0		0	£0	£139	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	9.26	£296,115	25	231	£1,279	-£1,918	-154.4
S2	Installation of new centralised domestic hot water generation, pipework and controls	5.47	£19,741	25	137	£144	-£1,332	-14.8
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	6.56	£24,676	20	131	£188	£3,279	7.5
S5	Addition of high efficiency fans, pumps and drives	5.33	£19,741	25	133	£148	£223	88.5
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£718	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	15	0	£0	£0	0.0

32.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 197kW (based on a rule of thumb of 100W/m²) with the peak cooling demand of 142kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 42kW and 36kW for heating and cooling respectively.

32.6 Key Risks & Challenges

The Sherwell Centre is noted by Historic England as having listed status. This will need to be considered during the planning and design stages for the proposed solution.

It is likely that the available electrical capacity for Sherwell Centre (Lecture Theatre) will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

33. Skardon Place (Greenhouses)

33.1 Description of Building

Skardon Place Greenhouses are located to the north-east of the main campus site, accessed from Alexandra Road via Skardon Place. The building is used for horticultural research as a potting shed.



Fig. 33.1 Skardon Place Greenhouses

33.1.1. Building Fabric

Skardon Place Greenhouses comprises 3No. Tomtech computerised glasshouses. The glasshouses are single-storey, steel-framed structures with fully-glazed facades. We have not analysed the building fabric of this structure due to the nature of its use.

33.1.2. Mechanical Services

The Rolle Marquee is provided with high-level gas fired radiant heaters mounted to metal trunkig which is suspended from the roof frame.

33.1.3. Electrical Services

The electricity supply serving Skardon Place is derived from the Low Voltage (LV) installation from the adjacent building.

The glasshouses contain small power installations via surface mounted containment and accessories. Lighting is provided via suspended fluorescent linear luminaires with manual control.

The glasshouses are provided with 10No. solar PV panels.

33.1.4. Metering

Skardon Place Greenhouses are independently sub-metered for gas and water consumption, however we do not have data for electricity consumption and have relied on bulk figures provided by the University estates team.

33.1.5. Condition & Operation

The glasshouses and services are generally considered to be in fair condition.

33.1.6. Planned Future CAPEX Works

We understand that there are currently no CAPEX works planned for Skardon Place Greenhouses.

33.1.7. Opportunities for Heat Networks

None applicable.

33.2 Energy & Carbon Emissions

33.2.1. The following table identifies the energy consumption and carbon emissions from the Rolle Marquee based on the energy consumption figures provided from site.

Table 36.1 – Energy Consumption & Carbon Emissions – Rolle Marquee

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	931,054 kWh	0.184 $kgCO_2e/kWh$	171.31 TCO_2e
Grid Electricity	20,121 kWh	0.105 $kgCO_2e/kWh$	2.11 TCO_2e
Total	951,175 kWh	N/A	173.43 TCO_2e

33.2.2. Table 5.59 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values. There is no standardised benchmark value for energy consumption within greenhouses, however we have sourced anecdotal evidence suggesting average energy consumption is around 330kWh/m². The figures below are based on a Gross Internal Area (GIA) of 216.7m². The performance of Skardon Place greenhouses is poor compared to the benchmarks. The building is not provided with an EPC or DEC.

Table 36.2 – Energy Consumption & Carbon Emissions Benchmarking – Rolle Marquee

Fuel Type	(Actual 2021)		Typical Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	4,296.51	790.56	-	-	N/A
Grid Electricity	92.85	9.75	-	-	N/A
Total	4,389.36	800.31	330	52.56	N/A

33.2.3. Gas meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2022 as the most recent full year. The metering portal does not provide detailed data for electrical consumption.

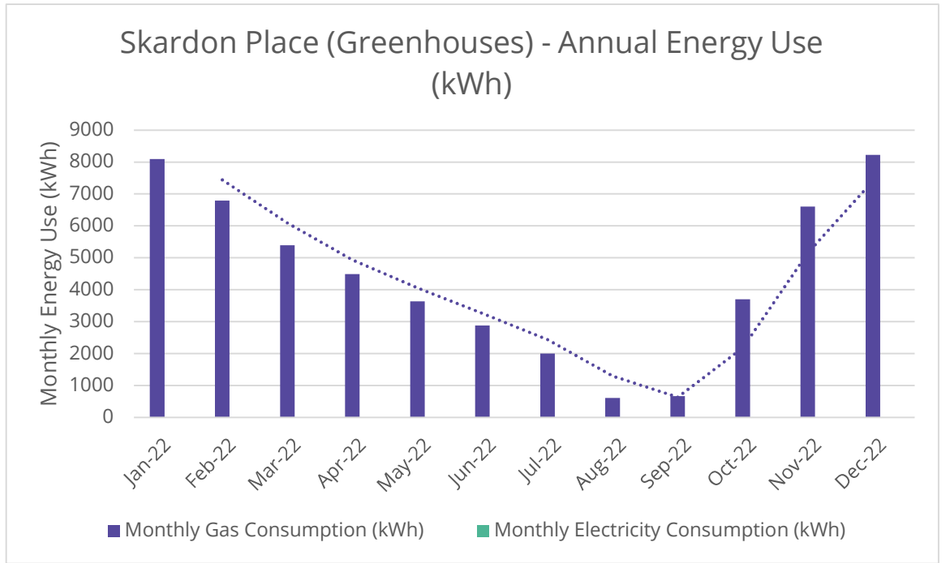


Fig. 33.2 Skardon Place annual energy usage profile

33.2.4. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. Although the gas consumption values are erroneous, the resulting trend line demonstrates a correlation coefficient of 0.844 which suggests a relatively strong correlation between degree days and heat consumption.

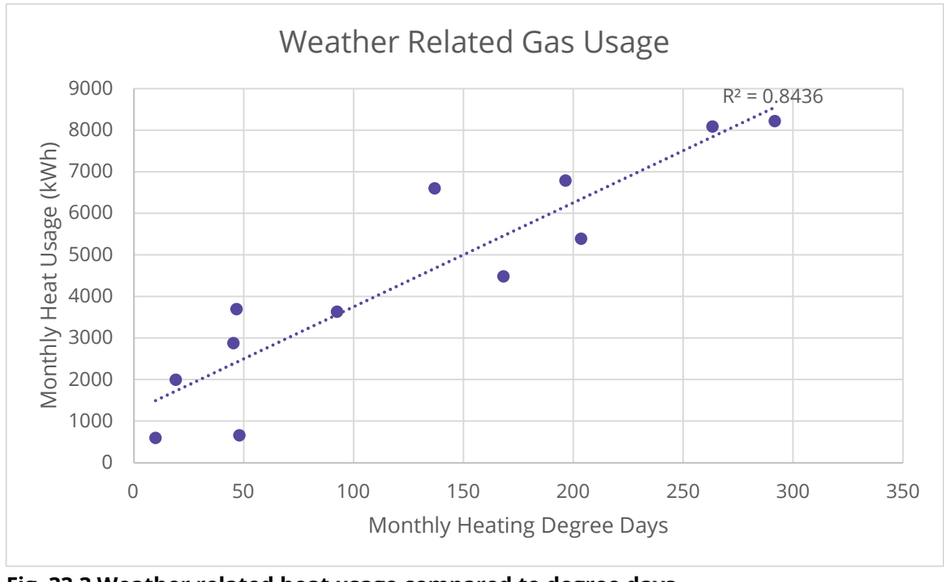


Fig. 33.3 Weather related heat usage compared to degree days

33.2.5. We have analysed the estimated energy consumption by end use according our understanding of the use of the facility.

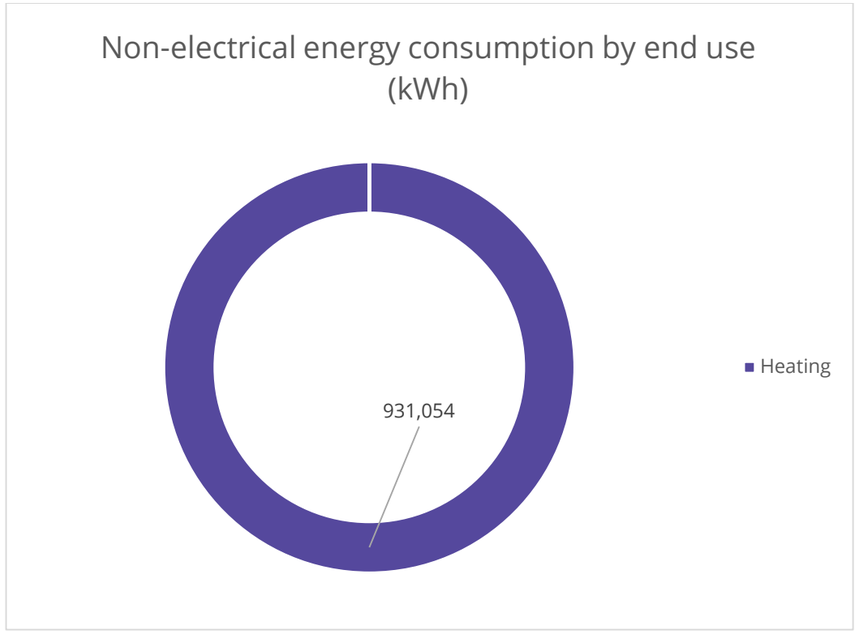


Fig. 33.4 Non-electrical energy consumption breakdown by end use

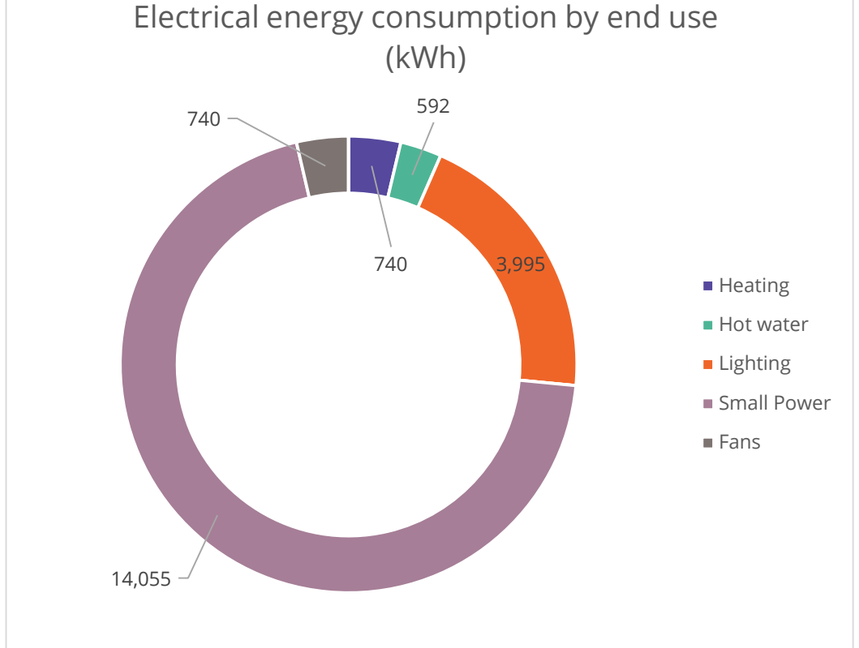


Fig. 33.5 Electrical energy consumption breakdown by end use

33.3 Technical Solution

33.3.1. Building Fabric Solution

We have not considered any technical solutions to the building fabric due to the specialist nature of the facility.

33.3.2. Building Services Solution

The nature of the facility means that the typical solutions being considered across the rest of the portfolio are not generally appropriate for Skardon Place, with the exception of S3 which would involve the replacement of existing fluorescent lighting with new LED technology and controls.

Decarbonisation of the heating system could be achieved by replacing the gas fired radiant heaters with infrared electric heaters. Although this would result in an increase in electricity consumption and peak power demand, the switch to electric heating would reduce carbon emissions and remove direct carbon emissions from the building.

33.4 Energy & Carbon Savings – Skardon Place Greenhouses

Table 32.3 – Carbon savings summary – Skardon Place

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	0.00	£0	30	0	0	0	0.0
F2	Addition/replacement of roof insulation	0.00	£0	30	0	0	0	0.0
F3	Replacement of glazing to improve thermal performance	0.00	£0	20	0	0	0	0.0
F4		0.00	£0		0	0	0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	0.00	£0	25	0	0	0	0.0
S2	Installation of new centralised domestic hot water generation, pipework and controls	0.00	£0	25	0	0	0	0.0

S3	Replacement of existing lighting with LED technology and upgraded controls	73.70	£17,336	15	1,106	£16	£366	47.4
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	0.00	£0	20	0	0	0	0.0
S5	Addition of high efficiency fans, pumps and drives	0.00	£0	25	0	0	0	0.0
S6	Installation of heat recovery on air systems	0.00	£0	0	0	0	0	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	15	0	0	0	0.0
-	Replacement of gas heating with infrared electric heaters and controls	75.78	£13,002	15	1,137	£11	£5,550	2.3

33.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 22kW (based on a rule of thumb of 100W/m²). Assuming system efficiencies in line with Table 4.1 (100% for electric heating) provides an indicative increase in electrical load of circa 22kW.

33.6 Key Risks & Challenges

It is likely that the available electrical capacity for Skardon Place will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The replacement of gas heating with infrared electric heating will need to be considered in the context of the use of the building and whether it is compatible with the nature of operation.

34. Student Union

34.1 Description of Building

34.1.1. General

The Student Union building is located toward the south of the main campus site, adjacent to the Davy building. The building houses the bar and night club for the University's Student Union.



Fig. 34.1 Student Union

34.1.2. Building Fabric

The Student Union is a three-storey building constructed circa 1970's comprising of a masonry frame construction with a combination of faced brickwork, metal cladding and powder coated aluminium framed units incorporating sealed double-glazed opening lights and glazed shop frontage.

The roofs were not inspected however, from our review of 'Google Maps; the roofs are understood to comprise shallow sloped roofs covered with metal roof sheets.

Powder coated aluminium framed doors incorporating double glazed units are provided to the main entrance and exit to the building.

During our inspection of Student Union, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe the cavity wall insulation and rigid roof insulation boards are in fair and poor condition respectively. However, the detailed specification has not been provided.

It is recommended to consider a thermographic survey to identify in detail where improvements could be made to the thermal performance of the building envelope.

Consideration should be s given to the upgrade of insulation to the walls and roofs subsequent to clarification of the existing. Any potential insulation upgrade would be subject to liaison with consultants and building control.

The above-mentioned records the condition of the double-glazed windows as fair. The application of window film may provide an area for considered upgrade. Subject to a review of a thermographic survey, as-built data, and liaison with consultants.

34.1.3. Mechanical Services

The Students Union is supplied with LTHW via dedicated gas fired boiler plant located in the main plantroom. The LTHW system feeds wall mounted radiators.

The building is generally naturally ventilated via roof turrets and opening windows. Mechanical extract ventilation is provided to toilets and cleaners stores etc. and to the commercial kitchens.

Domestic Hot water is generated by the LTHW system via hot water calorifier.

34.1.4. Electrical Services

Power is distributed throughout from the main LV switch panel on the ground floor via vertical risers located throughout the building. The LV distribution system feeds local metered distribution boards on each level.

Lighting is generally provided via fluorescent luminaires with manual switching.

34.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The BMS provides sub-metering data for the electrical system including kitchens and other building areas.

34.1.6. Condition & Operation

We understand that the building was constructed in the 1970s however was subjected to a major refurbishment in 2016 meaning the engineering services are circa 7 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 13-18 years, subject to appropriate maintenance.

The engineering services generally appear to be in good condition however we understand that the controls/BMS is in poor condition and requires renewal/refurbishment.

34.1.7. Planned Future CAPEX Works

We understand that a programme of capex works to replace existing lighting with LED is scheduled for the short term.

34.1.8. Opportunities for Heat Networks

The building is adjacent to the Davy energy centre. Any changes to the energy centre for the purposes of enabling the proposed 5DHC would allow the addition of the Student Union to the network.

If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Student Union to the 5DHC network when it becomes operational.

34.2 Energy & Carbon Emissions

34.2.1. The following table identifies the energy consumption and carbon emissions from the Student Union based on the energy consumption figures provided from site.

Table 32.1 – Energy Consumption & Carbon Emissions – Student Union

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	931,054 kWh	0.184 $kgCO_2e/kWh$	171.31 TCO_2e
Grid Electricity	394,172 kWh	0.105 $kgCO_2e/kWh$	41.39 TCO_2e
Total	1,325,226 kWh	N/A	212.70 TCO_2e

34.2.2. Table 5.51 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for Restaurant buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 2,583m². The performance of Student Union exceeds the current benchmarks overall. The figures correspond reasonably closely with those stated on the current DEC.

Table 32.2 – Energy Consumption & Carbon Emissions Benchmarking – Student Union

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	360.45	66.32	370	70.3	304.93
Grid Electricity	152.60	16.02	90	49.5	170.89
Total	513.06	82.35	460	119.8	475.72

34.2.3. The building would have been constructed to 1980's building regulations therefore the thermal performance and energy efficiency standards are likely to be average when compared against typical University Campus building stock.

34.2.4. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2021 as the most recent full year. The metering data shows the energy consumption profile for Student Union however erroneous values within the gas readings prevent an accurate analysis of the annual energy profile.

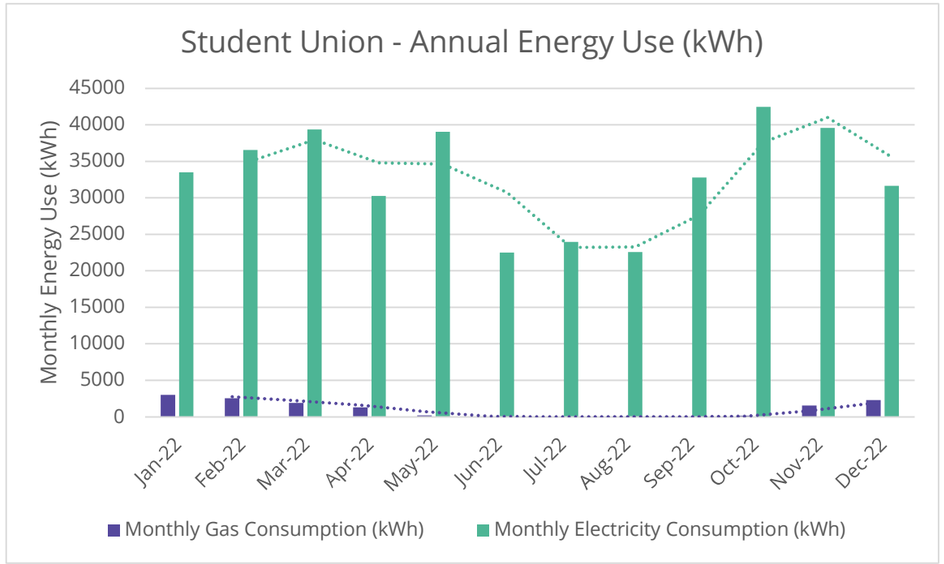


Fig. 34.2 Student Union annual energy usage profile

34.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. Although the gas consumption values are erroneous, the resulting trend line demonstrates a correlation coefficient of 0.889 which suggests a relatively strong correlation between degree days and heat consumption, however this data cannot be relied upon as accurate.

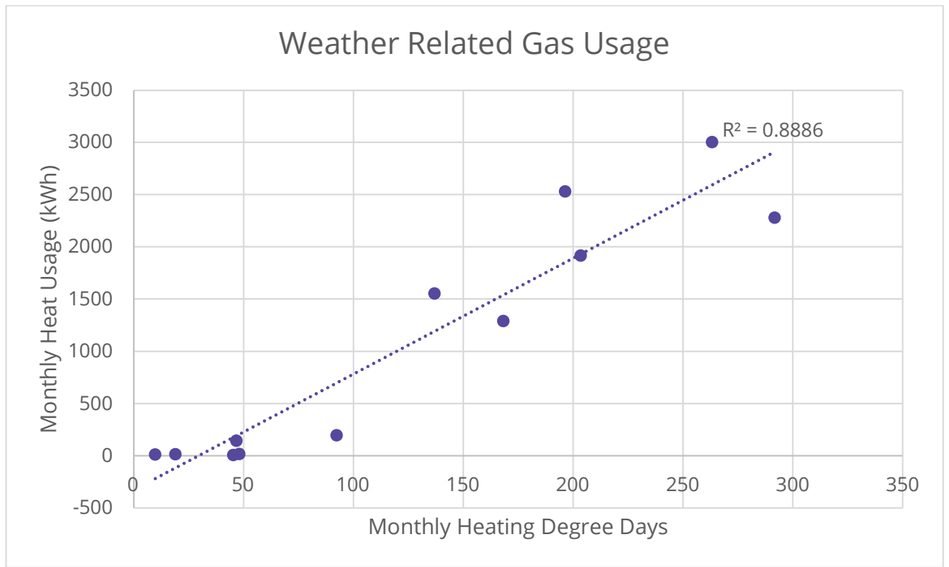


Fig. 34.3 Weather related heat usage compared to degree days

34.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

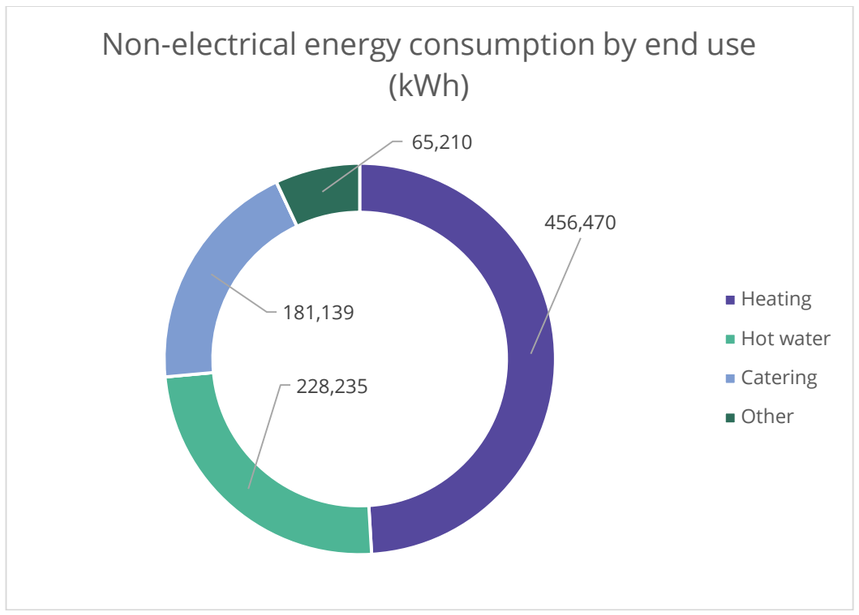


Fig. 34.4 Non-electrical energy consumption breakdown by end use

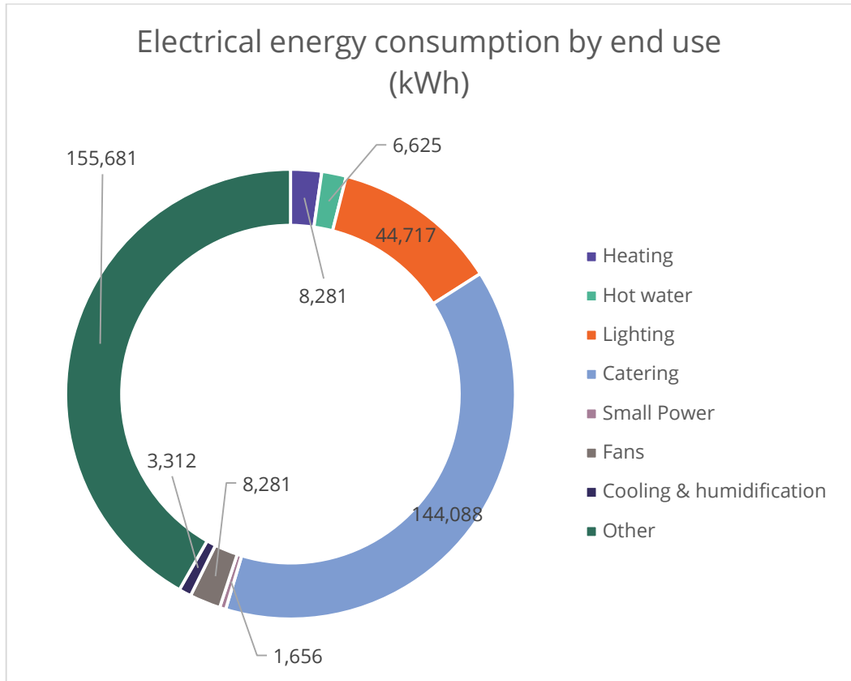


Fig. 34.5 Electrical energy consumption breakdown by end use

34.3 Technical Solution

34.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Student Union is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management states the existing cavity wall insulation as being in fair condition. There may be opportunity to upgrade the existing wall insulation however, we do recommend a thermographic survey to identify in detail the areas where meaningful improvements could be made to the thermal performance of the building envelope.

Option F2: The installation of new or additional roof insulation

The above-mentioned report states the existing roof insulation as being in poor condition. Subject to review of as-built data and intrusive inspection there be opportunity to provide internal/external insulation upgrade. Any external upgrade would require an over-clad scheme, the more intrusive option would be wholesale refurbishment. If external upgrade is to be considered this may have to be undertaken in conjunction with upgrade to the elevations as a raised roof would alter the juncture between roof and elevation walls. The considered works would be subject to review of as-built data and liaison with consultants. 'Refer to above comment for recommended thermographic survey'.

Option F3: Installation of reflective/ absorptive film on curtain glazing system to reduce heat gain

The above-mentioned report states the existing double windows as being in fair condition. Wholesale replacement is an option to consider but alternatively the provision of reflective/absorptive window film may provide suitable benefit. 'Refer to above comment for a recommend a thermographic survey'.

To assess the impact of installing a reflective/absorptive film we have assumed a 5% improvement in the cooling demand for the building due to reduced solar gain.

34.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Student Union. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Student Union we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

34.4 Energy & Carbon Savings – Student Union

Table 32.3 – Carbon savings summary – Student Union

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	85.90	£45,499	30	2,577	18	9,593	4.7
F2	Addition/replacement of roof insulation	86.53	£45,419	30	2,596	17	10,080	4.5
F3	Replacement of glazing to improve thermal performance	83.38	£323,597	20	1,668	194	7,636	42.4
F4		0.00	£0		0	0	0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	93.05	£387,450	25	2,326	167	-118,950	-3.3
S2	Installation of new centralised domestic hot water generation, pipework and controls	79.81	£90,405	25	1,995	45	-103,361	-0.9
S3	Replacement of existing lighting with LED technology and upgraded controls	75.20	£206,640	0	0	0	4,093	50.5
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	78.69	£32,288	20	1,574	21	12,793	2.5
S5	Addition of high efficiency fans, pumps and drives	73.60	£25,830	25	1,840	14	108	238.6
S6	Installation of heat recovery on air systems	0.00	£0	0	0	0	0	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	15	0	0	0	0.0

34.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 258kW (based on a rule of thumb of 75W/m²) with the peak cooling demand of 186kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 54kW and 46kW for heating and cooling respectively.

34.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Student Union which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Student Union will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

35. Thomas Pitts Hall

35.1 Description of Building

35.1.1. General

Thomas Pitts Hall is located approximately 250m south-east of the main campus site. The building comprises a sports hall with changing facilities, toilets and storage for sports equipment.



Fig. 35.1 Thomas Pitts Hall

35.1.2. Building Fabric

Thomas Pitts Hall is a single-storey building with lower ground provision constructed circa 1904 comprising of a masonry construction incorporating single-glazed opening lights and cement render elevation finishes.

The roofs were not inspected however, from street level and our review of Google Maps the roofs are understood to comprise pitched roofs with tile roof coverings.

Timber panel single and double doors are provided to the main entrance and exit to the building.

During our inspection of Thomas Pitts Hall, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe there is no wall insulation. The glass rock and mineral wool roof insulation is recorded as poor. A detailed specification has not been provided.

It is recommended to consider a thermographic survey to identify in detail where improvements could be made to the thermal performance of the building envelope.

We would anticipate enhancement works to include provision and upgrade of insulation to the walls and roofs respectively. These anticipated works would be subject to a thermographic survey, liaison with consultants and building control.

Ideally the existing timber framed single-glazed windows would be replaced. However, this would subject to the above-mentioned report findings, liaison with consultants and possible listed building/planning consent.

35.1.3. Mechanical Services

Thomas Pitts Hall is provided with gas fired heating via radiant tube heaters installed in the main hall. The changing areas and toilets are heated via gas fired boiler and radiators.

There are no cooling systems present in Thomas Pitts Hall.

The main sports hall is provided with supply air via a ducted fan feeding a central supply duct and nozzle diffusers. Opening windows are provided at high level. Mechanical extract ventilation is provided to toilets and cleaners stores etc.

Domestic Hot water is generated by the DHN via a central hot water calorifier.

35.1.4. Electrical Services

The electricity supply to Thomas Pitts Hall is served with a metered Low Voltage (LV) three phase electricity supply derived from the electricity supply network operated by the local district network operator.

Power is distributed throughout from the main LV main switch gear and local distribution board on the ground floor via final circuits to sockets and lighting installation.

Lighting is generally provided via a variety of LED luminaires, with some evidence of fluorescent luminaires replaced for LED equivalents with manually switched lighting controls serving communal and training spaces.

35.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and heat network consumption. The system provides data for the gas consumption, however there is no dedicated sub-metering data for Thomas Pitts Hall in respect of electricity therefore we have relied on data provided by the estates team for analysis

35.1.6. Condition & Operation

We understand that the building was constructed prior to 1950. The engineering services are circa 15-20 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 5-10 years, subject to appropriate maintenance.

The engineering services generally appear to be in poor condition and would benefit from renewal/refurbishment in the short term.

35.1.7. Planned Future CAPEX Works

We understand that there are no current capex works scheduled for Thomas Pitts Hall.

35.1.8. Opportunities for Heat Networks

The building is remote from the main campus however is within the PCC area of opportunity for heat networks. If suitable technology is installed as part of any planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Reynolds Building to a future heat network if and when it becomes operational.

35.2 Energy & Carbon Emissions

35.2.1. The following table identifies the energy consumption and carbon emissions from the Thomas Pitts Hall based on the energy consumption figures provided from site.

Table 33.1 – Energy Consumption & Carbon Emissions – Thomas Pitts Hall

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	78,930 kWh	0.184 $kgCO_2e/kWh$	14.52 TCO_2e
Grid Electricity	13,778 kWh	0.105 $kgCO_2e/kWh$	1.45 TCO_2e
Total	92,708 kWh	N/A	15.97 TCO_2e

35.2.2. Table 5.53 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for a dry sports and leisure facility and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 505.7m². The performance of Thomas Pitts Hall is very good with overall energy usage and carbon emissions around half the current benchmark. We would suggest this is due to limited usage of the facility compared with benchmark values. There is no current DEC available.

Table 33.2 – Energy Consumption & Carbon Emissions Benchmarking – Thomas Pitts Hall

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	156.08	28.72	330	62.7	N/A
Grid Electricity	27.25	2.86	95	52.3	N/A
Total	183.33	31.58	425	115.0	N/A

35.2.3. The building was constructed before 1950 therefore the thermal performance and energy efficiency standards a likely to be poor when compared against typical University Campus building stock.

35.2.4. Gas meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2021 as the most recent full year. The metering data shows the energy consumption profile for Thomas Pitts Hall throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. We have not been able to extract electrical consumption information from the Portal therefore we are unable to analyse the electrical energy profile.

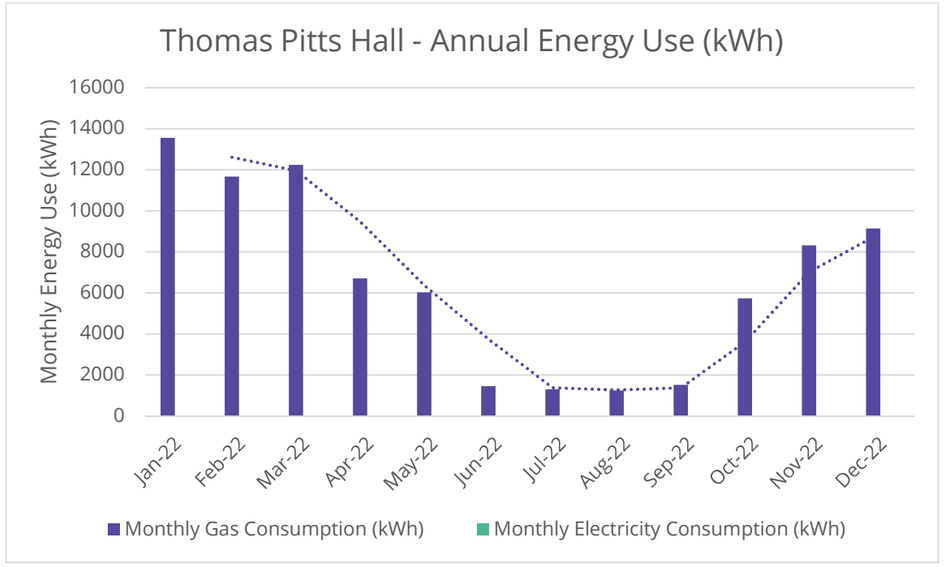


Fig. 35.2 Thomas Pitts Hall annual energy usage profile

35.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.781 which suggests a reasonable correlation between degree days and heat consumption, however this value suggests there is some inherent inefficiency in the system.

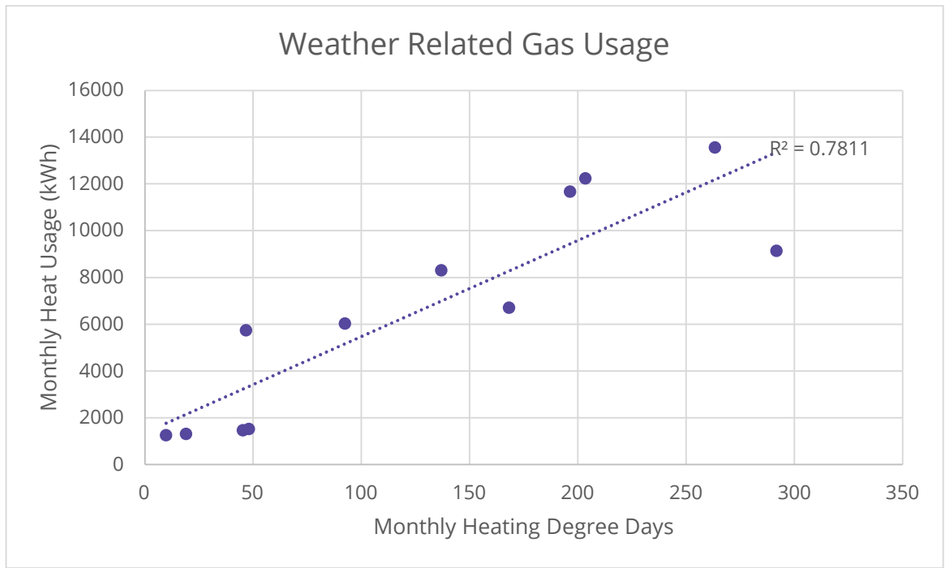


Fig. 35.3 Weather related heat usage compared to degree days

35.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

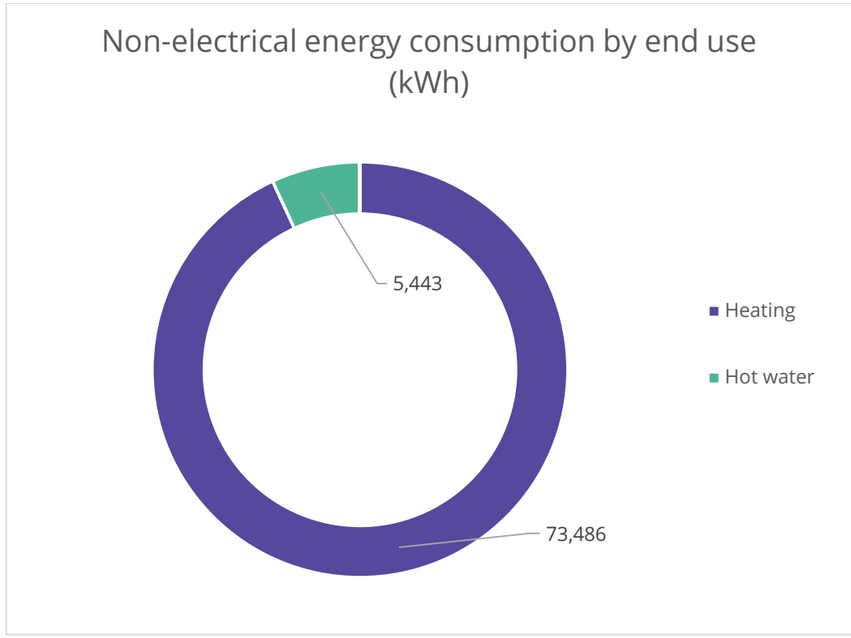


Fig. 35.4 Non-electrical energy consumption breakdown by end use

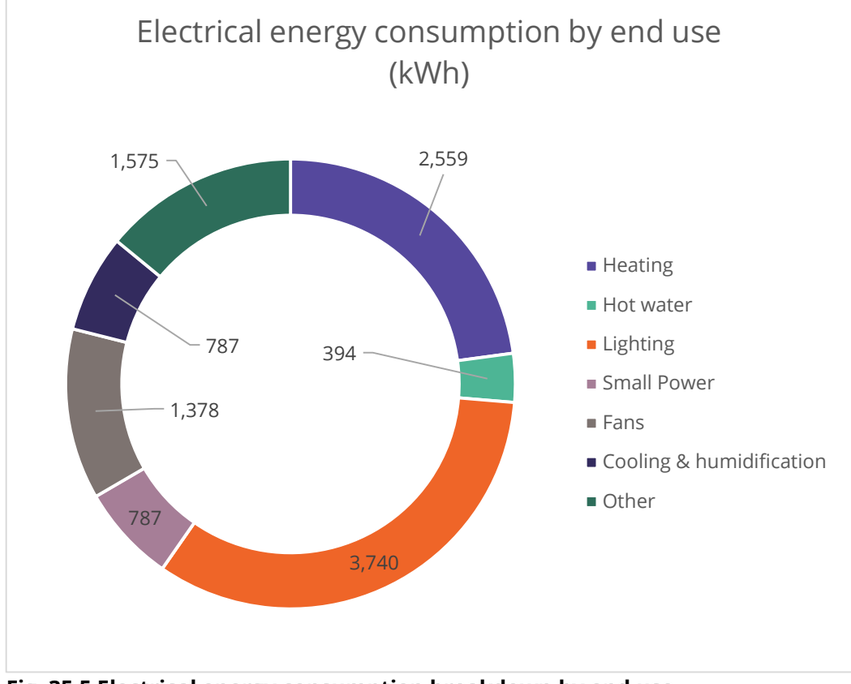


Fig. 35.5 Electrical energy consumption breakdown by end use

35.3 Technical Solution

35.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Thomas Pitts Hall is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management records there being no thermal wall insulation. The options would be to either retrospectively install external or internal to the entirety of the masonry elevations or a multiple of the two. The agreed insulation would be fitted internally by way of adhesive to existing walls or battens with insulation quilt/plasterboard, rigid insulation board or a mixture of the two. External insulation generally, comprises of rigid insulation board mechanically fixed to the existing walls but often having an applied render coat to either option or being of a prefinished insulation board/panel. However, the proposed works may be subject listed building/planning consent, which preclude the option to provide external wall insulation.

We recommend a thermographic survey to identify in detail the areas where meaningful improvements could be made to the thermal performance of the building envelope.

Option F2: The installation of new or additional roof insulation

The above-mentioned report states the existing roof insulation as being in poor condition. Recommendations to consider are the installation of internal rigid board/glass rock insulation. Alternatively, the refurbishment of the roofs externally, which would involve the strip, installation of insulation and the reinstatement of the existing roofs. ‘Refer to above comment for recommended thermographic survey’.

Option F3: Installation of reflective/ absorptive film on curtain glazing system to reduce heat gain

The above-mentioned report states the existing single-windows as being in poor condition. Consideration should be given for the replacement of all windows with new double-glazed units. These works should include the replacement of existing doors with new composite type door. The works may be subject to listed building/local planning consent. ‘Refer to above comment for a recommend a thermographic survey’.

35.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Thomas Pitts Hall. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Thomas Pitts Hall we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

Option S7: Expansion of roof mounted solar PV installation.

With an available roof area of approximately 2048m² we anticipate that an additional 1,220m² of solar PV cells could be installed, subject to detailed design and structural feasibility assessment. This would also need to be considered within the design of the additional roof insulation and potential location of plant on the roof.

35.4 Energy & Carbon Savings – Thomas Pitts Hall

Table 33.3 – Carbon savings summary – Thomas Pitts Hall

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
F1	Addition of wall insulation	8.26	£3,857	30	248	£16	£1,575	2.4
F2	Addition/replacement of roof insulation	8.37	£10,004	30	251	£40	£1,655	6.0
F3	Replacement of glazing to improve thermal performance	7.85	£43,685	20	157	£278	£1,253	34.9
F4		6.24	£0		0	£0	£3	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	6.91	£75,855	25	173	£439	-£12,532	-6.1
S2	Installation of new centralised domestic hot water generation, pipework and controls	6.39	£7,586	25	160	£47	-£12,144	-0.6
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£342	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	6.71	£15,171	20	134	£113	£1,179	12.9
S5	Addition of high efficiency fans, pumps and drives	6.24	£5,057	25	156	£32	£18	280.7
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	15	0	£0	£0	0.0

35.4.1. Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 51kW (based on a rule of thumb of 100W/m²) with the peak cooling demand of 36kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 13kW and 10kW for heating and cooling respectively.

35.4.2. Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Thomas Pitts Hall which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Thomas Pitts Hall will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

36. Wellbeing Centre

36.1 Description of Building

36.1.1. General

The Wellbeing Centre is located to the north of the main site, adjacent to the main vehicle entrance to the campus. The building houses the University's law clinic and a GP surgery on the ground floor. The building contains mainly office accommodation, meeting and consulting rooms and welfare facilities.



Fig. 36.1 Wellbeing Centre

36.1.2. Building Fabric

The Wellbeing Centre is a three-storey building constructed circa 2011 comprising of a reinforced concrete and steel construction enclosed with a combination of powder coated aluminium framed units incorporating sealed double-glazed walling, metal cladding panels and cement render finishes.

The roofs were not inspected however, from our review of Google Maps the roofs are understood to comprise flat and pitched roofs covered with a proprietary membrane and profiled metal roof sheets respectively.

Powder coated aluminium framed doors incorporating double glazed units are provided to the main entrance and exit to the building.

During our inspection of Wellbeing Centre, we did not observe any issues of major concern in respect of the building fabric, and none was report by site management. From information provided by site management we believe the condition of the double-glazed windows, external wall insulation and rigid insulation roof boards is fair. However, the detailed specification has not been provided.

It is recommended to consider a thermographic survey to identify in detail where improvements could be made to the thermal performance of the building envelope.

Subject to the findings of a thermographic survey report, liaison with consultants and building control there may opportunity to enhance the existing insulation and double-glazing.

36.1.3. Mechanical Services

The Wellbeing Centre is supplied with LTHW gas fired boilers located in the main plantroom. The LTHW system feeds wall mounted radiators.

Local cooling is provided to key areas (comms rooms etc.) via DX cooling systems via external mounted condensers.

The building is generally naturally ventilated via opening windows to atmosphere. Mechanical extract ventilation is provided to toilets and cleaners stores etc.

Domestic Hot water is generated by local unvented electric water heaters.

36.1.4. Electrical Services

The electricity supply to the Wellbeing Centre is served with a metered Low Voltage (LV) three phase electricity supply derived from the electricity supply network operated by the local district network operator.

Power is distributed throughout from the main LV main switch gear and local distribution board on the ground floor via final circuits to electric heating, sockets and lighting installation.

Lighting is generally provided via a variety of fluorescent lamped luminaires, with some evidence of failed luminaires replaced for LED equivalents with manually switched lighting controls serving communal and offices spaces.

The building is provided with a roof mounted solar PV array comprising 32No. panels.

36.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and water consumption as well as solar PV yield. The BMS also provides heat metering data for the LTHW circuits. Electrical sub-metering is provided to the Old building and the PV system. The full list of electrical sub-meters is included below:

- GndFlr DB
- 1stFlr DB
- 2ndFlr DB
- Mechanical Panel
- Pharmacy

Heat meters are provided to the following areas:

- GndFlr LTHW Heat
- 1stFlr LTHW Heat
- 2ndFlr LTHW Heat

A Water sub-meter is provided to the University Medical Centre.

36.1.6. Condition & Operation

We understand that the building was constructed in 2014 meaning the engineering services are circa approaching 10 years old. According to CIBSE Guide M the systems should have a remaining serviceable life of 10-15 years, subject to appropriate maintenance.

We understand that the estates team have recommended that the building is fitted with comfort cooling. The building has been the subject of numerous complaints I respect of overheating during the summer period.

The engineering services generally appear to be in good condition however we understand that the controls/BMS is in poor condition and requires renewal/refurbishment which is scheduled to be undertaken as soon as possible.

36.1.7. Planned Future CAPEX Works

We understand that there are currently no capex works scheduled for the Wellbeing Centre.

36.1.8. Opportunities for Heat Networks

If suitable technology is installed as part of the planned capex works along with appropriate future-proofing measures it would potentially be feasible to connect Wellbeing Centre to the 5DHC network when it becomes operational.

36.1.9. The following table identifies the energy consumption and carbon emissions from the Wellbeing Centre based on the energy consumption figures provided from site.

36.2 Energy & Carbon Emissions

Table 34.1 – Energy Consumption & Carbon Emissions – Wellbeing Centre

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	10,926 kWh	0.184 $kgCO_2e/kWh$	2.01 TCO_2e
Grid Electricity	11,086 kWh	0.105 $kgCO_2e/kWh$	1.16 TCO_2e
Total	22,012 kWh	N/A	3.17 TCO_2e

36.2.1. Table 5.55 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 894.3m². The performance of Wellbeing Centre is very good with overall energy usage and carbon emissions well below the current benchmark. We would suggest this is because the building is typically operating with very low occupancy. The figures are well below those stated on the current DEC.

Table 34.2 – Energy Consumption & Carbon Emissions Benchmarking – Wellbeing Centre

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	12.22	2.25	240	44.16	62.22
Grid Electricity	12.40	1.30	80	8.40	55.49
Total	24.62	3.55	320	52.56	117.61

36.2.2. The building would have been constructed to 2010 building regulations therefore the thermal performance and energy efficiency standards should be good when compared against typical University Campus building stock.

36.2.3. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2021 as the most recent full year. The metering data shows the energy consumption profile for Wellbeing Centre throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays.

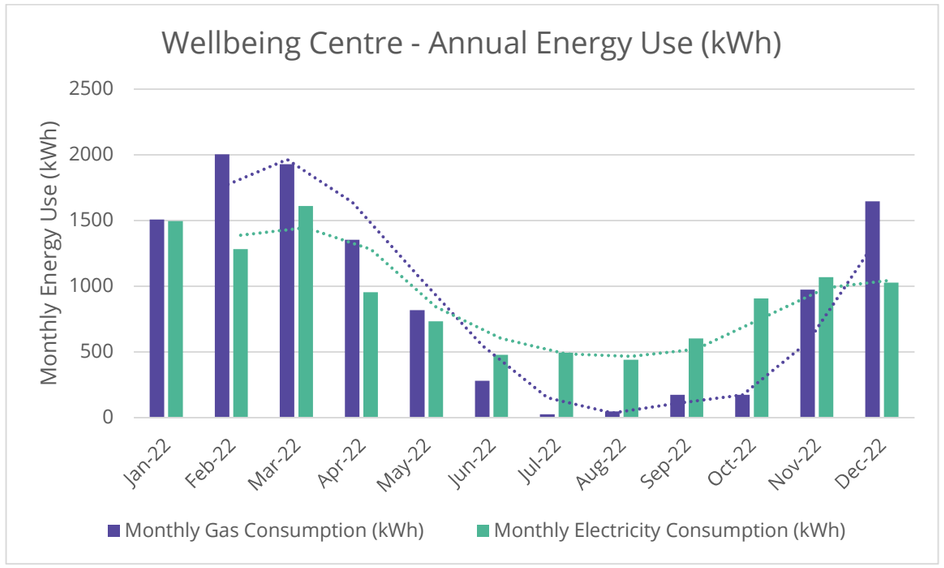


Fig. 36.2 Wellbeing Centre annual energy usage profile

36.2.4. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.838 which suggests a relatively strong correlation between degree days and heat consumption, however this value suggests there is some inherent inefficiency in the system.

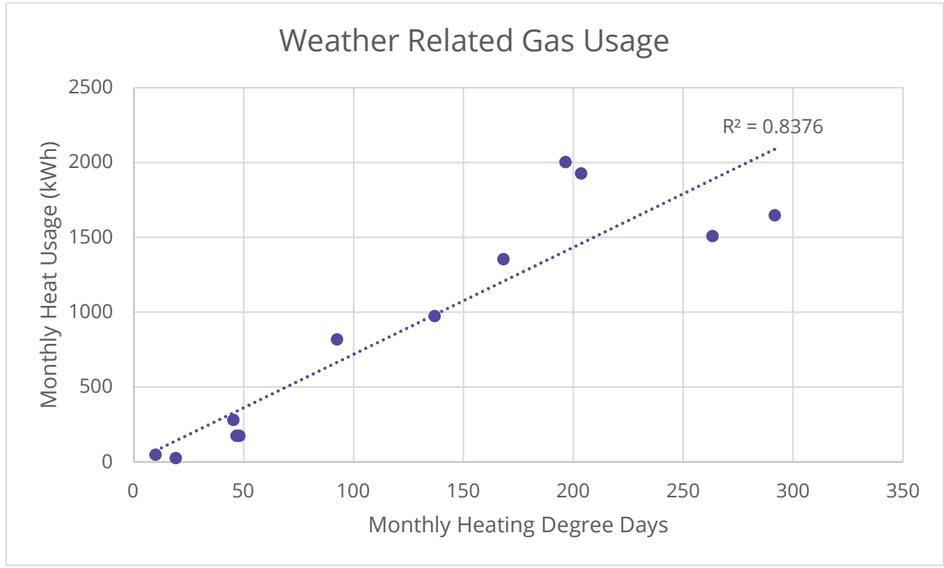


Fig. 36.3 Weather related heat usage compared to degree days

36.2.5. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

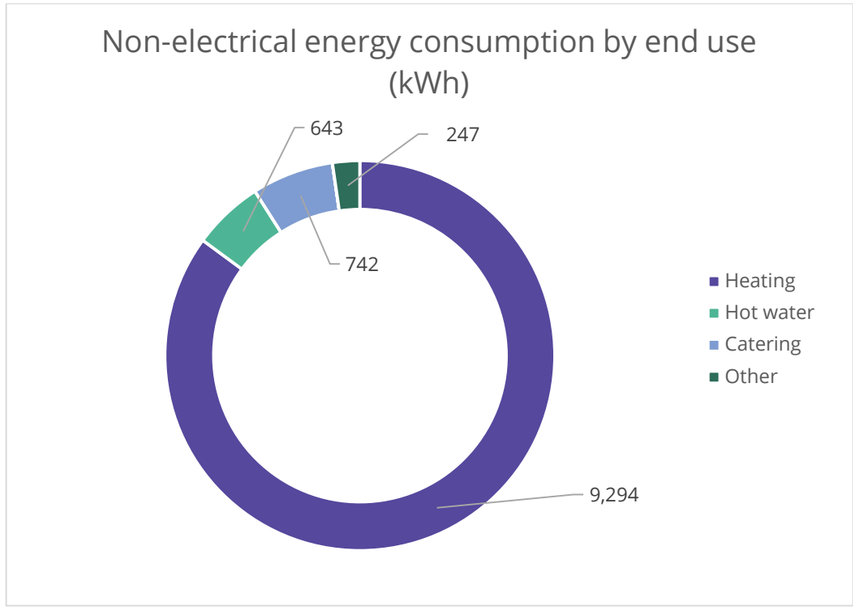


Fig. 36.4 Non-electrical energy consumption breakdown by end use

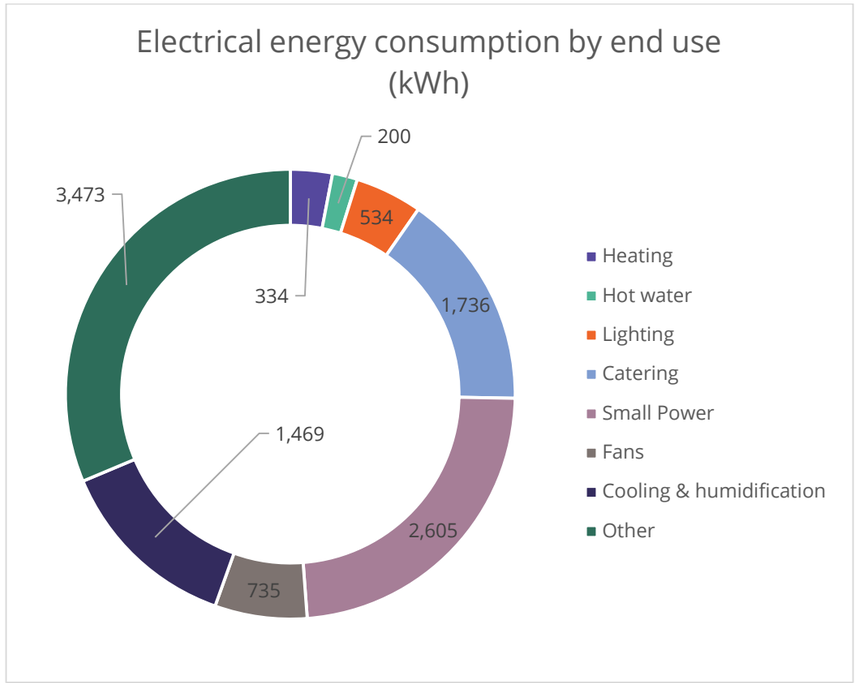


Fig. 36.5 Electrical energy consumption breakdown by end use

36.3 Technical Solution

36.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Wellbeing Centre is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management states the external wall is in fair. Given, this is a more recent construction, we would recommend a thermographic survey to identify in detail the areas where meaningful improvements could be made to the thermal performance of the building envelope.

Option F2: The installation of new or additional roof insulation

The above-mentioned report states the existing roof insulation as being in fair condition. 'Refer to above comment for recommended thermographic survey'. Any considered works would be subject to review of as-built data, intrusive inspection and liaison with consultants.

Option F3: The Installation of reflective/ absorptive film on curtain glazing system to reduce heat gain

The above-mentioned report records the existing double-glazed windows as being in fair. Based on the information collated to date we would recommend the overhaul of all glazing to ensure correct operation. In addition, the provision reflective/absorptive window film may provide area for the reduction in energy consumption. 'Refer to above comment for a recommend a thermographic survey'.

To assess the impact of installing a reflective/absorptive film we have assumed a 5% improvement in the cooling demand for the building due to reduced solar gain.

36.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Wellbeing Centre. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Wellbeing Centre we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

36.4 Energy & Carbon Savings – Wellbeing Centre

Table 34.3 – Carbon savings summary – Wellbeing Centre

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
-	Addition of external window film to reduce solar heat gain	0.16	£3,176	15	2	£1,323	£70	45.5
F1	Addition of wall insulation	0.95	£3,857	30	29	£135	£76	50.7
F2	Addition/replacement of roof insulation	0.96	£10,004	30	29	£347	£74	135.1
F3	Replacement of glazing to improve thermal performance	0.96	£43,685	20	19	£2,279	£6	7290.2
F4		0.00	£0		0	£0	£0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	2.08	£75,855	25	52	£1,457	£1,128	67.2
S2	Installation of new centralised domestic hot water generation, pipework and controls	0.89	£20,228	25	22	£914	£49	413.7
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	£0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	0.97	£15,171	20	19	£785	£10	1579.5
S5	Addition of high efficiency fans, pumps and drives	0.87	£5,057	25	22	£233	£218	23.2
S6	Installation of heat recovery on air systems	0.00	£0	0	0	£0	£0	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	0.00	£0	15	0	£0	£0	0.0

36.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 89W (based on a rule of thumb of 100W/m²) with the peak cooling demand of 64kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 19kW and 16kW for heating and cooling respectively.

36.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Wellbeing Centre which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Wellbeing Centre will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

37. Brixham Laboratory

37.1 Description of Building

37.1.1. General

The Brixham Laboratory is located in Brixham, approximately 35 miles east of the main University campus in Plymouth City Centre. The building was acquired by the University from AstraZeneca in 2014 and now serves as a business hub, with the laboratory facility providing ecotoxicology, environmental and analytical chemistry services to the agrochemical, pharmaceutical and chemical industries. The building contains commercial office space, meeting and conference facililties, laboratories, café and welfare facilities.

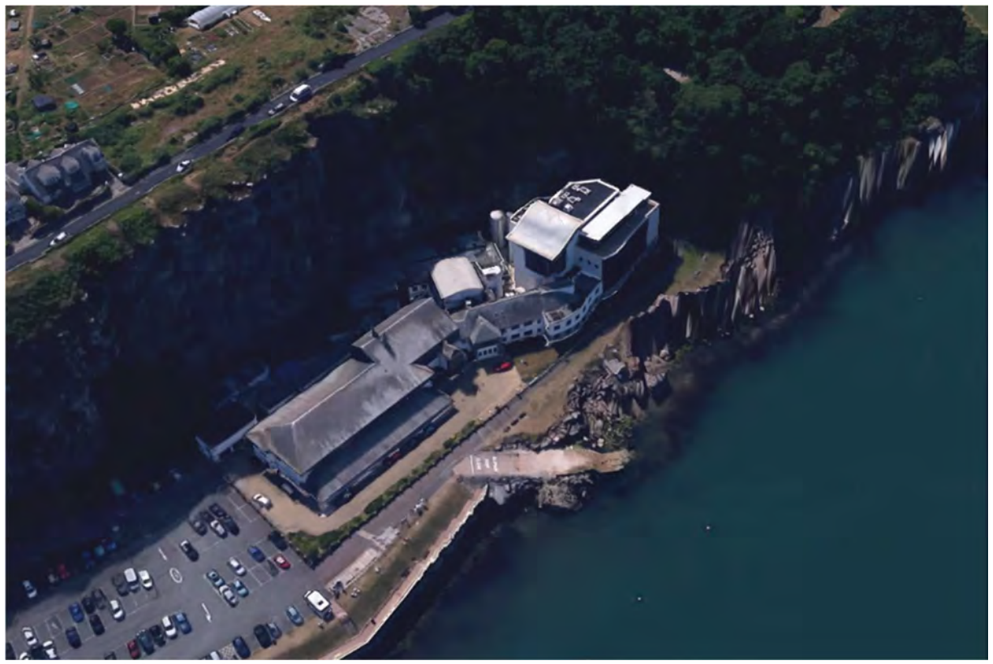


Fig. 37.1 Brixham Laboratory

37.1.2. Building Fabric

Brixham Laboratory is a two and four storey complex developed between 1981 to 1990. The buildings comprise of reinforced concrete and steel frame construction enclosed with a combination of powder coated aluminium framed units incorporating sealed double-glazed walling and opening lights, composite cladding, cement rendered masonry, faced stonework, faced brickwork and concrete cladding.

The roofs were not inspected however, from our review of Google Maps the roofs are understood to comprise flat, 'mansard' roofs, curved and pitched roofs covered with a mixture of proprietary membranes, roof tiles and profiled metal sheets. Some pitched tile covered roofs incorporate 'Velux' type roof lights.

Powder coated steel and aluminium framed doors some incorporating double glazed units are provided to the main entrance and exit to the building.

We did not observe any issues of major concern in respect of the building fabric however, cracking was observed to the concrete cladding adjacent to 'porthole' type windows to the north-west elevation. From information provided by site management we believe the double-glazed windows, external wall insulation and rigid roof insulation boards are in fair condition. However, the detailed specification has not been provided.

It is recommended to consider a thermographic survey to identify in detail where improvements could be made to the thermal performance of the building envelope.

Subject to the findings of a thermographic survey, anticipated works may include the upgrade of wall/roof insulation and the enhancement to glazing,

Any potential upgrade/enhancement would be subject to liaison with consultants and building control.

37.1.3. Mechanical Services

Brixham Laboratory is supplied with LTHW via 2No boiler installations. The newer north wing is provided with 2No. Ygnis gas fired pressure jet boilers located in the rooftop plantroom. The older link section and south wing is provided with a modular boiler installation comprising 8No. Hamworthy gas fired boiler modules within the ground floor plantroom. The LTHW systems feed a combination of wall mounted radiators and 4-pipe fan coil units. The boilers also provide heating to sea water to maintain water temperature for the storage of marine animals.

The building is provided with comfort cooling via roof mounted packaged water-cooled chillers generating chilled water fed from dry air coolers. Comfort cooling is delivered via 4-pipe fan coil units.

Process cooling is provided via 2No. packaged air-cooled chillers located in the rear yard. Local cooling is provided to labs via 2No. downflow units fed with chilled water located in the rooftop plantroom.

The building is generally mechanically ventilated via a series of packaged AHUs which are supplied with LTHW and chilled water. Fume extract is provided to fume cupboards in labs via a centrifugal fan located in the main plantroom.

Domestic Hot water is generated via local unvented electric water heaters.

37.1.4. Electrical Services

The electricity supply to Brixham Laboratory is served from the district network operators HV network which terminates at 1000kVA rated transformer and substation located to the rear of the building. We believe, the agreed electricity supply capacity serving the building is at 550kVA.

Power is distributed throughout from the main LV main switch gear and local distribution board on the ground floor via final circuits to sockets and lighting installation.

Lighting is generally provided via a variety of fluorescent lamped luminaires with some evidence of LED replacement luminaires and manually switched and automatic lighting controls serving communal and offices spaces.

37.1.5. Metering

The C3ntinel metering system provides data in respect of electrical, gas and water consumption. The system provides data for the electrical system, however there is no dedicated sub-metering data for Brixham Laboratory in respect of major plant items and electrical distribution.

37.1.6. BMS/Controls

The Brixham Laboratory is provided with an extensive BMS based on Satchwell Sigma and Honeywell equipment. Laboratories and aquarium tanks are provided with individual control outstations located in plant areas.

37.1.7. Condition & Operation

We understand that the building was originally constructed in the 1980s with the north wing added in the 2000s meaning the engineering services range from 10-40 years old. According to CIBSE Guide M the systems installed during the 2000s should have a remaining serviceable life of 5-10 years, subject to appropriate maintenance.

The process plant and equipment is considered to be in fair condition.

The engineering services generally appear to be in good condition.

37.1.8. Planned Future CAPEX Works

We understand that a programme of capex works is underway to replace the heating system in order to decarbonise the site.

37.1.9. Opportunities for Heat Networks

Based on the location of the building and its proximity to other properties we would suggest options to connect the Brixham Laboratory to a heat network are limited.

37.2 Energy & Carbon Emissions

37.2.1. The following table identifies the energy consumption and carbon emissions from the Brixham Laboratory based on the energy consumption figures provided from site.

Table 35.1 – Energy Consumption & Carbon Emissions – Brixham Laboratory

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	1,364,792 kWh	0.184 $kgCO_2e/kWh$	251.12 TCO_2e
Grid Electricity	1,000,542 kWh	0.105 $kgCO_2e/kWh$	105.06 TCO_2e
Total	2,365,334 kWh	N/A	356.18 TCO_2e

37.2.2. Table 5.57 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings and the current Display Energy Certificate (DEC). This is based on a Gross Internal Area (GIA) of 13260.4m². The performance of Brixham Laboratory is very good with overall energy usage and carbon emissions around half the current benchmark. The figures correspond closely with those stated on the current DEC.

Table 35.2 – Energy Consumption & Carbon Emissions Benchmarking – Brixham Laboratory

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	102.92	18.93	240	44.16	101.39
Grid Electricity	75.45	7.92	80	8.40	80.21
Total	178.37	26.85	320	52.56	181.60

37.2.3. The building would have been constructed to 2000/2006 building regulations therefore the thermal performance and energy efficiency standards should be reasonable when compared against typical University Campus building stock.

37.2.4. Electricity and heat meter readings have been provided for the site via the C3ntinel metering portal. Data is available back as far as 2015 however we have exported the data for 2021 as the most recent full year. The metering data shows the energy consumption profile for Brixham Laboratory throughout the year and demonstrates a reduced demand for heat during the summer/autumn period due to warmer weather and summer holidays. The data shows an increase in electrical consumption through the winter when there is an increased demand for lighting however this is tempered by an increased demand for cooling in the summer which is provided via the roof mounted chiller plant.

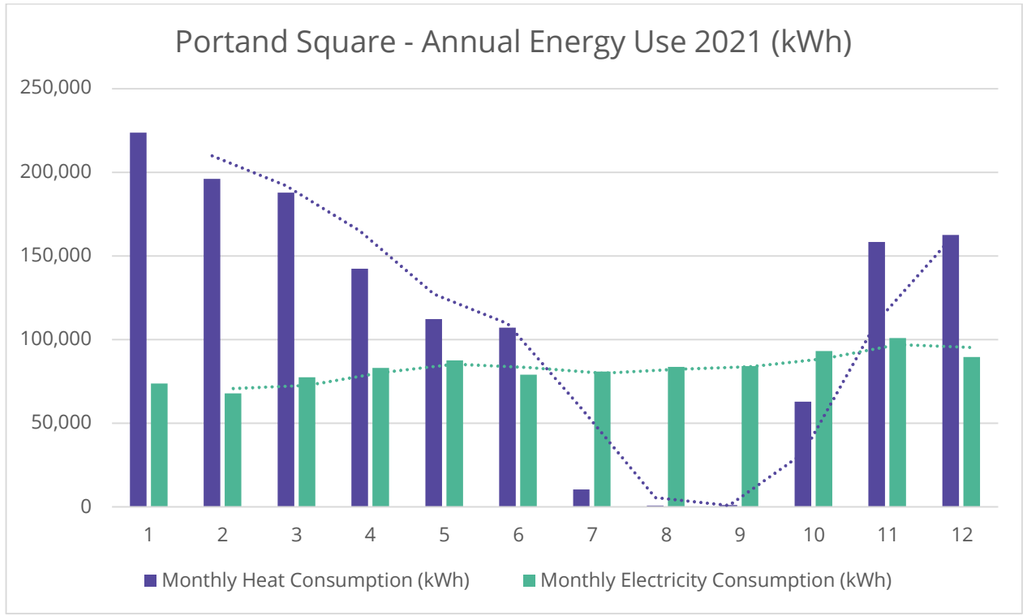


Fig. 37.2 Brixham Laboratory annual energy usage profile

37.2.5. We have obtained degree day data for Plymouth from an online database using the closest weather location to the site (Plymouth Airport – EGDB). The data has been plotted against the monthly heat usage in kWh. The resulting trend line demonstrates a correlation coefficient of 0.877 which suggests a relatively strong correlation between degree days and heat consumption, however this value suggests there is some inherent inefficiency in the system. This can be explained by the fact that the heat network is metered within the Mary Newman building and that there are likely to be significant pipework heat losses between the heat source and the emitters.

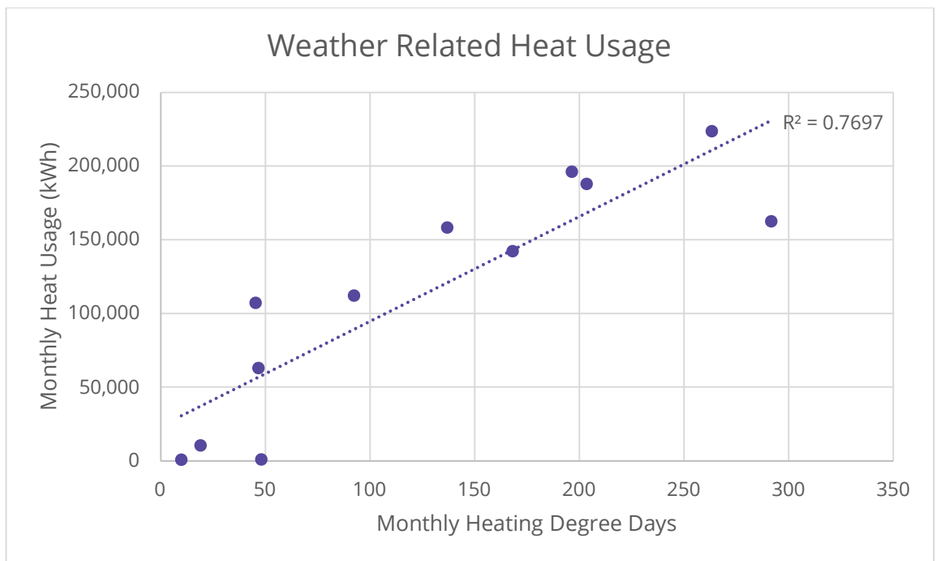


Fig. 37.3 Weather related heat usage compared to degree days

37.2.6. We have analysed the estimated energy consumption by end use according to the Building Energy Efficiency Survey (BEES) sector report for the education sector.

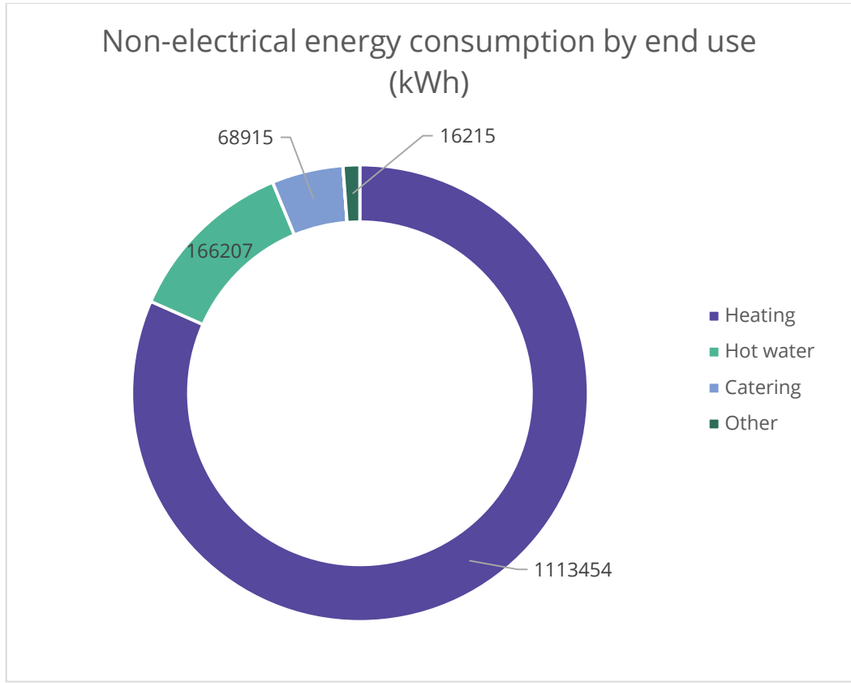


Fig. 37.4 Non-electrical energy consumption breakdown by end use

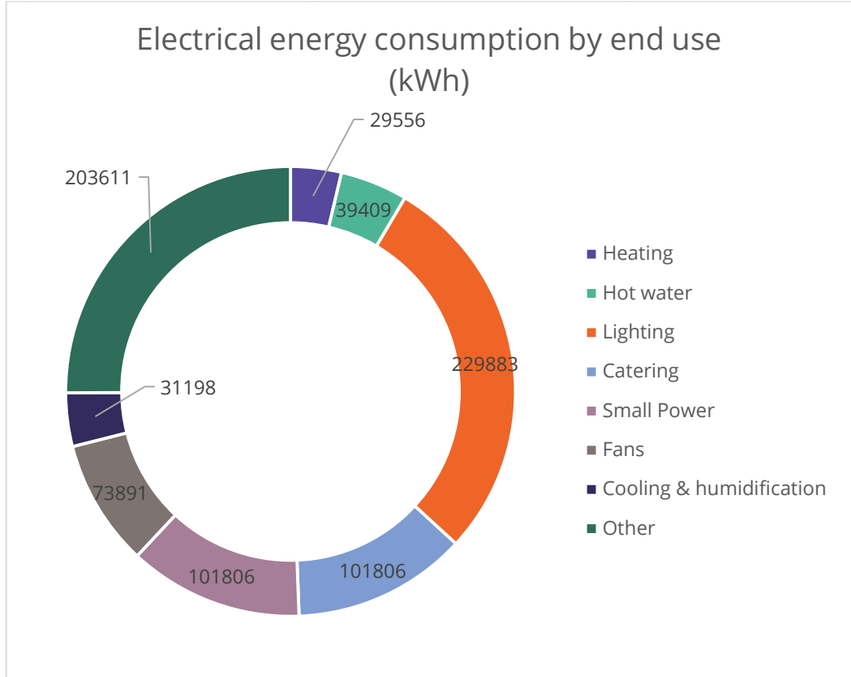


Fig. 37.5 Electrical energy consumption breakdown by end use

37.3 Technical Solution

37.3.1. Building Fabric Solution

Based on the summary in Table 7.2, the solution proposed for Brixham Laboratory is as follows:

Option F1: The addition of internal or external wall insulation

The report provided by site management states the external wall is in fair. In order to agree potential upgrade works we would recommend a thermographic survey to identify in detail the areas where meaningful improvements could be made to the thermal performance of the building envelope.

Option F2: The installation of new or additional roof insulation

The above-mentioned report states the existing roof insulation as being in fair condition. 'Refer to above comment for recommended thermographic survey'. Any considered works would be subject to review of as-built data, intrusive inspection and liaison with consultants.

Option F3: The Installation of reflective/ absorptive film on curtain glazing system to reduce heat gain

The above-mentioned report records the existing double-glazed windows as being in fair. Based on the information collated to date we would recommend the overhaul of all glazing to ensure correct operation. In addition, the provision reflective/absorptive window film to glazed walls may provide area for the reduction in energy consumption. 'Refer to above comment for a recommend a thermographic survey'.

To assess the impact of installing a reflective/absorptive film we have assumed a 5% improvement in the cooling demand for the building due to reduced solar gain.

37.3.2. Building Services Solution

Option S1: Replace existing LTHW heat exchanger with a new high temperature water-water heat pump chiller with ambient water loop and dry air coolers.

This system will remove the building from the existing campus DHN and remove any requirement for fossil fuel consumption on site in connection with Brixham Laboratory. The proposal of a water-water heat pump chiller and ambient water loop is based on the potential for the installation of a new 5th Generation District Heating & Cooling (5DHC) ambient ground loop.

Subject to design, the water-water heat pump chiller should be compatible with the ambient ground loop, however the building will require heating and cooling in the interim period, hence the requirement for ambient loop dry air coolers to provide low grade heat for the chillers.

The heat pump chillers would either be mounted on the roof or at ground level subject to space and structural considerations with enabling works required in either scenario along with possible acoustic treatment.

Reconfiguration of the existing heating system, pipework and controls will be required to facilitate the heat pump installation. However, as the building is circa 20 years old, we anticipate that the heating system will require lifecycle renewal in the medium term, and this should be considered within the overall decarbonisation solution.

Option S2: Replace hot water generation plant with new central hot water generation system fed from the high temperature heat pump.

This system will involve the replacement of the central hot water generation plant to facilitate hot water generation via the high temperature heat pump. The central system should be designed to serve high-volume outlets and core areas such as toilets, cleaners sinks, kitchens etc. however remote or low-use outlets should be fed from local unvented electric water heaters to reduce the total storage volume and associated standing and distribution/circulation losses.

Option S4: Replacement of existing Building Management System (BMS) with new Building Energy Management System (BEMS)

The existing BMS is noted as being in poor condition and would therefore benefit from replacement. The existing BMS is ageing and contains previous generation/obsolete technology and components as well as providing limited coverage for energy monitoring and reporting.

For Brixham Laboratory we would recommend developing a new metering strategy to provide monitoring and reporting for all major energy consuming systems. The new BEMS should be fully network linked operating on suitable communication protocol for integration into future site-wide BEMS upgrade.

Option S5: Addition of high efficiency fans, pumps and drives to provide greater plant efficiency

The main LTHW and chilled water circulation pumps and AHU/fan motors are ageing and would benefit from replacement with modern inverter technology to provide variable speed control and higher energy efficiency.

Option S7: Expansion of roof mounted solar PV installation.

With an available roof area of approximately 1000m² we anticipate that an additional 600m² of solar PV cells could be installed, subject to detailed design and structural feasibility assessment. This would also need to be considered within the design of the additional roof insulation and potential location of plant on the roof.

37.4 Energy & Carbon Savings – Brixham Laboratory

Table 35.3 – Carbon savings summary – Brixham Laboratory

Ref.	Recommended Measure	Estimated Annual Carbon Reduction (TCO_2e)	Cost Estimate	Life Expectancy (years)	Estimated Lifetime Carbon Saving (TCO_2LT)	Cost per Tonne CO_2eLT Lifetime	Running Cost Saving	Simple Payback (Years
-	Addition of external window film to reduce solar heat gain	174.77	£59,540	15	2,622	23	£175	340.7
F1	Addition of wall insulation	225.01	£115,110	30	6,750	17	£40,207	2.9
F2	Addition/replacement of roof insulation	224.68	£114,906	30	6,740	17	£39,952	2.9
F3	Replacement of glazing to improve thermal performance	219.88	£818,676	20	4,398	186	£36,223	22.6
F4			£0		0	0	0	0.0
S1	Installation of new water-to-water heat pump, plate heat exchanger, ancillaries and controls	287.39	£980,220	25	7,185	136	-£110,321	-8.9
S2	Installation of new centralised domestic hot water generation, pipework and controls	177.74	£163,370	25	4,443	37	-£99,141	-1.6
S3	Replacement of existing lighting with LED technology and upgraded controls	0.00	£0	0	0	0	£0	0.0
S4	Replacement of existing BMS with new BEMS providing energy monitoring and targeting	193.64	£81,685	20	3,873	21	£50,779	1.6
S5	Addition of high efficiency fans, pumps and drives	174.01	£65,348	25	4,350	15	£1,890	34.6
S6	Installation of heat recovery on air systems	0.00	£0	0	0	0	£20,373	0.0
S7	Install building mounted solar Photo-Voltaic (PV) array	176.64	£192,000	15	2,650	72	£8,435	22.8

37.5 Utility & Infrastructure Requirements

We have estimated the peak heating demand at circa 653kW (based on a rule of thumb of 100W/m²) with the peak cooling demand of 471kW (based on a rule of thumb of 120W/m² applied to 60% of the floor area). Assuming system efficiencies in line with Table 4.1 (4.00 heating, 3.75 cooling) provides an indicative increase in electrical load of circa 163kW and 125kW for heating and cooling respectively.

37.6 Key Risks & Challenges

The installation of heat pumps will require significant enabling works and potential structural alterations, however there is an existing recent chiller installation on the roof of Brixham Laboratory which suggests that significant structural enhancement may not be necessary.

It is likely that the available electrical capacity for Brixham Laboratory will need to be increased to supply the additional requirements for the heat pump installation. In isolation, this is unlikely to pose a significant challenge however when considered alongside the mass electrification/decarbonisation of the site there may be a risk in terms of available upstream capacity.

The technical solution to increasing the insulation within the walls and roof will need to be carefully considered. The walls are most likely to require an internal solution which will reduce the available floor area and require the relocation of Fixed Furniture and Equipment (FF&E). To replace/enhance the roof insulation externally would likely require the temporary removal/relocation of plant and equipment and careful consideration given to weathering, penetrations and drainage.

38. Rolle Marquee

38.1 Description of Building

38.1.1. General

Rolle Marquee is a fabric marquee/temporary building located in the courtyard adjacent to the Rolle Building. The structure provides exhibition/events space.

38.1.2. Building Fabric

We have not analysed the building fabric of this structure.

38.1.3. Mechanical Services

The Rolle Marquee is provided with portable electric heating.

38.1.4. Electrical Services

The electricity supply serving Rolle Marquee is derived from the Low Voltage (LV) installation from the adjoining building.

Power is distributed within the Marquee for performance requirements serving Audio/Visual system and lighting which is generally provided via suspended LED luminaires and manually controlled.

38.1.5. Metering

The Rolle Marquee is not independently sub-metered.

38.1.6. Condition & Operation

The building is a temporary structure. The condition of the engineering services is considered good.

38.1.7. Planned Future CAPEX Works

We understand that the Rolle Marquee is to be mothballed within 2-3 years.

38.1.8. Opportunities for Heat Networks

None applicable.

38.1.9. The Rolle Marquee is a temporary building and as such, detailed sub-metering data is not available. The below analysis is based on bulk consumption figures provided by the University Estates team.

38.2 Energy & Carbon Emissions

38.2.1. The following table identifies the energy consumption and carbon emissions from the Rolle Marquee based on the energy consumption figures provided from site.

Table 36.1 – Energy Consumption & Carbon Emissions – Rolle Marquee

Fuel Type	Consumption	2022 Carbon Emission Factor	Total Carbon Emissions
Fossil Fuel	0 kWh	0.184 $kgCO_2e/kWh$	0 TCO_2e
Grid Electricity	26,981 kWh	0.105 $kgCO_2e/kWh$	2.83 TCO_2e
Total	26,981 kWh	N/A	2.83 TCO_2e

38.2.2. Table 5.59 compares the Energy Use Intensity (EUI) and Carbon Intensity against typical benchmark values provided within CIBSE TM46 Energy Benchmarks for University Campus buildings. This is based on a Gross Internal Area (GIA) of 630m². The performance of Rolle Marquee is very good with overall energy usage and carbon emissions around half the current benchmark. The building is not provided with fixed heating systems and is served by portable electric heaters.

Table 36.2 – Energy Consumption & Carbon Emissions Benchmarking – Rolle Marquee

Fuel Type	(Actual 2021)		CIBSE TM46 Benchmark		Current DEC (October 2022)
	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	EUI (kWh/m²)	Carbon Intensity ($kgCO_2e/m^2$)	Annual Energy Use (kWh/m²)
Fossil Fuel	0	0	240	44.16	N/A
Grid Electricity	42.82	7.92	80	8.40	N/A
Total	42.82	7.92	320	52.56	N/A

38.3 Technical Solution

38.3.1. Building Fabric Solution

We have not considered any technical solutions to Rolle Marquee due to the temporary nature of the building and construction characteristics.

39. Intercity Place

39.1 Description of Building

39.1.1. General

Intercity Place was originally constructed in the 1950s is currently undergoing a major refurbishment, scheduled to complete in 2023. The building is located approximately 200m to the north-west of the main campus, just to the south of Plymouth Railway Station and will be home to inter-professional clinical skills facilities for the University's Allied Health Professions and Nursing and Midwifery, as well as additional educational services.



Fig. 39.1 Intercity Place

39.1.2. Building Fabric

Intercity Place is a multi-storey high-rise structure understood to comprise reinforced concrete frame construction enclosed with a combination of concrete panels and aluminium framed windows.

The roofs were not inspected however, from our review of 'Google Maps' the roofs are understood to comprise flat roofs covered with a proprietary single-ply membrane.

39.1.3. Building Services

We have limited information on the nature of the building services installations however we understand that the heating system will comprise Air Source Heat Pumps with gas fired domestic hot water generation.

We anticipate that the lighting installations will comprise LED luminaires.

We note that there is a roof mounted solar PV installation comprising 120No. panels.

39.2 Energy & Carbon Emissions

39.2.1. We have been provided with bulk electricity and gas consumption figures from prior to the refurbishment being commenced. These figures are now obsolete and do not reflect the current scenario.

39.3 Technical Solution

39.3.1. Building Fabric Solution

We do not anticipate any improvements will be necessary to the building fabric on completion of the refurbishment.

39.3.2. Building Services Solution

We understand that the building will incorporate heat pump technology alongside substantial renewal of the engineering services therefore we do not anticipate any further works to the building services on completion of the refurbishment.

40. Current Site Services & Infrastructure

40.1 Mechanical, Electrical & Public Health (MEP) Services

District Heat Network (DHN)

40.1.1. The campus DHN is fed by 2No. 585kW gas fired boilers and a 527kWth Combined Heat & Power (CHP) unit which also generates electricity via a gas-powered internal combustion engine. The main Low Temperature Hot Water (LTHW) plant is located within the Davy building energy centre. The heat network was installed in 2012 however one of the boilers was replaced during 2022.

40.1.2. The CHP unit has a rated output of 450kWe and 527kWth (1436kW gross input) however we understand that the CHP unit is generally unreliable and is often not operating.

40.1.3. The DHN operates at a primary flow temperature from the boilers of 90°C with the secondary flow temperature to the plate heat exchangers of 86°C. The maximum return temperature to the boilers/CHP unit is 80°C. The plate heat exchangers are designed to operate with a flow temperature of 85°C.

The Davy DHN serves the following buildings:

- Davy (Not included in study)
- Main Hall
- Link Building (Not included in study)
- Smeaton (Not included in study)
- Marine Building (Not included in study)
- The House (Not included in study)

40.1.4. There is a second DHN with boiler plant located in the Mary Newman Building however we were unable to gain access to this area during our survey. This DHN serves the following buildings:

- Mary Newman
- Fitzroy
- Portland Square

40.1.5. The Mary Newman DHN is currently inoperable following a catastrophic boiler failure and is served by temporary boiler plant. A programme of works is underway to assess options for replacement.

40.2 Utilities & Infrastructure

Natural Gas

40.2.1. The main gas supply for the site enters via James Street. The primary gas supply is a 250mm (10”) Polyethylene (PE) Low Pressure (LP) service. The natural gas network is distributed across the campus below ground to serve the various boiler rooms and energy centres.

Mains Electricity

40.2.2. The site is served by an 11,000V (11kV) High Voltage (HV) electricity network which is owned and operated by the University. We understand that the University has an agreed supply capacity of 3.985MVA (3,985kVA). The main HV connection points are via the substation within the Davy building and the Gilwell Substation which serves Cookworthy, Robbins and Thomas Pitts Hall.

40.2.3. The site is also served by a network of 230V and 400V Low Voltage (LV) electricity supplies which are owned and operated by the district network operator Western Power Distribution (WPD). The LV supplies generally serve the cluster of terrace buildings, to name a few such as, Kirkby Terrace/Place, Portland Mews/Villas and Sherwell Centre.

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40.3 Building Fabric Summary

Building Name	Building Type	Gross Internal Area (m²)	Site Life (years)	Age of Building (Year building finished)	Condition of building	Wall Insulation Type	Condition (of wall insulation)	Roof Insulation Type	Condition (of roof insulation)	Window Type	Condition (of windows)
Babbage	Campus Building	7455.6	80	1971-1980	D	External wall insulation	Good (Recently upgraded)	Rigid insulation boards	Good (Recently upgraded)	Double glazed	Good (Recently upgraded)
Brunel	Campus Building	3685.1	80	1951-1960	D	No thermal insulation	Poor (Short-term)	Glass rock and mineral wool insulation	Poor (Short-term)	Single glazed	Poor (Short-term)
Caprera Cottage	Campus Building	126.7	80	1800-1900	B	No thermal insulation	Fair (Medium-term)	Glass rock and mineral wool insulation	Fair (Medium-term)	Single glazed	Poor (Short-term)
Cookworthy	Campus Building	6662.6	80	1981-1990	C	Cavity wall insulation	Fair (Medium-term)	Glass rock and mineral wool insulation	Fair (Medium-term)	Double glazed	Poor (Short-term)
Derriford Research Facility	Campus Building	3805.1	80	2011 Onwards	B	External wall insulation	Good (Recently upgraded)	Rigid insulation boards	Good (Recently upgraded)	Double glazed	Good (Recently upgraded)
Endsleigh Place (No. 14-24)	Campus Building	1239.9	80	1800-1900	C	No thermal insulation	Poor (Short-term)	Glass rock and mineral wool insulation	Fair (Medium-term)	Double glazed	Poor (Short-term)
Fitness Complex	Sports Hall	658.4	80	2001-2010	B	Cavity wall insulation	Fair (Medium-term)	Rigid insulation boards	Fair (Medium-term)	Double glazed	Fair (Medium-term)
Fitzroy	Campus Building	2988.4	80	1961-1970	C	No thermal insulation	Poor (Short-term)	Rigid insulation boards	Poor (Short-term)	Single glazed	Poor (Short-term)
Francis Drake Café	Canteen/Cafeteria	383.3	80	2001-2010	A	Cavity wall insulation	Fair (Medium-term)	Rigid insulation boards	Fair (Medium-term)	Double glazed	Fair (Medium-term)
Hepworth House	Campus Building	1630.7	80	1800-1900	B	No thermal insulation	Poor (Short-term)	Glass rock and mineral wool insulation	Poor (Short-term)	Single glazed	Poor (Short-term)
Intercity Place	Campus Building	5364.2	80	1951-1960	D	External wall insulation	Good (Recently upgraded)	No loft insulation	Good (Recently upgraded)	Double glazed	Good (Recently upgraded)
John Bull Building	Campus Building	5178.8	80	2001-2010	B	External wall insulation	Good (Recently upgraded)	Rigid insulation boards	Good (Recently upgraded)	Double glazed	Good (Recently upgraded)
Kirkby Lodge	Campus Building	377.7	80	1981-1990	B	No thermal insulation	Good (Recently upgraded)	Glass rock and mineral wool insulation	Good (Recently upgraded)	Double glazed	Good (Recently upgraded)
1 Kirkby Place	Campus Building	113.7	80	1800-1900	C	No thermal insulation	Poor (Short-term)	Glass rock and mineral wool insulation	Poor (Short-term)	Double glazed	Poor (Short-term)
Kirkby Place (No. 2-11)	Campus Building	2007	80	1800-1900	B	No thermal insulation	Poor (Short-term)	Glass rock and mineral wool insulation	Poor (Short-term)	Double glazed	Poor (Short-term)
12 Kirkby Place	Campus Building	378.3	80	1800-1900	B	No thermal insulation	Poor (Short-term)	Glass rock and mineral wool insulation	Poor (Short-term)	Double glazed	Poor (Short-term)
Kirkby Terrace (No. 1-4)	Campus Building	455.7	80	1901-1950	C	No thermal insulation	Poor (Short-term)	Glass rock and mineral wool insulation	Poor (Short-term)	Double glazed	Poor (Short-term)
Kirkby Terrace (No. 5-13)	Campus Building	908.9	80	1901-1950	C	No thermal insulation	Poor (Short-term)	Glass rock and mineral wool insulation	Poor (Short-term)	Double glazed	Poor (Short-term)
Kirkby Terrace (No. 14-15)	Campus Building	230.6	80	1901-1950	B	No thermal insulation	Poor (Short-term)	Glass rock and mineral wool insulation	Poor (Short-term)	Double glazed	Poor (Short-term)
Kirkby Terrace (No.	Campus Building	149.3	80	1901-1950	B	No thermal insulation	Poor (Short-term)	Glass rock and mineral wool insulation	Poor (Short-term)	Double glazed	Poor (Short-term)

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Library	Library	8471.9	80	1971-1980	C	External wall insulation	Fair (Medium-term)	Rigid insulation boards	Good (Recently upgraded)	Double glazed	Fair (Medium-term)
Main Hall	Campus Building	1406	80	1961-1970	B	External wall insulation	Fair (Medium-term)	Rigid insulation boards	Fair (Medium-term)	Double glazed	Fair (Medium-term)
Marine Station	Campus Building	1687.8	80	2011 Onwards	B	External wall insulation	Good (Recently upgraded)	Rigid insulation boards	Good (Recently upgraded)	Double glazed	Good (Recently upgraded)
Mary Newman	Plant room	668	80	1961-1970	B	Cavity wall insulation	Fair (Medium-term)	Rigid insulation boards	Poor (Short-term)	Double glazed	Fair (Medium-term)
Nancy Astor	Campus Building	4123.6	80	2001-2010	B	External wall insulation	Fair (Medium-term)	Rigid insulation boards	Fair (Medium-term)	Double glazed	Fair (Medium-term)
Nursery Building	Campus Building	1781.5	80	2001-2010	C	Cavity wall insulation	Fair (Medium-term)	Rigid insulation boards	Fair (Medium-term)	Double glazed	Fair (Medium-term)
Portland Mews	Campus Building	676.5	80	1981-1990	C	Cavity wall insulation	Poor (Short-term)	Glass rock and mineral wool insulation	Poor (Short-term)	Double glazed	Poor (Short-term)
Portland Square	Campus Building	13260.4	80	2001-2010	B	External wall insulation	Fair (Medium-term)	Rigid insulation boards	Fair (Medium-term)	Double glazed	Fair (Medium-term)
Portland Villas	Campus Building	6173.9	80	1800-1900	C	No thermal insulation	Fair (Medium-term)	Glass rock and mineral wool insulation	Poor (Short-term)	Double glazed	Fair (Medium-term)
Reynolds	Campus Building	1330.9	80	1800-1900	C	No thermal insulation	Poor (Short-term)	Glass rock and mineral wool insulation	Poor (Short-term)	Single glazed	Poor (Short-term)
Robbins Conference Centre	Campus Building	3149	80	1991-2000	C	Cavity wall insulation	Fair (Medium-term)	Rigid insulation boards	Poor (Short-term)	Double glazed	Fair (Medium-term)
Roland Levinsky Building	Campus Building	13464.4	80	2001-2010	A	External wall insulation	Fair (Medium-term)	Rigid insulation boards	Fair (Medium-term)	Double glazed	Good (Recently upgraded)
Rolle Building	Campus Building	6754.1	80	2001-2010	B	External wall insulation	Fair (Medium-term)	Rigid insulation boards	Fair (Medium-term)	Double glazed	Fair (Medium-term)
Rolle Academic Building	Campus Building	6754.1	80	2001-2010	B	External wall insulation	Fair (Medium-term)	Rigid insulation boards	Fair (Medium-term)	Double glazed	Fair (Medium-term)
Sherwell Centre (Lecture Theatre)	Campus Building	1974.1	80	1800-1900	A	No thermal insulation	Poor (Short-term)	Glass rock and mineral wool insulation	Poor (Short-term)	Single glazed	Poor (Short-term)
Skardon Place (Greenhouses)	Campus Building	216.7	80	1971-1980	C	Cavity wall insulation	Poor (Short-term)	Glass rock and mineral wool insulation	Poor (Short-term)	Single glazed	Poor (Short-term)
Student Union	Students Union	2583	80	1971-1980	B	Cavity wall insulation	Fair (Medium-term)	Rigid insulation boards	Poor (Short-term)	Double glazed	Fair (Medium-term)
Thomas Pitts Hall	Sports Hall	505.7	80	1901-1950	C	No thermal insulation	Poor (Short-term)	Glass rock and mineral wool insulation	Poor (Short-term)	Single glazed	Poor (Short-term)
Wellbeing Centre	Campus Building	894.3	80	2011 Onwards	B	External wall insulation	Fair (Medium-term)	Rigid insulation boards	Fair (Medium-term)	Double glazed	Fair (Medium-term)
Brixham Laboratory	Laboratory	6534.8	80	1981-1990	B	External wall insulation	Fair (Medium-term)	Rigid insulation boards	Fair (Medium-term)	Double glazed	Fair (Medium-term)
Rolle Marquee	Campus Building	630	80	2011 Onwards	B	External wall insulation	Fair (Medium-term)	Structural insulated panels	Fair (Medium-term)	Double glazed	Fair (Medium-term)

40.4 MEP Services Summary

Building Name	Building Type	Gross Internal Area (m²)	Existing Heating System	Existing Heating Fuel	Age of Existing Heating System (years)	Display Energy Certificate (DEC) Rating	Existing Annual Fossil Fuel Use (kWh/year)	Existing Annual Electricity Use (kWh/year)	Controls Type	Condition (of controls)	Lighting Type	Condition (of lighting)	Other Key Electrical Loads
Babbage	Campus Building	7455.6	Fossil fuel powered district heating	Gas	10	C	266111	683259	BEMS - not remotely managed	Good (Recently upgraded)	LED	Good (Recently upgraded)	
Brunel	Campus Building	3685.1	Fossil fuel powered district heating	Gas	10	D	313603	442920	No heating controls	Poor (Short-term)	Fluorescent lamps	Poor (Short-term)	Workshops
Caprera Cottage	Campus Building	126.7	Gas boiler	Gas	25	C	265	22377	Don't know	Poor (Short-term)	LED	Fair (Medium-term)	
Cookworthy	Campus Building	6662.6	Gas boiler	Gas	29	A	234198	159160	BEMS - remotely managed	Fair (Medium-term)	Fluorescent lamps	Fair (Medium-term)	
Derriford Research Facility	Campus Building	3805.1	Gas boiler	Gas	10	G	1249006	1066186	BEMS - remotely managed	Poor (Short-term)	LED	Good (Recently upgraded)	Home office research facility + 2 X CHP
Endsleigh Place (No. 14-24)	Campus Building	1239.9	Gas boiler	Gas	30	F	136168	45237	No heating controls	Poor (Short-term)	Fluorescent lamps	Poor (Short-term)	
Fitness Complex	Sports Hall	658.4	Gas boiler	Gas	21	B	20358	82809	BEMS - remotely managed	Poor (Short-term)	LED	Fair (Medium-term)	
Fitzroy	Campus Building	2988.4	Fossil fuel powered district heating	Gas	29	B	224295	86895	BEMS - remotely managed	Poor (Short-term)	LED	Fair (Medium-term)	
Francis Drake Café	Canteen/Cafeteria	383.3	Gas boiler	Gas	14	F	3145	123282	BEMS - remotely managed	Poor (Short-term)	LED	Fair (Medium-term)	
Hepworth House	Campus Building	1630.7	Gas boiler	Gas	27	B	154573	35517	BEMS - not remotely managed	Poor (Short-term)	Fluorescent lamps	Fair (Medium-term)	
Intercity Place	Campus Building	5364.2	Other	Gas	59	N/A	599153	375635	BEMS - remotely managed	Good (Recently upgraded)	LED	Fair (Medium-term)	
John Bull Building	Campus Building	5178.8	Gas boiler	Gas	18	C	683185	376872	BEMS - remotely managed	Poor (Short-term)	LED	Good (Recently upgraded)	High grade research facility
Kirkby Lodge	Campus Building	377.7	Gas boiler	Gas	13	B	17620	13669	BEMS - remotely managed	Good (Recently upgraded)	LED	Fair (Medium-term)	
1 Kirkby Place	Campus Building	113.7	Gas boiler	Gas	28	N/A	13547	2707	No heating controls	Poor (Short-term)	Fluorescent lamps	Poor (Short-term)	
Kirkby Place (No. 2-11)	Campus Building	2007	Gas boiler	Gas	28	N/A	105846	78276	BEMS - remotely managed	Poor (Short-term)	Fluorescent lamps	Poor (Short-term)	
12 Kirkby Place	Campus Building	378.3	Gas boiler	Gas	22	C	20063	14770	BEMS - remotely managed	Poor (Short-term)	Fluorescent lamps	Poor (Short-term)	
Kirkby Terrace (No. 1-4)	Campus Building	455.7	Gas boiler	Gas	22	E	19596	8254	No heating controls	Poor (Short-term)	Fluorescent lamps	Poor (Short-term)	
Kirkby Terrace (No. 5-13)	Campus Building	908.9	Gas boiler	Gas	26	E	104480	24152	BEMS - remotely managed	Poor (Short-term)	Fluorescent lamps	Poor (Short-term)	

Kirkby Terrace (No. 14-15)	Campus Building	230.6	Gas boiler	Gas	30	E	21396	2761	BEMS - remotely managed	Poor (Short-term)	Fluorescent lamps	Poor (Short-term)	
Kirkby Terrace (No. 16)	Campus Building	149.3	Gas boiler	Gas	7	E	12897	2394	BEMS - remotely managed	Poor (Short-term)	Fluorescent lamps	Poor (Short-term)	
Library	Library	8471.9	Gas boiler	Gas	18	D	925763	729211	BEMS - remotely managed	Poor (Short-term)	LED	Fair (Medium-term)	
Main Hall	Campus Building	1406	Fossil fuel powered district heating	Gas	10	C	194109	95786	BEMS - remotely managed	Good (Recently upgraded)	LED	Fair (Medium-term)	
Marine Station	Campus Building	1687.8	CHP	Gas	8	C	731709	34582	BEMS - remotely managed	Poor (Short-term)	LED	Good (Recently upgraded)	marine research
Mary Newman	Plant room	668	Gas boiler	Gas	29	D	65090	14644	BEMS - remotely managed	Poor (Short-term)	LED	Fair (Medium-term)	
Nancy Astor	Campus Building	4123.6	Gas boiler	Gas	14	C	403439	200260	BEMS - remotely managed	Poor (Short-term)	LED	Fair (Medium-term)	
Nursery Building	Campus Building	1781.5	Gas boiler	Gas	17	B	88906	41514	BEMS - remotely managed	Poor (Short-term)	LED	Fair (Medium-term)	
Portland Mews	Campus Building	676.5	Electric heating	Electricity	34	D	0.1	60530	Manual controls	Poor (Short-term)	Fluorescent lamps	Poor (Short-term)	
Portland Square	Campus Building	13260.4	Fossil fuel powered district heating	Gas	29	C	1364792	809518	BEMS - remotely managed	Poor (Short-term)	LED	Fair (Medium-term)	Data centre
Portland Villas	Campus Building	6173.9	Gas boiler	Gas	27	E	399767	814382	BEMS - remotely managed	Poor (Short-term)	Fluorescent lamps	Poor (Short-term)	
Reynolds	Campus Building	1330.9	Gas boiler	Gas	25	A	45921	26014	BEMS - remotely managed	Poor (Short-term)	LED	Fair (Medium-term)	
Robbins Conference Centre	Campus Building	3149	Gas boiler	Gas	29	D	39563	245703	BEMS - remotely managed	Poor (Short-term)	LED	Fair (Medium-term)	
Roland Levinsky Building	Campus Building	13464.4	Gas boiler	Gas	15	C	1311739	860043	BEMS - remotely managed	Good (Recently upgraded)	LED	Good (Recently upgraded)	art gallery space
Rolle Academic Building	Campus Building	6754.1	Gas boiler	Gas	14	B	250971	301763	BEMS - remotely managed	Poor (Short-term)	LED	Fair (Medium-term)	
Sherwell Centre (Lecture Theatre)	Campus Building	1974.1	Gas boiler	Gas	28	B	84697	111498	BEMS - remotely managed	Good (Recently upgraded)	LED	Fair (Medium-term)	
Skardon Place (Greenhouses)	Campus Building	216.7	Gas boiler	Gas	15	N/A	52815	20121	Manual controls	Poor (Short-term)	Fluorescent lamps	Poor (Short-term)	
Student Union	Students Union	2583	Gas boiler	Gas	15	F	931054	255389	BEMS - remotely managed	Poor (Short-term)	LED	Fair (Medium-term)	Student union
Thomas Pitts Hall	Sports Hall	505.7	Gas boiler	Gas	30	C	81192	13778	Heating - discrete controls	Poor (Short-term)	Fluorescent lamps	Poor (Short-term)	
Wellbeing	Campus Building	894.3	Gas boiler	Gas	8	C	68894	20863	BEMS - remotely	Poor (Short-	LED	Fair (Medium-term)	

Centre									managed	term)			
Brixham Laboratory	Laboratory	6534.8	Gas boiler	Gas	30	N/A	2038034	2375042	BEMS - remotely managed	Poor (Short-term)	LED	Fair (Medium-term)	High grade research facility
Rolle Marquee	Campus Building	630	Electric heating	Electricity	8	N/A	0.1	26981		Poor (Short-term)	Fluorescent lamps	Fair (Medium-term)	

41. Summary of Energy & Carbon Savings

Building Name	Current Fossil Fuel Consumption (kWh)	Current Electrical Consumption (kWh)	Total Consumption (kWh)	Annual Running Cost - 2023/24 (Inc. maintenance)	Percentage of Sample	Total Carbon Emissions (kgCO2/yr)	Potential Energy Saving - Fabric (kWh)	Potential Energy Saving - Services (kWh)	Potential Carbon Reduction (kgCO2) - 2023	Potential Carbon Reduction (kgCO2) - 2030	Est. PV Area (m^2)	Est. PV Yield (kWh/yr)	PV Carbon Saving ($kgCO_2e$)	Lifecycle Carbon Savings (TCO2e)	Running Cost Saving - 2023/24	Running Cost Saving - 2024/25	Estimated Annual Maintenance Cost	Percentage of overall operational carbon savings
Babbage	266,111	730,252	996,363	£401,243	4.20%	125,641	251,708	204,973	68,974	81,927		0	0	1,379	£157,112	£141,121	£160,295	2.85%
Brixham Laboratory	2,193,042	2,181,280	4,374,321	£1,009,203	18.43%	632,554	1,441,232	1,445,921	476,401	512,093	600	144,000	11,664	9,528	£432,944	£388,880	£140,498	17.84%
Brunel	313,603	442,920	756,523	£241,590	3.19%	104,210	0	0	24,775	42,931		0	0	495	£0	£0	£79,230	1.50%
Caprera Cottage	265	22,377	22,642	£9,267	0.10%	2,398	3,337	1,874	568	986		0	0	11	£0	£0	£2,724	0.03%
Cookworthy	190,949	253,658	444,607	£237,438	1.87%	61,769	199,598	214,836	58,601	59,325	240	57,600	4,666	1,172	£8,784	£7,890	£143,246	2.07%
Derriford Research Facility	1,084,204	1,182,876	2,267,080	£541,701	9.55%	323,696	278,668	1,395,944	261,486	275,706	475	114,000	9,234	5,230	£172,479	£154,924	£81,810	9.61%
Endsleigh Place	110,765	42,201	152,966	£50,747	0.64%	24,812	76,263	24,585	19,340	20,590		0	0	387	£15,173	£13,628	£26,658	0.72%
Fitness Complex	20,358	82,809	103,167	£40,432	0.43%	12,441	9,603	48,914	7,753	8,824		0	0	155	£15,164	£13,621	£14,156	0.31%
Fitzroy	224,295	85,148	309,443	£112,940	1.30%	50,211	158,824	114,709	46,440	47,302	300	72,000	5,832	929	£10,454	£9,390	£64,251	1.65%
Francis Drake Café	190,949	253,658	444,607	£102,433	1.87%	61,769	0	160,791	31,968	38,780		0	0	639	£8,784	£7,890	£8,241	1.36%
Hepworth House	142,376	35,517	177,893	£60,571	0.75%	29,926	93,117	71,038	28,484	28,814		0	0	570	£3,999	£3,592	£35,060	1.00%
Intercity Place	0	0	0	£115,330	0.00%	0	0	0	0	0		0	0	0	£0	£0	£115,330	0.00%
John Bull Building	554,109	678,417	1,232,526	£367,891	5.19%	173,190	145,829	731,247	135,868	144,398	960	230,400	18,662	2,717	£103,479	£92,947	£111,344	5.03%
Kirkby Lodge	30,878	12,396	43,273	£15,019	0.18%	6,983	6,924	36,069	6,954	6,960		0	0	139	£82	£73	£8,121	0.24%
Kirkby Place	139,456	95,753	235,209	£96,465	0.99%	35,714	87,001	64,346	26,908	28,921		0	0	538	£19,045	£17,107	£53,729	1.01%
Kirkby Terrace	153,565	122,162	275,727	£89,434	1.16%	41,083	103,274	80,106	31,387	33,603		0	0	628	£26,884	£24,148	£37,507	1.17%
Library	1,177,633	514,553	1,692,186	£457,431	7.13%	270,713	788,963	569,652	235,688	243,693		0	0	4,714	£97,109	£87,226	£182,146	8.49%
Main Hall	648,610	16,903	665,513	£104,266	2.80%	121,119	436,378	303,901	128,969	127,175	300	72,000	5,832	2,579	-£21,766	-£19,551	£30,229	4.43%
Marine Station	184,756	39,290	224,046	£67,413	0.94%	38,121	41,532	193,022	39,224	38,972	530	127,200	10,303	784	-£3,059	-£2,748	£36,288	1.36%
Mary Newman	65,090	15,644	80,734	£25,852	0.34%	13,619	0	0	13,619	7,080		0	0	272	£0	£0	£14,362	0.25%
Nancy Astor	313,066	289,527	602,593	£206,305	2.54%	88,004	65,779	342,894	67,643	72,297	340	81,600	6,610	1,353	£56,454	£50,708	£88,657	2.52%
Nursery Building	73,613	42,201	115,814	£58,432	0.49%	17,976	28,282	71,691	16,313	16,693		0	0	326	£4,611	£4,142	£38,302	0.58%
Portland Mews	190,949	253,658	444,607	£108,737	1.87%	61,769	199,598	214,836	58,601	59,325		0	0	1,172	£8,784	£7,890	£14,545	2.07%
Portland Square	1,364,792	809,518	2,174,310	£666,198	9.16%	336,121	286,847	1,394,202	284,329	296,167	2048	491,520	39,813	5,687	£143,598	£128,983	£285,099	10.32%
Portland Villas	299,171	814,382	1,113,553	£401,701	4.69%	140,558	218,963	209,425	68,615	85,059		0	0	1,372	£199,465	£179,164	£132,739	2.96%
Reynolds	67,858	40,761	108,619	£47,712	0.46%	16,766	48,280	35,574	14,165	14,760	400	96,000	7,776	283	£7,210	£6,476	£28,614	0.51%
Robbins Conference Centre	39,563	245,703	285,266	£143,448	1.20%	33,078	44,347	67,750	14,896	19,052		0	0	298	£50,413	£45,282	£67,704	0.66%
Roland Levinsky Building	998,947	1,065,231	2,064,178	£706,042	8.69%	295,656	290,066	1,446,805	261,288	269,144	1800	432,000	34,992	5,226	£95,286	£85,588	£289,485	9.38%
Rolle Academic Building	220,117	321,596	541,713	£262,292	2.28%	74,269	69,508	347,257	61,150	64,148		0	0	1,223	£36,375	£32,673	£145,213	2.24%
Rolle Marquee	0	26,981	26,981	£21,400	0.11%	2,833	0	0	2,833	648		0	0	57	£0	£0	£13,545	0.02%
Sherwell Centre (Lecture Theatre)	66,316	184,467	250,783	£103,212	1.06%	31,571	74,929	61,013	19,513	22,269		0	0	390	£33,433	£30,030	£42,443	0.78%
Skardon Place (Greenhouses)	52,815	20,121	72,936	£16,145	0.31%	11,831	0	0	0	5,923		0	0	0	£0	£0	£4,659	0.21%
Student Union	931,054	394,172	1,325,226	£269,499	5.58%	212,702	334,948	323,641	142,705	158,704		0	0	2,854	£194,071	£174,319	£55,535	5.53%
Thomas Pitts Hall	78,930	13,778	92,708	£23,294	0.39%	15,970	54,994	15,934	13,683	14,206		0	0	274	£6,340	£5,695	£10,873	0.50%
Wellbeing Centre	10,926	11,086	22,012	£23,619	0.09%	3,174	2,770	13,866	2,610	2,739		0	0	52	£1,565	£1,406	£19,227	0.10%
Total (HCDP Study)	12,399,132	11,340,996	23,740,128	7,204,704		3,472,245	5,841,560	10,206,818	2,698,381	2,869,758	7,993	1,918,320	155,384	53,435	1,884,274	1,692,494		

42. Electrical Infrastructure

42.1 Utility Network & Power Supply

42.1.1. The existing HV infrastructure comprises the following HV/LV transformers and capacities associated with the buildings included in the study:

Ref.	Location	Capacity
TX2 – East	Cookworthy	500kVA
TX3 – East	Robbins Sub-station	500kVA
TX4 – East	Robbins Sub-station	500kVA
TX3 – West	Portland Square	1250kVA
TX4 – West	Mary Newman	800kVA
TX5 – West	Nancy Astor	1000kVA
TX6 – West	Library	1000kVA
TX7 – West	Rolle Building	1500kVA
TX8 – West	Frances Drake	1000kVA
TX9 – West	Brunel	800kVA
TX10 – West	Babbage	1000kVA
TX11 - West	Roland Levinsky Building	1000kVA

42.1.2. As the Brunel Building is to be demolished this will potentially return 800kVA (diversified) capacity to the HV ring main which would be available to serve additional load provided the load does not exceed the capacity of the existing transformers.

42.1.3. We would recommend installing load monitoring on the existing transformers to establish a complete load profile and determine the available spare capacity.

42.1.4. The main campus site is served by an 11,000V (11kV) High Voltage (HV) electricity network which is owned and operated by the University. We understand that the University has an agreed supply capacity of 3.985MVA (3,985kVA) which was reduced from 5.00 MVA (5,000kVA in February 2019). The main HV connection point is via the substation within the Davy building. The Robbins Conference Centre, Cookworthy Building and Thomas Pitts Hall are fed via an 11kV HV ring main supplied from the Gilwell Sub-station operated by WPD.

42.1.5. Data provided by Western Power Distribution (WPD) indicates a maximum demand for the previous 3 years of approximately 2.06MVA (2,058kVA) suggesting that there is currently available spare capacity of circa 1.93MVA (1,927kVA). We understand the historic peak demand for the site is 2.69MVA (2,686kVA) recorded in February 2015.

42.1.6. It is likely that the majority of the available spare capacity will be utilised throughout the decarbonisation process as a result of mass electrification of heat. In addition, demand for Electric Vehicle (EV) charging is expected to increase significantly which will place further demand on the electrical infrastructure.

42.1.7. Based on nominal peak heating and cooling rates of 75-100W/m² for heating and 120W/m² for cooling we have estimated that following decarbonisation of the assets, the heating and cooling demand for the portfolio would be circa 2.1MVA and 1.9MVA respectively. Making reasonable allowances for lighting, power, mechanical services and other miscellaneous electrical loads we have estimated the total peak electrical load from the portfolio as circa 8.26MVA.

42.1.8. As a minimum, we would anticipate an increase in the agreed maximum supply capacity, however the secondary infrastructure and Low Voltage (LV) distribution serving the buildings on site is also likely to require reinforcement to cope with the increase in electrical demand and esure sufficient capacity for continued normal university operations. Depending on the capacity available within the upstream network, the University may be responsible for costs associated with reinforcing the local utility network to support the required increase in demand.

42.1.9. We would recommend that the University engage with WPD to determine whether the original 5.00MVA capacity is still available in the upstream network and consider reserving this capacity for future use in the medium term. We would also recommend that the University carry out a more detailed load assessment with a view to engaging with WPD to ensure sufficient upstream capacity is reserved for future use in the long term. The load assessment should also consider additional demand required by Electric Vehicle Charging Points (EVCPs)

42.2 Running Costs

42.2.1. We understand that the utility running costs for 2023/24 are estimated at circa £6.3M based on the University's agreed rates, comprising £4.5M for electricity and £1.3M for natural gas. Based on the implementation of the proposed measures, we estimate that the running costs would fall to approximately £4.4M, this excludes standing charges and assumes that there are no capacity breaches which would potentially result in higher charges.

43. Recommendations & Next Steps

43.1 Summary

43.1.1. The recommended solution to decarbonise all assets incorporates all measures identified with the exception of reflective/absorptive film on the external glazing. As a standalone measure this does not offer efficiency in terms of cost per TCO_2 saved and offers little benefit in terms or carbon reduction and where glazing replacement is recommended, this will likely deliver improved solar performance.

43.1.2. The results suggest that the proposed measures could deliver an overall reduction in carbon emissions of over 2,990 Tonnes of CO_2 per annum by 2030 compared to 2022 emissions which reflects a reduction of around 86%. The estimated lifetime carbon saving would be over 40,300 Tonnes of CO_2 when considering a typical life expectancy of 20 years.

43.1.3. The chart below provides a comparison of the expected carbon emissions between the buildings being maintained in their current form and the implementation of the recommended solution. The data suggests that the buildings included in the assessment will retain residual annual carbon emissions of circa 480 TCO_2e by 2030 compared with potential emissions of 3,470 TCO_2e if no action is taken.

43.1.4. Total estimated aggregate carbon emissions between 2022 and 2030 would be 19,630 TCO_2e compared to 30,630 TCO_2e if no action were taken, a reduction of circa 37%.

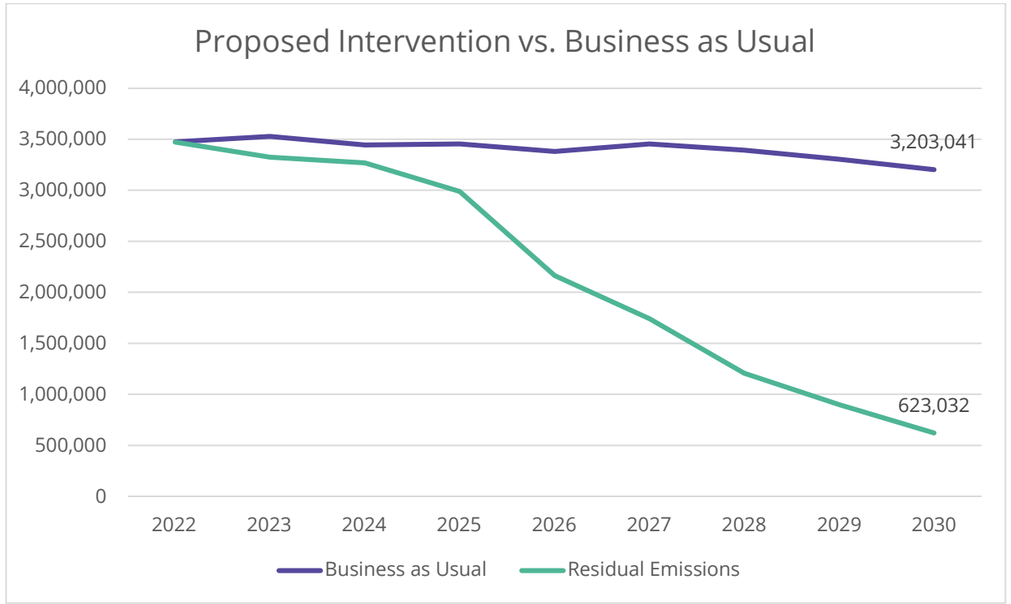


Fig. 43.1 Residual emissions after decarbonisation programme

43.2 Optimisation

43.2.1. Existing BMS systems should be reviewed to ensure they are operating effectively and controlling systems in an energy efficient manner. Obsolete BMS systems should be assessed and where required systems upgraded to modern BMS systems. All sensors and controllers to be validated and replaced or recalibrated where required. Control strategies and settings to be reviewed to ensure appropriate for any changes of building use / patterns of use. We would recommend ensuring a single BMS provider and platform is utilised across all University of Plymouth sites.

43.2.2. Where sub-metering is not currently provided this should be implemented as part of any decarbonisation or optimisation works in order to monitor and assess the effectiveness of each intervention. We would recommend a detailed metering strategy is developed to compliment the existing system to ensure consistent data capture across assets. As a minimum this should include:

- Space heating and cooling plant either via gas/electricity sub-meters or heat meters from the existing heat network.
- Domestic Hot Water generators.
- Ventilation/Air Handling plant.
- Lighting and small power.

43.2.3. Where pipe and duct systems are to be retained or works are scheduled in the longer term, all thermal insulation should be subjected to detailed inspection and repaired/replaced where necessary.

43.3 Brunel Park Borehole Array Investigation

43.3.1. An initial estimate based on Erda's inclined borehole technology suggests that it may be possible to deliver between 7 and 10 GWh of thermal energy from the proposed borehole site beneath the Brunel building supporting a peak load of around 5-7MW. This is well in excess of the estimated requirement for the buildings included in the assessment and would potentially allow the whole site to be fed from such an installation.

43.3.2. At this stage these are high-level, indicative capacity estimates only, and would need to be verified through a detailed design process. The next recommended next step would be to carry out a desktop based geo-environmental study. The scope (and cost) of this would need to be discussed and agreed with the University, but would typically include:

- Review of available site surveys for the proposed site.
- Review of a site specific British Geological Survey (BGS) Geo-report and highlight any potential adverse ground conditions for the borehole system.
- Assessment of thermophysical properties of ground to borehole depth.
- Evaluation of the environmental risk consistent with Environment Agency regulations / guidance.
- Evaluation of the drilling risk consistent with Environment Agency regulations / guidance.
- Review of Archaeological sensitivities on the proposed site.
- Contact with Coal Authority, Local Authority.
- A qualitative risk assessment of the potential to cause a potential pollutant pathway linkage (PPL) and provide advisory mitigation with regards to the borehole installation.
- Advise on the relevant technical standards and legislation to be reviewed and discharged during the installation and operation of the system.
- Assessment of site access and logistics for drilling operations.
- Electrical load testing and analysis to establish the connected electrical load to each building, this will identify what spare capacity is available and what could be released if the improvements were made to the electrical infrastructure via the introduction of new LED lighting solutions and Solar PV's.
- A programme of utility works to increase capacity where necessary and renew the infrastructure would need to be undertaken. We would recommend this is informed by a programme of load monitoring across the HV/LV transformers to confirm the current demand and capacity within the customer network.
- Early engagement with the electricity supply company to determine the availability of additional supply capacity.

44. Delivery Plan

44.1 Procurement & Resources

44.1.1. All measures within the recommended solution will be subject to detailed design and a procurement process in line with the University's procurement policies and standards. In order to develop a detailed design, the University is likely to need to appoint the following professionals:

- Project Manager (PM)
- Contract Administrator (CA) (may be the same individual/organisation as PM
- Principal Designer/CDM Co-ordinator
- Architect
- Structural/Civil Engineer
- Building Services Engineer
- Quantity Surveyor
- Planning Consultant
- Building Control Officer/Approved Inspector

44.1.2. Project management/Contract Administration responsibilities would be retained by the University and carried out by permanent staff. Day-to-day decisions on development of business cases, design and programming will be taken by the University sustainability team.

44.1.3. Although we recognise that all projects have individual characteristics and time commitments, we would recommend an allowance of 1 working day (8 hours Full-Time Equiavalent (FTE) per week of project duration e.g. for a project duration of 12 months, the PM/CA requirement would be circa 52 days. We have included an estimate of the resource requirement for the PM/CA role within the outline project plan.

44.1.4. It is likely that the University will outsource some of these roles (design, QS, engineering) to an external professional consultancy team. We have included costs for professional fees within our budget estimates at a rate of 12.5% of the estimated capital cost (excluding VAT).

44.1.5. The construction/installation works would be carried out by external contractors appointed via a competitive tender process to achieve best value.

44.1.6. There is also likely to be a significant commitment from the University's estates team in order to manage the information gathering process and facilitate access, health and safety and management of contractors on site during the works.

44.1.7. We would suggest that the works would be established in two phases; phase 1 would incorporate the recommended fabric works and phase 2 would encompass the services works. These phases would not necessarily need to be carried out consecutively however elements of the services installations may affect the fabric works (i.e. penetrations/openings, structural elements/support, plant bases etc.) and should be considered during the detailed planning stage.

44.1.8. Maintenance of the buildings and new installations will be carried out by incumbent contractors via the existing maintenance framework.

44.1.9. Key personnel within the University will be involved in the delivery of the HCDP projects and may retain one or more of the professional roles/responsibilities identified above. These individuals are:

- Head of Sustainability
- Energy Manager
- BMS Manager
- Head of Building and Engineering
- Maintenance Manager
- Building services engineer
- Finance business partner
- Capital Project Manager

44.1.10. The outline project plan below identifies the relevant projects and estimated programme durations. Red signifies high priority projects, amber, medium priority and green low priority. We have also included an indicative programme for the borehole installation and the infrastructure works.

44.2 Outline Project Plan

Building Name	PM/CA (days)	2023				2024				2025				2026				2027				2028				2029				2030				2031			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Infrastructure/Utility Works	260																																		
Borehole/Ambient Loop Installation	104																																		
Babbage (In progress)																																			
Brunel (Demolition)																																			
Caprera Cottage																																			
Cookworthy	52																																		
Derriford Research Facility	65																																		
Endsleigh Place	52																																		
Fitness Complex	52																																		
Fitzroy	52																																		
Francis Drake Café	26																																		
Hepworth House	52																																		
Intercity Place																																			
John Bull Building	65																																		
Kirkby Lodge	26																																		
Kirkby Place	39																																		
Kirkby Terrace	39																																		
Library (Priority!)	78																																		
Main Hall	39																																		
Marine Station	39																																		
Mary Newman	26																																		
Nancy Astor	52																																		
Nursery Building	26																																		
Portland Mews (need to confirm)	13																																		
Portland Square	91																																		
Portland Villas	52																																		
Reynolds	26																																		
Robbins Conference Centre	26																																		
Roland Levinsky Building	52																																		
Rolle Academic Building	52																																		
Sherwell Centre (Lecture Theatre)	52																																		
Skardon Place (Greenhouses)																																			
Student Union	39																																		
Thomas Pitts Hall	52																																		
Wellbeing Centre	39																																		
Brixham Laboratory	78																																		
Rolle Marquee	13																																		

45. Key Challenges

45.1 Utility Costs

45.1.1. 2022 has seen an unprecedented rise in the unit costs of energy due to various global factors and the make-up of the UK energy market. Although the government has introduced an energy price cap for domestic consumers, there is no such cap for commercial business however the University has agreed a flexible procurement contract for their energy supply and have agreed unit costs for the supply of gas and electricity until July 2025. The unit prices are listed below.

	Unit Price for Utility Supplies per MWh	
FY	**Gas**	**Electricity**
2022/23	£120.40	£303.90
2023/24	£106.56	£291.12
2024/25	£81.57	£261.49

45.1.2. Although it is anticipated that recent high unit prices will return to more typical levels, it is a risk that unit prices could rise beyond those currently agreed when the next supply contract for 2025/26 onwards is negotiated.

45.2 Utilities Capacity

45.2.1. The estimated electrical capacity requirement is 7.85MVA. The site infrastructure is geared to an original capacity of 5.0MVA however this was reduced by agreement to 3.985MVA. Further investigation will be required to determine whether suitable upstream capacity is available within the network and liaison with WPD to establish confirm what is available and to secure sufficient capacity is available. The HCDP will need to be reviewed should suitable upstream capacity be unavailable.

45.3 Asbestos

45.3.1. Due to the age of many buildings on the estate it is likely that asbestos will be present and poses a potential risk to the implementation of the decarbonisation programme. It is likely that some buildings will require specialist asbestos removal to complete the works.

45.3.2. We would recommend a full review of the University's asbestos register to ensure it is up-to-date and this should be fully referenced during detailed design and programming of the works.

45.4 Longevity of Existing Systems

45.4.1. Many of the existing engineering services systems are ageing although have generally been well-maintained. However, significant items of plant are approaching end-of-life and the risk of failure is ever-increasing. An example of this is the boilers within Mary Newman which have suffered significant failures through 2022 resulting in a requirement for temporary boilers to be used to serve the DHN.

46. Approval of HDCP

46.1.1. This HCDP has been subjected to a stakeholder review by the University of Plymouth including technical and financial oversight from the estates team. The review/approval process is outlined in our application submission.

46.1.2. This report has been submitted to and reviewed by Jack Roberts (UoP Energy Manager) along with the Sustainability Advisory Group and other key University personnel responsible for the planning and delivery of capital projects.

46.1.3. Delegated authority for the sign off of the final HCDP sits with the Director of Estates. The director is responsible for the capital plan of which the delivery of the works will feed into.

46.1.4. The University's overall Carbon Management Plan (CMP) outlines the governance procedures in respect of the delivery the Carbon Strategy and this report has been approved by each group up to and including the University's Governors.

46.1.5. The following table identifies the key roles of the individuals who will be responsible for the approval and implementation of the overall CMP.

University Executive Group: has overall responsibility for the Carbon Strategy and the Carbon Management Plan. The Vice-Chancellor delegates responsibility for undertaking aspects of these duties through line management and identified roles.
The following people and groups are identified as having responsibilities for carbon management.
Sustainability Advisory Group: oversees the carbon management activity across the University, including for research and teaching and learning, and reports into UEG regularly on sustainability performance.
Executive Dean, Faculty of Science and Engineering: chair of the SAG, and has delegated senior responsibility for the delivery of the Carbon Strategy and leadership for this strategy across the University.
Director of Estates and Facilities: deputy chair of the SAG, overall responsibility for ensuring sustainability and carbon management is delivered throughout Estates and Facilities.
Heads of School: to cooperate and collaborate with the SAG and any responsible persons to enable the Carbon Strategy and Carbon Management Plan to be delivered. Ensure that operational activities comply and deliver against the Carbon Management Plan and to engage with collaboration on process change.
Head of Sustainability: delegated responsibility for the day-to-day management of the Carbon Management Plan and to ensure that it is implemented and continually developed.
Energy Manager: delegated responsibility for the day-to-day management of energy, gas and water use and ensuring that the requirements of the Carbon Management Plan in respect of utility use is implemented.
Head of Engineering: overall responsibility for the engineering and maintenance function of the Estates and Facilities directorate, required to ensure that this function incorporates the requirements of the Carbon Management Plan. Delegated responsibility to project managers within the function to deliver the low carbon projects.
Head of Facilities: overall responsibility for the facilities function of the Estates and Facilities directorate, required to ensure that this function incorporates the requirements of the carbon management plan, particularly in relation to waste management.
Head of Capital Developments: overall responsibility for ensuring ultra-low carbon design incorporated into capital projects.
Head of Procurement: champions the requirements of the Carbon Management Plan, with particular attention given to addressing emissions associated with supply chain and the University's acquisition of goods, works and services. This will also include evolving procurement strategies and processes; liaising with and making recommendations to internal stakeholders and suppliers.
Director of the Sustainable Earth Institute: overall responsibility for creating a collaborative, interdisciplinary and innovative research environment and culture around sustainability (including low carbon) and supporting knowledge exchange and research impact with the wider world.
Manager of the Sustainable Earth Institute: delegated responsibility for creating a collaborative, interdisciplinary and innovative research environment and culture around sustainability (including low carbon) and supporting knowledge exchange and research impact with the wider world.
Centre for Sustainable Futures Lead: distributed leadership responsibility for encouraging across the sustainability education community of practice, the integration of low carbon change consideration within the curriculum and pedagogy of undergraduate and masters programmes of study.
Staff and students: responsibility to ensure their activities comply with the requirements of the Carbon Management Plan and any relevant legislation and departmental codes of practice. Also, to collaborate with the sustainability activity on campus, helping to take forward new initiatives and behaviour change.

Appendix I

Display Energy Certificates

Appendix II

Supporting Information

Appendix III

Example Datasheets

Appendix IV

Building Floorplans

Appendix V

HV Schematics

Appendix VI

Images

Ref	Building	
1.	Brixham Laboratory	
2.	Brixham Laboratory – Gas fired boilers	

3.	Brixham Laboratory – Chiller Plant	
4.	Caprera Cottage – Electric heating	

5.	Caprera Cottage – Lighting	
6.	Charles Seale-Hayne Library	

7.	Charles Seale-Hayne Library	
8.	Charles Seale-Hayne Library – General, lighting	

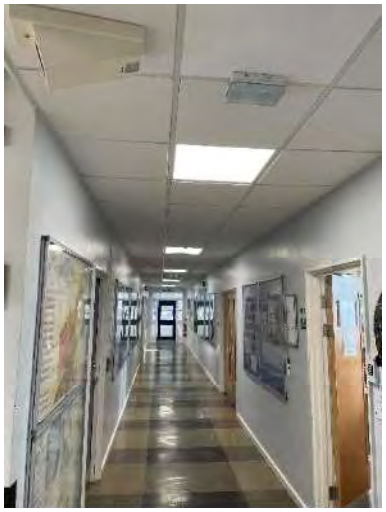
9.	Cookworthy	
10.	Cookworthy	

11.	Cookworthy – Heating	
12.	Cookworthy – Domestic Hot Water	

13.	Derriford Research Facility	
14.	Derriford Research Facility	

15.	Derriford Research Facility – AHU Plant	
16.	Derriford Research Facility – Rooftop chiller plant	

17.	Endsleigh Place	
18.	Fitzroy	

19.	Fitzroy – General internal	
20.	Hepworth House	

21.	Hepworth House – Boiler plant	
22.	John Bull Building	

23.	John Bull Building – Domestic Hot Water plant	
24.	John Bull Building – CHP Plant	

25.	Kirkby Lodge	
26.	Kirkby Lodge – Gas boiler	

27.	Kirkby Lodge – General services pipework	
28.	Kirkby Place	

29.	Kirkby Place – Domestic Hot Water	
30.	Kirkby Place – Gas boiler	

31.	Kirkby Terrace – Gas Boiler	
32.	Kirkby Terrace – General fluorescent lighting	

33.	Main Hall	
34.	Main Hall – General internal, lighting	

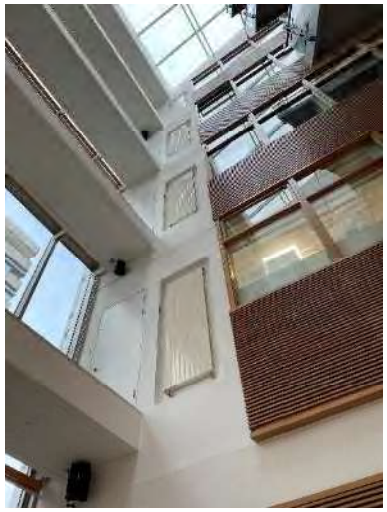
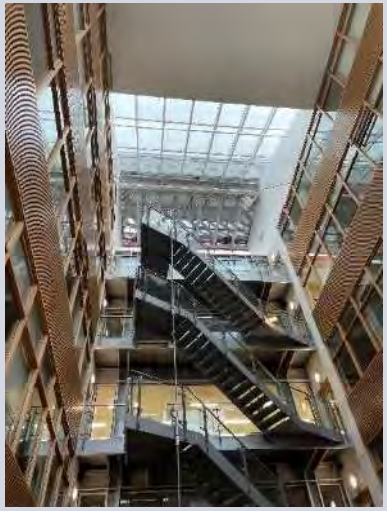
35.	Main Hall – Heating	
36.	Marine Station	

37.	Marine Station – General services	
38.	Marine Station – General internal, lighting	

39.	Nancy Astor Building	
40.	Nancy Astor Building	

41.	Nursery and Fitness	
42.	Nursery and Fitness – General internal	

43.	Portland Villas – Under construction	
44.	Portland Square	

45.	Portland Square – LTHW heating	
46.	Portland Square - General internal	

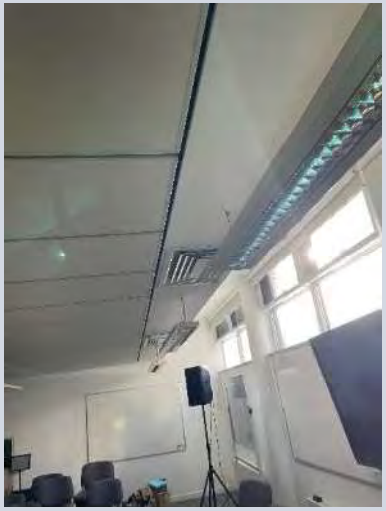
47.	Reynolds Building	
48.	Reynolds Building – General internal, heating	

49.	Reynolds Building – General internal, lighting	
50.	Robbins Centre	

51.	Robbins Centre – Heating	
52.	Robbing Centre – Heating, lighting	

53.	Roland Levinsky Building – General internal	
54.	Roland Levinsky Building – Main heating plant	

55.	Roland Levinsky Building – BMS Control Panel	
56.	Rolle Academic Building	

57.	Rolle Academic Building – General internal	
58.	Rolle Academic Building – General services	

59.	Sherwell Centre	
60.	Sherwell Centre – General internal, ventilation, lighting	

61.	Sherwell Centre – Gas boiler	
62.	Student Union	

63.	Student Union	
64.	Thomas Pitts Hall	

65.	Thomas Pitts Hall – General internal, heating, ventilation	
66.	Thomas Pitts Hall – General internal, lighting, ventilation, domestic services	

67.	Wellbeing Centre	
68.	Davy Energy Centre – Boiler No. 2	

69.	Davy Energy Centre – CHP Unit	
70.	Davy Sub-station	

Contact details

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