

AtkinsRéalis



# Estate Decarbonisation Plan Update

University of Hertfordshire

6 May 2025

## ESTATE DECARBONISATION PLAN 2025 UPDATE

# Notice

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# Executive Summary

In 2021, the University of Hertfordshire (UH) published its Climate Change Vision<sup>1</sup>. It sets out UH's commitment to becoming a Net Zero (NZ) Higher Education Institution (HEI) by 2050. UH's Climate Change Vision identifies four pathways to Net Zero carbon emissions.

The 'UH Estate Decarbonisation Plan' ("EDP") was first developed in 2023, focusing on the second pathway of reducing operational carbon emissions from the buildings on UH's campuses. The methodology adopted comprised visual surveys of the buildings and their engineering systems, a review of campus-wide energy infrastructure, investigations into control systems and operations, analysis of energy consumption and operational carbon emissions, and appraisals of Net Zero retrofit options.

In 2024, AtkinsRéalis were commissioned to update the EDP, considering the updated 'UH Estates Vision 2035', works completed across the campuses since 2023, and the latest available energy consumption and utility data.

The scope covers sixty-seven buildings, including all academic buildings and the buildings included in the Private Finance Initiative (PFI) arrangement on the de Havilland campus. Process loads (e.g. specialist equipment used in teaching or research) and carbon emissions from the consumption of diesel by UH's bus fleet (UNO) are not included in the scope of the EDP.

The EDP is based on the following interlinked themes:

- **ELECTRIFY** – switch from burning fossil fuel to electrically-driven heating and hot water systems
- **CONTROL** – active energy and carbon management and enhanced building control systems
- **INSULATE** – reduce peak loads and annual demand for thermal energy

The EDP sets out retrofit measures which reduce energy consumption and carbon emissions compared to the baseline, taken as UH'S financial year 2023/24 (August to July). The following baselines (Table 1) have been derived from analysis of meter readings and consumption data:

**Table 1 – Baselines: Grid Energy Consumption and Carbon Emissions (2024 carbon factors)**

|               | Previous EDP Issue (2021/22<br>Baseline) |                                                  | Current EDP Issue (2023/24<br>Baseline)  |                                                  |
|---------------|------------------------------------------|--------------------------------------------------|------------------------------------------|--------------------------------------------------|
|               | Grid Energy<br>Consumption<br>(kWh p.a.) | Carbon<br>Emissions<br>(tCO <sub>2</sub> e p.a.) | Grid Energy<br>Consumption<br>(kWh p.a.) | Carbon<br>Emissions<br>(tCO <sub>2</sub> e p.a.) |
| Gas and LPG   | 24,754,179                               | 4,558                                            | 19,203,890                               | 3,516                                            |
| Electricity   | 29,328,141                               | 4,075                                            | 27,265,573                               | 4,063                                            |
| <b>Totals</b> | <b>54,082,321</b>                        | <b>8,633</b>                                     | <b>46,469,463</b>                        | <b>7,579</b>                                     |

Since the original EDP issue, representing the Baseline against which UH will report progress, energy consumption across the in-scope buildings has reduced by 14%, resulting in a carbon emissions reduction of 12%. This has been achieved through a combination of decarbonisation and energy efficiency improvements being implemented in buildings, as well as a reduction in the carbon factors of grid electricity consumption. It should be noted that additional buildings and associated energy consumption have been included within the scope of analysis of the EDP update, namely Park & Ride and Spectra. A period of downtime for the Main Boiler House on the College Lane campus has

<sup>1</sup> Herts.ac.uk. 2021. *The University of Hertfordshire Climate Vision*. [online] Available at: <<https://www.herts.ac.uk/about-us/environment-and-sustainability/our-climate-change-vision>>.



also been reported, resulting in a drop in natural gas consumption. Additionally, only raw energy consumption data has been analysed, weather-normalised energy consumption analysis has not been conducted. For reference, the heating demand has been found to be 5% lower in 2024 than the previous year.

The following Net Zero retrofit measures have been considered for UH's estate (Appendix H):

1. Building Fabric Improvements (thermal insulation and airtightness)
2. LED Lighting and Controls Retrofit
3. Decarbonisation of Heating and HWS
4. Cooling Upgrades
5. Building Management System (BMS) and Active Energy & Carbon Management
6. Ventilation Upgrades
7. Solar PV – on-site and off-site

The operational carbon emissions from buildings are part of Scope 1 and Scope 2 defined in the Greenhouse Gas Protocol. Scope 3 emissions are not affected by the EDP. Gas consumption for catering is not included in the scope of the EDP. However, when commercial kitchens are refurbished, it is expected that gas equipment will be removed and will be replaced with electrical catering equipment.

The in-scope buildings range from the original WW2 college buildings to the recently completed buildings on the de Havilland campus and the SPECTA Building (Science Physics Engineering and Computer Science) on the College Lane campus. In 2025, the average age of the buildings across the estate is thirty years, which means that they are more thermally efficient compared to older estates.

Most buildings are heated by gas-fired boilers, which are a major source of carbon emissions. Many boilers are due for replacement due to their age and condition, or are approaching the end of their economic life in the next ten years. Consequently, the risk to UH of loss of heat due to boiler failure will increase significantly. However, there is the opportunity to replace them incrementally with alternative low/zero carbon (electric) heat sources in a planned programme, subject to the availability of funding. If internal funding is constrained, there may be alternative off-balance-sheet solutions that UH could consider, either as a standalone 'Design/Build/Finance/Operate' arrangement or integral to a new Facilities Management contract (the existing contract with Tenon is due to expire in September 2026).

There are no District Heat Networks (DHN) near the campuses and there are no plans to build any, according to information available from the Local Planning Authority. The option of UH building a DHN and central Energy Centre on the de Havilland Campus has been appraised, however the decentralised, incremental approach to heat decarbonisation is more cost effective and lower risk and is therefore preferred.

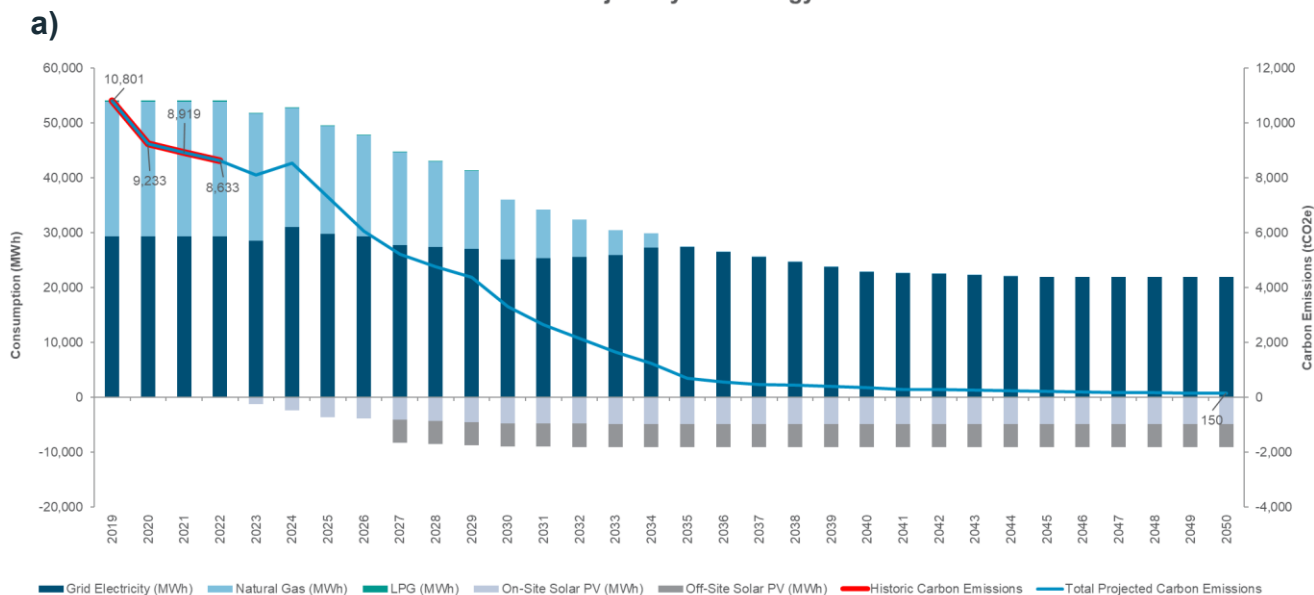
The total indicative capital cost of all the recommended measures that can contribute to the NZ programme is estimated to be £143.1m (at Q1 2025 prices, excluding VAT). This achieves a 99% reduction in annual carbon emissions compared to the Baseline. UH have an annual budget for decarbonisation and energy efficiency works in 2025/26 of £2.85m per annum. It is assumed that this budget will increase in line with the inflationary factor applied to capital costs of 3.5% per annum. The UH annual budget up to 2050 totals £118m and is therefore not sufficient to include all recommended measures within the period to 2050. Consequently, the optimal selection of measures has been proposed, in line with the budget allowance (i.e. biggest savings in operational carbon emissions). A total capital expenditure of £74.7m is projected (at Q1 2025 prices, excluding VAT), aligned to the recommended measures to undertake within the budget allocation, focusing on heat decarbonisation and BMS upgrades. AtkinsRéalis recommend that UH continue with their current budget as this follows a pragmatic and value-based approach.

Sources of uncertainty associated with the EDP include the rate at which the UK's electricity grid decarbonises and future climate scenarios (potentially milder winters). The risks (Appendix C) include technical obsolescence, industry capacity, supply-chain bottlenecks, funding (including the availability of grants from government) and planning risk.

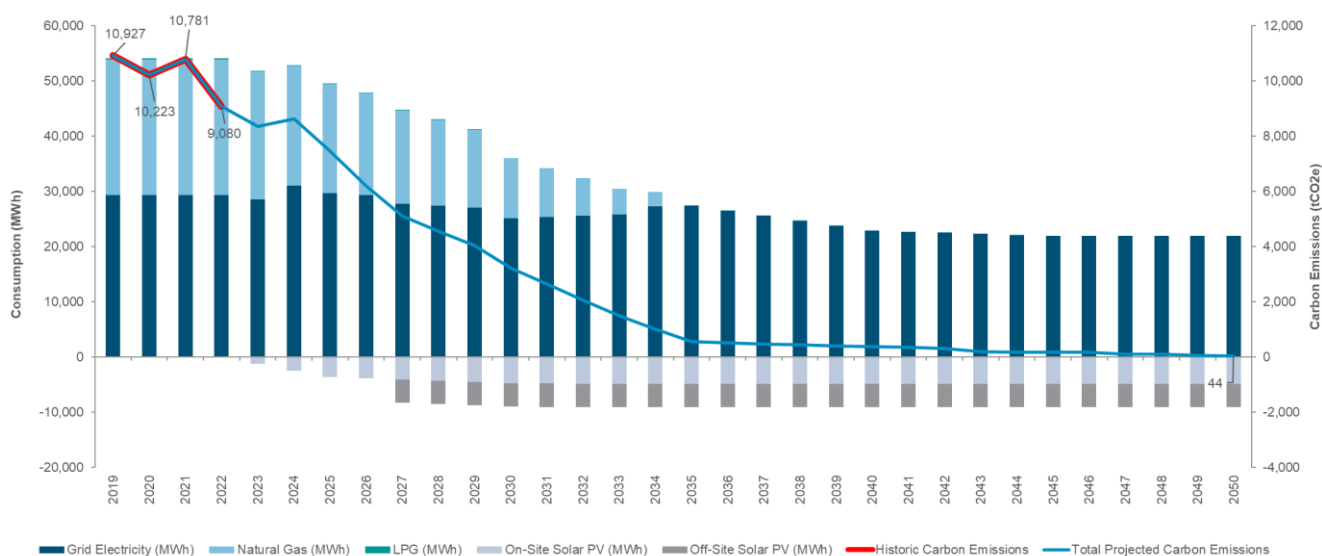


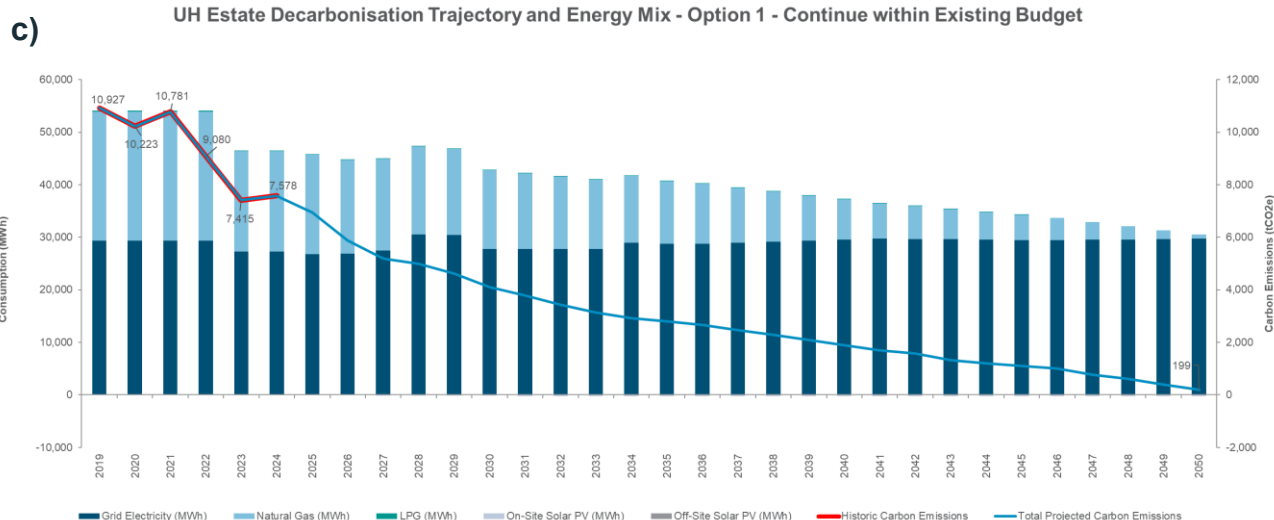
The carbon trajectory associated with a) the previous EDP issue, b) the previous EDP issue with the latest carbon factors and c) the current recommended programme of Net Zero retrofit works is shown in Figure 1. To note, historic carbon factors have been updated by the Department for Energy Security and Net Zero (DESNZ, formerly BEIS), hence the variance in emissions from 2019-2023, despite no change in magnitude in historic energy consumption. It is based on an incremental approach with the Net Zero retrofit measures being coordinated with other programmes of works programmes, thereby leveraging the PPM/minor works budgets in combination with UH's Net Zero budget of £2.85million. UH are no longer eligible for public sector grant funding from Salix Finance due to changes in eligibility criteria for universities. However, this should be kept under review as Salix's eligibility criteria may change each year.

**UH Estate Decarbonisation Trajectory and Energy Mix - 2022/23 Issue**



**b)** **UH Estate Decarbonisation Trajectory and Energy Mix - 2022/23 Issue with Latest Carbon Factors**





**Figure 1 - Decarbonisation Trajectory and Energy Supply Mix**

Figure 1a) shows the projected residual carbon emissions in 2050 from the original EDP issue (150 tCO<sub>2</sub>e). Figure 1b) shows the same programme of works with current carbon factors (the projected residual carbon emissions in 2050 fall to 44 tCO<sub>2</sub>e as a result of reduced carbon factors for natural gas and grid electricity). Figure 1(c) shows the recommended trajectory in line with UH's current budget allocation, with current carbon factors used (projected residual carbon emissions of 199 tCO<sub>2</sub>e in 2050). This represents a 97% reduction from the Baseline.

The revenue implications of the EDP should be reviewed regularly. The recent volatility in prices in the UK energy supply market means that bills and the financial impact of savings in grid energy consumption have varied significantly.

The operational carbon, grid energy consumption, renewable energy generation and financial (capital and revenue) implications of the proposed works should be evaluated during the design stage for each building. The evaluation should include the maintenance costs and the benefit from any export of renewable energy.

The supporting UH Delivery Plan enables scenario testing. This document also facilitates the evaluation and reporting of carbon savings and comparison of the actual decarbonisation trajectory against the EDP. Annual adjustments to the Net Zero programme of works can be considered accordingly. This will support the case for funding within the university.

The following recommendations are made:

1. Produce 'Annual Carbon Reduction Plan' to meet UH's Financial Planning Round
2. Incorporate the EDP into 'UH 2035 Estates Vision'
3. Review Service Levels for Facilities Management prior procurement of FM contract in 2026
4. Initiate Net Zero projects in 2024/25 and 2025/26
5. Establish project team to plan and deliver Net Zero projects
6. Agree the process for evaluating and reporting the operational carbon savings and other benefits, and for comparing the actual decarbonisation trajectory against the EDP

# 1. Understanding the Baseline

## 1.1 Strategic Context

We face a Climate Emergency and an Ecological Emergency. The scientific evidence of man's contribution to climate change is increasing each year. Average air and sea temperatures are rising, and extreme weather events are becoming increasingly common and more severe. To mitigate this, the United Nations 2030 Agenda for Sustainable Development was adopted by all UN states in 2015. It is based on the UN Sustainable Development Goals. The Paris Agreement set challenging targets to reduce greenhouse gas emissions to limit global warming by 1.5°C above pre-industrial levels.

Net Zero carbon refers to a balance between the amount of greenhouse gas emissions (carbon dioxide or equivalent) emitted to and the amount removed from the atmosphere. This can be achieved by a combination of reducing existing emissions and by sequestration by natural processes and technical solutions (e.g. tree Planting or Carbon Capture and Storage - CCS). Offset payments are invested in sequestration schemes.

The UK government set a target of Net Zero carbon by 2050 in its 2019 amendment to the Climate Change Act 2008. The volatility in international energy markets since Russia's invasion of Ukraine in February 2022 has also added to the urgent need to reduce fossil fuel consumption to improve resilience to market shocks.

In 2021, the University of Hertfordshire (UH) published its Climate Change Vision<sup>2</sup>. It sets out UH's commitment to becoming a Net Zero institution by 2050, which aligns with the government's target.

The Climate Change Vision aims to reduce UH's overall carbon impact whilst simultaneously empowering positive action through the community as part of their pledge to the 'Race to Zero' global campaign. The vision identifies the following four pathways to Net Zero carbon emissions:

1. Building a sustainable community
2. Reducing operational emissions
3. Education, student, and people experience
4. Research, enterprise, and global engagement

UH appointed AtkinsRéalis (formerly Faithful+Gould) to create the EDP in 2022, having worked for UH on several projects and demonstrated familiarity with UH's campuses and the Estates Department. This established the Baseline from which UH will report against in terms of progress to Net Zero. This document provides an update to the EDP, taking into account the updated 'UH Estates Vision 2035', works completed across the campuses since prior issue of the EDP, and the latest available energy consumption and utility data.

This EDP update focuses on the second pathway of reducing operational carbon emissions from UH's buildings. Therefore, the diesel consumed by the University's bus company, UNO, is not in the scope of the plan. It also excludes process loads (e.g. laboratory equipment).

It builds on the successful carbon reduction measures implemented by UH Estates since 2023 and prior, and complements UH's Strategic Asset Management Plan (SAMP) and the other programmes of works on the estate.

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<sup>2</sup> Herts.ac.uk. 2021. *The University of Hertfordshire Climate Vision*. [online] Available at: <<https://www.herts.ac.uk/about-us/environment-and-sustainability/our-climate-change-vision>> [Accessed 20 March 2023].

## 1.2 Background to UH and its Estate

The University of Hertfordshire is a successful and growing university which attracts undergraduate and post-graduate students from the UK and overseas. The area has a strong tradition of technical innovation and a proud history in aviation. The College Lane campus was originally built by the de Havilland Aircraft Company Limited. The company was established in 1920 by Geoffrey de Havilland.

The de Havilland company donated the College Lane site to Hertfordshire County Council for educational use. The site was then developed as Hatfield Technical College, which is now UH's College Lane Campus.

UH's estate comprises a range of building types, including residential, teaching, research facilities, student welfare and commercial buildings. For the purposes of this plan, the other buildings in the estate (e.g. Bayfordbury) are included with the College Lane campus buildings.

The scope of the EDP covers all the academic buildings on the campuses and the buildings included in the PFI arrangement on the de Havilland campus, totalling 67 buildings. The gross internal floor area (GIFA) of the in-scope buildings amounts to approximately 201,540 m<sup>2</sup>, with an average age of thirty years.

Changes in student numbers has altered requirements across the estate in terms of educational spaces and utilisation. The 'UH Estates Vision 2035' sets out the university's plans in response to these changes for its courses and research programmes.

The consequences for the EDP of the proposed demolition of old, unsuitable buildings on the College Lane Campus and the construction of new, purpose-designed, low carbon buildings is considered in Section 2.1.

## 1.3 Purpose of the EDP and Annual Updates

The purpose of this EDP is to describe how the organisation intends to replace fossil fuel systems with low carbon alternatives to decarbonise its buildings.

The EDP describes UH's consumption of grid electricity and gas in its buildings and its plans for decarbonising them to meet its target of Net Zero in 2050. The EDP outlines what UH has already done, what it is currently doing and describes its plans. It is intended to be used by the Estates Department and the Net Zero project teams to plan and deliver the Net Zero programme of works.

The management of the Net Zero programme, including securing funding the identification of sufficient and suitable resources, is key to delivering the intended outcomes of this plan. It is recognised that the programme needs to be flexible to respond to changing circumstances while maintaining the EDP's trajectory to Net Zero.

The progress towards Net Zero 2050 should be tracked annually. The impact of programmes of works and changes to the carbon factor for grid electricity and gas is measured in tonnes of carbon dioxide or equivalent per unit of energy (tCO<sub>2</sub>e/kWh). Figure 1b and 1c illustrate the progress made in 2023/24 (shown in the 2024 bar).

## 1.4 Methodology

UH appointed AtkinsRéalis (formerly Faithful+Gould) to create this EDP. The methodology adopted comprises visual surveys of the buildings and their engineering systems, a review of campus-wide energy infrastructure, investigations into control systems and operations, analysis of energy consumption data and the associated operational carbon emissions, and appraisals of Net Zero retrofit options. The findings have been integrated in the EDP.



Data analysis involved evaluating the buildings to assess their size and type as well as the quality of the billing and metering arrangements on site. Furthermore, the opportunity of district heat networks in the area was investigated along with an assessment of the HV/LV electrical infrastructure.

The energy and carbon emissions baseline (Table 1) were defined by analysing the consumption data using the financial year (FY) 2023-24 as the baseline. This considers previously completed energy efficiency and carbon reduction projects.

The visual surveys involved assessing the buildings, their mechanical and electrical engineering installations and fuel types. Once a picture was developed from this information, Net Zero retrofit solutions were developed to estimate the programme costs using benchmark pricing. The measures proposed for each building are identified in Appendix M, 'Outline Scopes of Works'.

## 2. Scope

### 2.1.1 de Havilland Campus

The de Havilland campus comprises the following Academic and Private Finance Initiative (PFI) buildings, (Tables 2 and 3 below). Further details on the de Havilland campus buildings are included in Appendix D.

**Table 2 - Academic Buildings on the de Havilland Campus**

| Site  | Name                               | Description                               |
|-------|------------------------------------|-------------------------------------------|
| P802M | Block M (Sir Brian Corby Building) | Business School (Including Atrium)        |
| P802N | Block N (Teaching Block)           | Lecture Theatres & Classrooms             |
| P802R | Block R (Humanities & Education)   | Humanities & Education (Including Atrium) |
| P803  | de Havilland Reception             | New Reception                             |
| P806  | Enterprise Hub                     | Teaching & Social Space                   |
| P808  | LRC                                | Learning Resources Centre                 |
| P839  | Law Court Building                 | New Law Court Building                    |
| P840  | Gatehouse                          | de Havilland Gatehouse & Barrier Control  |
| P825  | The Street                         | Enclosed Link Between Buildings           |
| P805  | The Weston Auditorium              | Auditorium                                |
| P838  | Institute of Sport                 | Teaching (LMS)                            |

The Academic buildings are owned and occupied by UH. Tenon are the hard FM provider for these buildings Their ten-year contract expires in September 2026. UH advised that any sustainability, energy efficiency and net zero interventions are not included within the scope of the current FM contract. Similarly, optimisation of the BMS controls is not in scope within their contract.

**Table 3 - Private Finance Initiative (PFI) Facilities on the de Havilland Campus**

|       |                              |                                      |
|-------|------------------------------|--------------------------------------|
| P810A | Sports Village               | Sports Village                       |
| P810A | Refectory                    | Refectory                            |
| -     | Outdoor Change               | Changing Rooms                       |
|       | RSO                          | Residence Office and Student Shop    |
| -     | Accommodation Blocks (11no.) | Student Accommodation/Summer Schools |

Due to their adjoining nature, the MNR blocks have been combined. Similarly, the Enterprise Hub and de Havilland Reception are considered as one building for the purposes of the EDP.

Approximately eight years remain on the de Havilland campus PFI concession period. UH has confirmed that no decision has been made regarding its future. The measures proposed have regard to this and should not limit the options available to UH as the expiry date for concession period gets closer.

The Special Purpose Vehicle (SPV) company responsible for administering the PFI facilities employs Pinnacle as the FM contractor. UH advised there is no direct contractual relationship between UH and Pinnacle.

However, UH pay the utility bills for the PFI buildings. Therefore, it these buildings should be in-scope, even though their operation and maintenance are governed by the PFI agreement.

## 2.1.2 College Lane Campus

The buildings on the College Lane campus are listed in Table 4. Buildings located at the Bayfordbury campus, Hatfield Business Park and others identified by the UH team are included in the College Lane campus scope. This includes the consumption associated with the Park and Ride bus service.

The buildings in Table 4 with an asterisk are scheduled for full demolition or disposal. Those with a double asterisk are scheduled for part demolition, in accordance with the Estates Vision 2035. Further details on the College Lane campus buildings are included in Appendix E.

**Table 4 – College Lane Campus Buildings**

| Site   | Name                                    | Forecasted Demolition/Disposal Year |
|--------|-----------------------------------------|-------------------------------------|
| P157   | Art & Design                            |                                     |
| P142   | Automotive Centre                       |                                     |
| P106   | Boiler House                            |                                     |
| P109A  | C.P. Snow Psychology*                   | 2030                                |
| P181   | Document Services Building              |                                     |
| P140   | Ele House                               |                                     |
| P103   | Film, Music & Media Facilities Building |                                     |
| P117   | H.I.C*                                  | 2030                                |
| P108   | Health Research Building                |                                     |
| P124   | Hillside House                          |                                     |
| P125/E | Hut E*                                  | 2025                                |
| P125/Q | Hut Q Research Centre*                  | 2025                                |
| P126   | Hutton**                                | 2035                                |
| P126A  | Hutton Hub                              |                                     |
| P110   | Innovation Centre                       |                                     |
| P165   | Key Centre                              |                                     |
| P127   | LRC College Lane Classroom Annexe       |                                     |
| P128   | LRC (Buxton Centre for Learning)        |                                     |
| P129   | Lindop                                  |                                     |
| P130   | Main**                                  | 2025 and 2030                       |
| P132   | Mercer                                  |                                     |
| P192   | Multi-Storey Car Park 1                 |                                     |
| P170   | New Science Building                    |                                     |
| P193   | Nursery                                 |                                     |
| P137   | Science Building                        |                                     |
| P138   | Services Building (ASE)                 |                                     |
| P120   | Spectra                                 |                                     |
| P191   | Student Forum                           |                                     |
| P145   | The Barn*                               | 2025                                |
| P146   | Todd                                    |                                     |
| P163   | VRS                                     |                                     |
| P149   | Wright*                                 | 2030                                |
| P149A  | Wright Extension*                       | 2030                                |
| P701   | Bayfordbury Science Block               |                                     |
| P708   | Patrick Moore Building (Rotunda)        |                                     |

|         |                    |      |
|---------|--------------------|------|
| P121    | Fielder Centre     |      |
| P133    | Meridian House*    | 2028 |
| P189    | MacLaurin Building |      |
| P500    | University Bus     |      |
| P188    | Titan Court        |      |
| P653(Y) | 49 Chantry Lane    |      |

UH has plans to demolish or dispose of ten in-scope buildings on the College Lane campus and to build three new buildings before 2050.

For the buildings to be demolished, no decarbonisation interventions have been considered and consumption attributable to these buildings has been removed at the year of forecasted demolition. The buildings coming into scope are listed below in Table 5. The four buildings which are due to be constructed on the College Lane campus are assumed to be all electric. Electricity consumption has been benchmarked using modified electricity benchmarks from CIBSE TM46 to represent electric heating systems. This has been added to the total consumption in the year of practical completion.

**Table 5 – UH Estates Vision 2035: Proposed Buildings**

| Name              | GIFA (m <sup>2</sup> ) | Anticipated Year of Completion |
|-------------------|------------------------|--------------------------------|
| Business School   | 4,062                  | 2028                           |
| Health Alliance   | 11,412                 | 2028                           |
| Teaching Building | 5,000                  | 2034                           |

## 2.2 Baseline Energy Consumption and Carbon Emissions

### 2.2.1 Data Quality

UH's Energy Team utilises 'Workplace Footprint Tracker', an energy management software system with a web portal for annual and periodic reporting on energy consumption and costs across the estate.

Energy consumption data was provided for FY 2023-24 (1st August to 31st July inclusive). Several data sets were provided, including half-hourly consumption data, monthly consumption data and annual consumption data. Where energy data could not be obtained, benchmark data from CIBSE TM46 has been utilised, as agreed with the Energy Manager at UH. A data hierarchy was agreed, with half hourly consumption data to be used where available, followed by monthly and annual data. The half hourly and monthly consumption data has been rationalised against the main fiscal metering outputs. It should also be noted that sub-metered data could not be supported by calibration certification, although the meters were made by a reputable manufacturer.

A period of downtime was reported for the Main Boiler House on the College Lane campus throughout 2023/24. This represents a significant contribution to the reduction in natural gas consumption in comparison to the Baseline.

The baseline energy consumption per building is given in Appendix F.

Fossil fuel consumed across the UH estate is predominantly natural gas, with Bayfordbury Science Block having LPG (Liquified Petroleum Gas) boilers.



The metering arrangements at the de Havilland and College Lane campuses are detailed in Appendix G. These identify the main fiscal meters, buildings with sub-meters and unmetered consumption.

The proportions of metered and unmetered data is summarised below in Table 6 below. It is recommended that the current roll-out of AMR meters is continued to enable active energy and carbon management in the future.

**Table 6 – Metered and Unmetered Proportions**

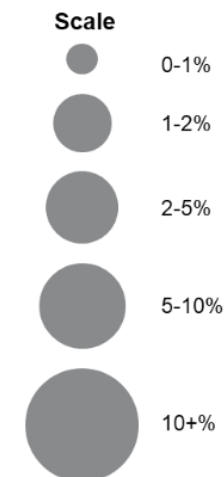
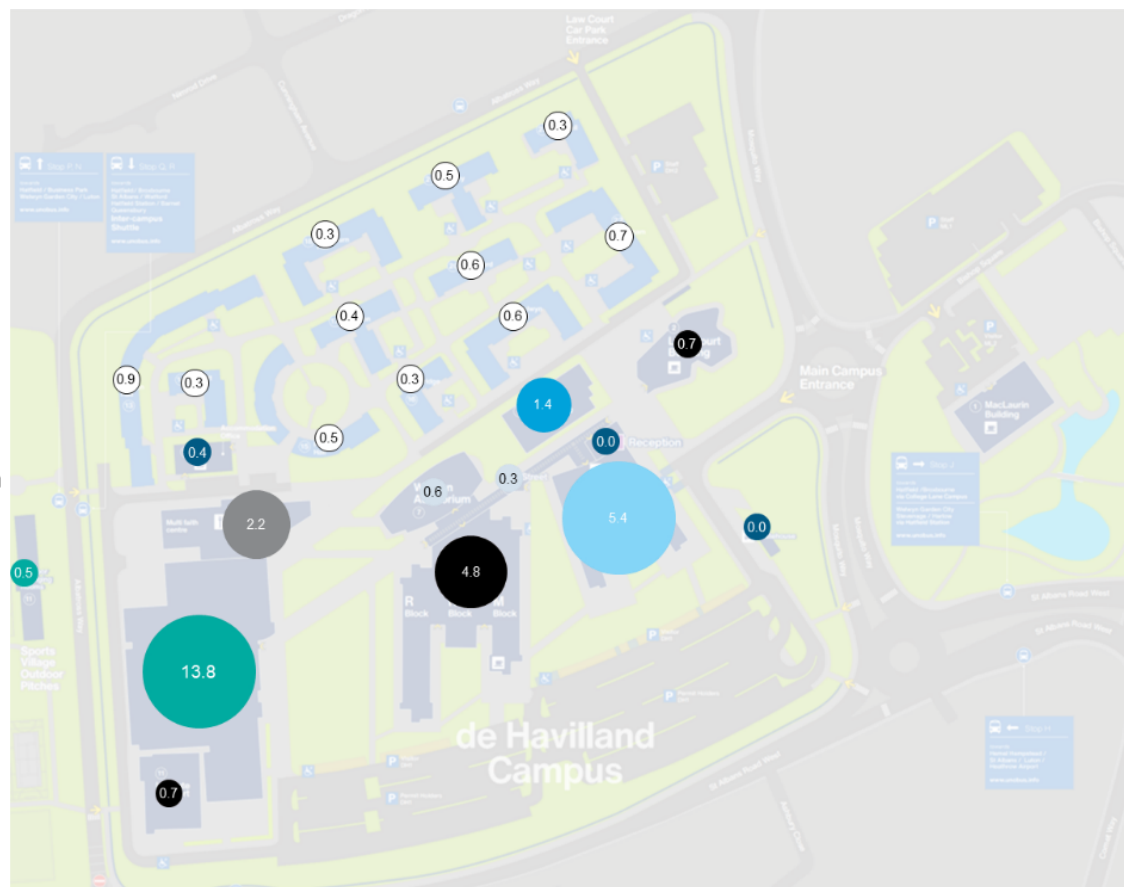
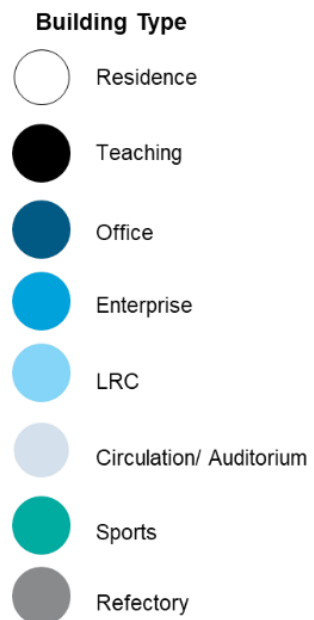
| Campus       | Buildings            | Fuel Type           | Percentage Metered (Fiscal) | Percentage Metered (Sub-Meter) | Percentage Estimated |
|--------------|----------------------|---------------------|-----------------------------|--------------------------------|----------------------|
| de Havilland | Academic             | Electricity         | 33                          | 56                             | 11                   |
| de Havilland | Academic             | Natural Gas         | 75                          | 25                             | 0                    |
| de Havilland | Sports & Residential | Electricity         | 73                          | 27                             | 0                    |
| de Havilland | Sports & Residential | Natural Gas         | 75                          | 25                             | 0                    |
| College Lane | All                  | Electricity         | 20                          | 63                             | 17                   |
| College Lane | All                  | Natural Gas and LPG | 46                          | 54                             | 0                    |

## 2.2.2 Analysis

Across the estate, there is a wide range of building uses. For analysis purposes, these have been grouped by building types. On the de Havilland campus, Residential accommodation represents the greatest proportion of floor area accounting for 38% of the estate, followed by Teaching buildings at 22% and Sports and LRC at circa 13%. On the College Lane campus, Teaching buildings form the greatest proportion of floor area accounting for 33% of the estate, followed by Offices at 16% and Laboratories at 10%.

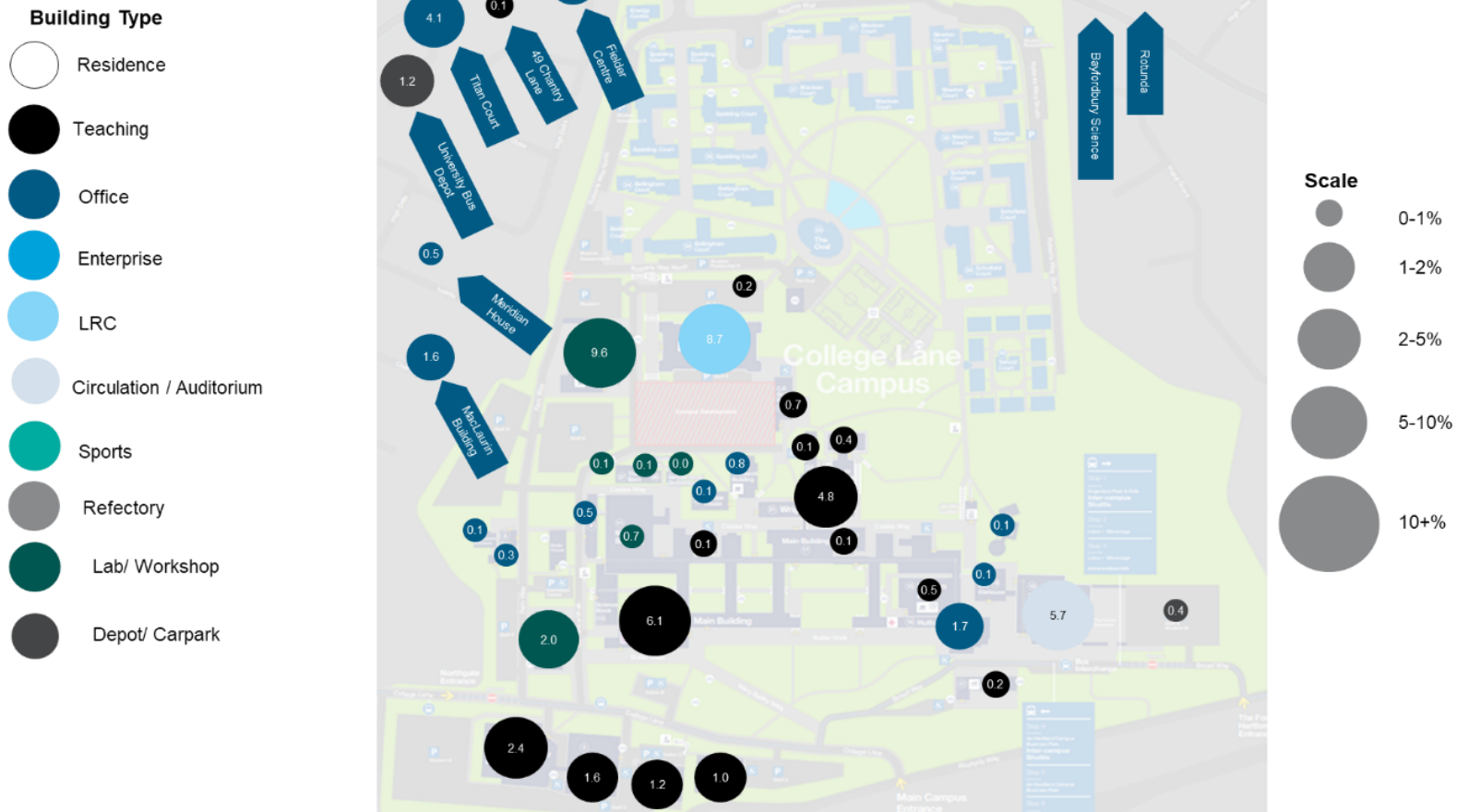
The energy consumption of the estate has been used as a proxy to calculate the baseline carbon emissions. Carbon emissions have been calculated using the DESNZ forecasted annual Commercial Grid Electric emissions factor and Natural Gas and LPG emissions factor<sup>3</sup>. The breakdowns of the buildings' carbon emissions as a percentage of the total for the de Havilland and College Lane campuses and whole UH estate is shown by building type in Figures 2 to 4 below.

<sup>3</sup> [Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal - GOV.UK](#)



**Figure 2 – de Havilland Campus: Baseline Carbon Emissions by Building Type**

Although Sports buildings on the de Havilland campus only occupy 13% of the total floor area, they are the largest typology emitter at 39% of the total emissions. Teaching buildings are the next highest emitting typology and account for 17%, with the LRC and Residences at 15% respectively.



**Figure 3 – College Lane Campus: Baseline Carbon Emissions by Building Type**

Teaching buildings are shown to be the largest carbon emitting typology on the College Lane campus at 26% of the campus total. These are followed by Laboratory buildings at 17%, Offices at 15% and the LRC at 14%.

It has been assumed that the combined heat and power (CHP) unit on the College Lane campus supplies electricity with the same carbon emission factor as Commercial Grid electricity. This assumption was agreed with the UH Estates team.



**Figure 4 – UH Estate: Baseline Carbon Emissions by Building Type**

Across the entire UH estate, Teaching buildings are shown to be the largest carbon emitting typology at 23%. This is followed by the Sports Buildings at 14% and LRCs at 14%. The Sports Village is shown to be the largest emitter across the estate, forming 12% of the total carbon emissions.

The split between fossil fuel and electricity consumption in academic year 2023/24 (August to July) across the campuses is provided below in Table 7. For the College Lane campus, LPG and natural gas consumption have been combined to form a total for fossil fuel. For the de Havilland campus, natural gas is the only fossil fuel used. In comparison to the Baseline, a 22% reduction in fossil fuel consumption has been achieved across the estate, most notably at the College Lane campus (29% reduction), with a 14% reduction in grid electricity consumption across the estate. Overall, a 14% reduction in energy consumption has been achieved in comparison to the Baseline.

**Table 7 –Energy Consumption (2023/24)**

| <b>Campus</b> | <b>Fossil Fuel<br/>(kWh p.a.)</b> | <b>Electricity Consumption<br/>(kWh p.a.)</b> |
|---------------|-----------------------------------|-----------------------------------------------|
| de Havilland  | 6,565,975                         | 10,409,598                                    |
| College Lane  | 12,637,915                        | 16,855,975                                    |
| <b>Total</b>  | <b>19,203,890</b>                 | <b>27,265,573</b>                             |

The operational carbon emissions attributable to the energy consumption (2023/24 energy data, 2024 carbon factors) are provided in Table 8. Since the original EDP issue, energy consumption across the in-scope buildings has reduced by 14%, resulting in a carbon emissions reduction of 12%. This has been achieved through a combination of decarbonisation and energy efficiency improvements being implemented in buildings, as well as a reduction in the carbon factors of grid electricity consumption.

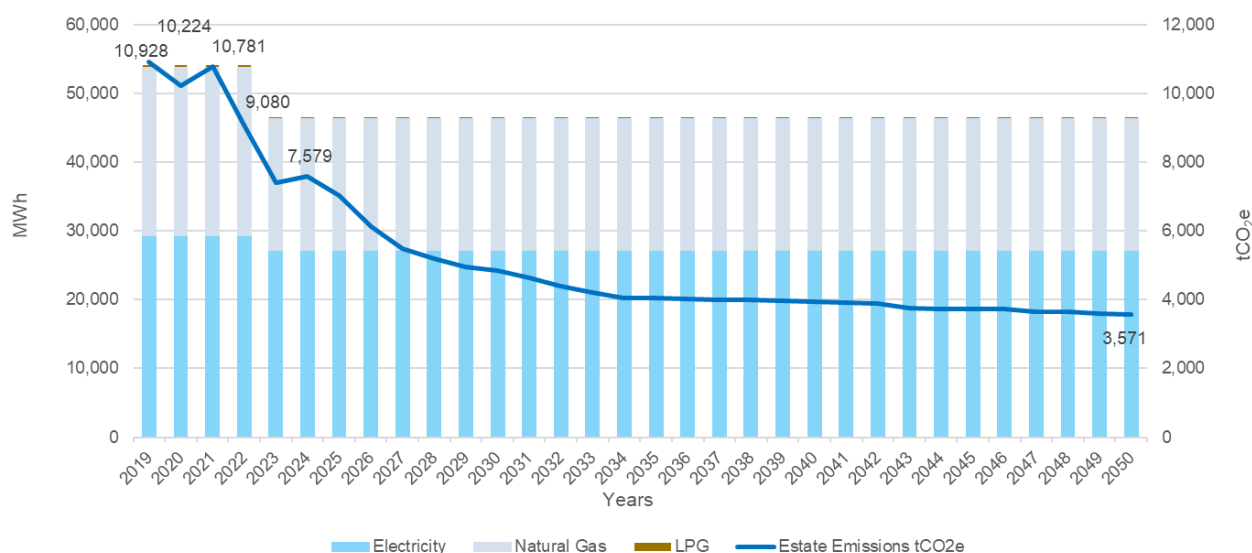
**Table 8 - Baseline Carbon Emissions (FY 2023/24)**

| <b>Campus</b> | <b>Fossil Fuels<br/>(tCO<sub>2</sub>e p.a.)</b> | <b>Electricity<br/>(tCO<sub>2</sub>e p.a.)</b> | <b>Total<br/>(tCO<sub>2</sub>e p.a.)</b> |
|---------------|-------------------------------------------------|------------------------------------------------|------------------------------------------|
| de Havilland  | 1,201                                           | 1,551                                          | 2,752                                    |
| College Lane  | 2,315                                           | 2,512                                          | 4,827                                    |
| <b>Total</b>  | <b>3,516</b>                                    | <b>4,063</b>                                   | <b>7,579</b>                             |

Figure 5 demonstrates the 'Do Nothing Scenario', illustrating the carbon emissions from each fuel source, assuming no change to the existing energy consumption across the UH estate. A reduction in carbon emissions across the UH estate to 3,571 tCO<sub>2</sub>e in 2050 can be seen. The drop in carbon emissions from 2024 to 2050 represents a 53% reduction. This is due to the decarbonisation of the UK's electricity grid and forecast reduction in carbon factors from 2024 to 2050.

Carbon emissions from previous years are also displayed, with total consumption from the previous EDP version utilising baseline energy data from FY 2021-22. Carbon emissions for previous years are higher due to larger magnitudes of energy consumption and higher carbon factors for electricity.

It is forecast that the National Grid will reach a minimum carbon emissions factor of 0.007 kgCO<sub>2</sub>e/kWh from 2048 onwards. Therefore, carbon emissions due to the usage of electricity will remain up to 2050. However, the development of new technologies and political are likely to promote increased energy efficiency and result in decarbonisation of grid electricity occurring ahead of current estimates, further reducing grid carbon emissions.



**Figure 5 – Do Nothing: Energy Consumption and Decarbonisation Trajectory**

The top ten buildings in terms of baseline carbon emissions normalised by unit of Gross Internal Floor Area (GIFA) are shown below in Table 9, forming a carbon intensity. These represent the “worst offenders” in terms of emissions and should be prioritised for retrofit. The Sports Village is the only building for which the carbon intensity has increased since the initial EDP. A comprehensive table ranking all in-scope buildings in terms of tCO<sub>2</sub>e/m<sup>2</sup> p.a., along with the magnitude of baseline carbon emissions, is included in Appendix K.

**Table 9 – Top Ten Carbon-Emitting Buildings Normalised by GIFA**

| Rank | Building                         | Normalised Carbon Emissions<br>by GIFA (tCO <sub>2</sub> e/m <sup>2</sup> p.a.) |
|------|----------------------------------|---------------------------------------------------------------------------------|
| 1    | Sports Village                   | 0.117                                                                           |
| 2    | Refectory                        | 0.106                                                                           |
| 3    | New Science Building             | 0.085                                                                           |
| 4    | RSO                              | 0.083                                                                           |
| 5    | LRC (Buxton Centre for Learning) | 0.056                                                                           |
| 6    | Wright Building                  | 0.056                                                                           |
| 7    | University Bus                   | 0.051                                                                           |
| 8    | Outdoor Change                   | 0.050                                                                           |
| 9    | Student Forum                    | 0.050                                                                           |
| 10   | 49 Chantry Lane                  | 0.046                                                                           |

## 2.2.3 Energy Costs

UH provided the latest utility prices for electricity, natural gas and LPG across the estate. These are summarised in Appendix J at the building level and exclude standing charges and availability charges

On the de Havilland campus, the Sports Village is the most expensive building to operate, with annual operational costs of over £630,000 followed by the LRC at £496,000. On the College Lane campus, the New Science Building is the both the most expensive building to operate on the campus and across the whole UH estate at £669,000 per annum. This is followed by the Main Building at £665,000.

A baseline cost of approximately £7.8M is incurred for all buildings. This represents a 22% reduction from the previous utility cost baseline, comprised of a reduction in electricity and fuel unit rates and reduced energy consumption.

**Table 10 - Estimated Annual Energy Costs**

| <b>Campus</b> | <b>Fossil Fuel Costs<br/>(£ in 2024)</b> | <b>Electricity Cost<br/>(£ in 2024)</b> | <b>Total Cost (£<br/>in 2024)</b> |
|---------------|------------------------------------------|-----------------------------------------|-----------------------------------|
| de Havilland  | 501,603                                  | 1,799,999                               | 2,301,601                         |
| College Lane  | 1,011,173                                | 4,502,134                               | 5,513,307                         |
| <b>Total</b>  | <b>1,512,776</b>                         | <b>6,302,132</b>                        | <b>7,814,908</b>                  |

There are several external factors impacting the international energy markets, including economic recovery following the Covid-19 pandemic and the war in Ukraine, resulting in steep fluctuations in energy costs.

Therefore, reduction of grid electricity and gas consumption is an increasingly important consideration for Net Zero retrofit programmes. This is likely to present additional opportunities for the programme and may result in a stronger business case for more on-site renewable generation and energy storage.

This will act to displace UH's current grid electricity consumption and offer a potential revenue stream through the sale of energy to neighbouring enterprises.

## 2.2.4 Display Energy Certificates (DEC)

DECs are based on actual energy consumption and include the benefit of any on-site renewable technologies. It provides an 'operational rating' on a scale of A to G, with 'A' being the most efficient, allowing for comparison of consumption against industry benchmarks for building typologies. The typical operational rating score is 100, corresponding with a band of "D". Buildings with lower band ratings (E-G) offer a greater "potential" for energy savings.

The DEC ratings for buildings on the de Havilland campus and College Lane campus are listed in Appendices D and E respectively. Most of the campus buildings have ratings at "D" or above, indicating that there is average opportunity for energy improvements.

## 2.3 Current Heating and Hot Water Systems

The current heating technologies for the buildings are described below:

### Academic Buildings

- Heat emitters for space heating generally comprise radiators. Some buildings also have some underfloor heating. The Weston Auditorium and the swimming pool in the Sports Centre have all-air systems where the air handling plant ventilates and heats the spaces.
- Heat is transferred throughout the buildings by Low Temperature Hot water (LTHW) heating circuits. Generally the circuits are Variable Volume, with Variable Speed Drives (VSDs) on the pump motors. Constant temperature circuits serve the air handling units. (e.g., Low, Medium, High Temperature Hot Water/Steam)

- The primary heat sources are gas-fired boilers. They are mostly large commercial boilers with gas burners and flue gas heat recovery systems (condensing). One building is served by LPG rather than gas.
  - The profile of consumption follows typical academic patterns, with most building operating from 8am to 6pm approximately, Monday to Friday. The LCR is open 24/7, although attempt at zoning the use of the space had some impact on heating demand. The sports Village is open longer hours at t the weekend. Heating demand includes the pool water heating system and pool hall heating/ventilation system (on set-back outside occupancy periods). The pool has a pool cover which is used to conserve energy and reduce evaporation from the pool surface.
  - Hot water is generated by a mix of storage calorifiers served by the boilers and local electric water heaters.
  - The condition of the boilers varies depending on age and use profiles. The remaining life of the boilers has been considered in developing the EDP, it is based on typical boiler lifespans published by CIBSE. In practice, some boilers may have shorter lives and others may remain in service longer, albeit at higher cost of maintenance and a higher risk of failure in service.
  - The condition of the heating distribution systems is generally good externally. The water treatment of the LTHW Heating circuits should maintain the internal condition of the pipework.
  - Similarly, the condition of the LTHW Heating heat emitters is generally good or fair. The emitters in the LCR and Law Building on the de Havilland campus are compatible with the lower flow and return temperatures from Air Source Heat Pumps (ASHPs). Generally, this is not the case in the other academic buildings. This means that the thermal performance of these buildings will have to be improved, supplementary/replacement heat emitter installed or a combination of these two measures.
- Compatibility with new heat sources (Heat Pumps)

Controls – a BMS controls the heating systems in the Academic Buildings. The head-end is located in the Estates offices and is used by the FM provider, Tenon, to monitor faults and to adjust settings in response to complaints. This approach does not constitute an active approach to energy and carbon management.

### **Student Residences (de Havilland Campus)**

- Heat emitters for space heating generally comprise electric radiators with local controls. In 2022, there was a programme of replacement of the electric radiators and controls. The presence detection was taken out and replaced with user controls. The impact of this change in the controls is due to be evaluated.
- Hot water is generated by electric immersion in heaters in storage calorifiers (cylinders) located by each cluster of rooms. The water is stored at 65°C to comply with the guidance on the control of legionella.
- The profile of electricity consumption for space heating and hot water is highly dependent on the number of rooms that are occupied, both in term-time and outside term-time when the residences are used for residential courses. Occupancy rates have not been consistent in recent years due to covid and other reasons.
- The condition of the heat emitters is new or good. They are compatible with 1phase/230V/50Hz electricity from any source, including solar PV panels.

## 2.4 Previously Completed Projects

UH has implemented several decarbonisation and energy saving measures across the estate within the Capital Repairs and Maintenance Programme on an ad hoc basis, including replacement of expired equipment with more energy efficient plant and installation of LED lighting and controls. The most recent energy saving projects are listed in Table 11. The impact of this on the baseline energy consumption data has been accounted for within calculations.

**Table 11 – Previous Energy Saving Projects**

| Campus                        | Building                          | Works Description                                                                                                          | Year Undertaken |
|-------------------------------|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------|-----------------|
| de Havilland and College Lane | Campus wide                       | LED Lighting Upgrades                                                                                                      | Ongoing         |
| de Havilland                  | Weston Auditorium                 | Replacement of gas boilers with ASHPs for heating and cooling, BMS upgrade                                                 | 2024            |
| College Lane                  | Mercer                            | Roof insulation and air handling unit replacement                                                                          | 2024            |
| College Lane                  | Spectra                           | Completion of all electric new-build                                                                                       | 2024            |
| de Havilland                  | Sports Village                    | Replacement of main pool air handling unit (AHU)                                                                           | 2021            |
| de Havilland                  | MNR Blocks                        | Replacement boilers installed                                                                                              | 2020            |
| de Havilland                  | LRC                               | LED Lighting and lighting controls retrofit (funded by PSDS grant)                                                         | 2020            |
| de Havilland                  | Institute of Sport                | Full replacement of HVAC and hot water systems undertaken                                                                  | 2020            |
| College Lane                  | LRC College Lane Classroom Annexe | DX units installed                                                                                                         | 2020            |
| de Havilland                  | Enterprise Hub                    | New building constructed                                                                                                   | 2019            |
| College Lane                  | Mercer and Lindop Buildings       | Packaged AHUs installed                                                                                                    | 2018            |
| College Lane                  | New Science Building              | CHP installed and gas boilers replaced                                                                                     | 2016            |
| College Lane                  | Hutton Hub                        | Space heating and cooling upgrades (ASHP, Variable Refrigerant Volume (VRV), Direct Expansion (DX) units and packaged AHU) | 2014            |
| College Lane                  | Patrick Moore Building (Rotunda)  | Electric radiant heater installed                                                                                          | 2012            |
| College Lane                  | 49 Chantry Lane                   | Replacement boilers installed                                                                                              | 2012            |
| de Havilland                  | Law Court Building                | BREEAM 'Excellent' building with low energy consumption design incorporating thermal mass arrangements                     | 2011            |

|              |                                                                                                                                                                                 |                       |   |
|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---|
| College Lane | Art & Design, Automotive Centre, Film, Music and Media Facilities Building, Hutton Hub, LRC (Buxton Centre for Learning), Lindop, Mercer, New Science Building, Todd, MacLaurin | Solar PV installation | - |
|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---|

## 2.4.1 Planned Works

UH has identified that there are no plans for major changes, demolitions, or refurbishments to the existing buildings on the de Havilland campus.

On the College Lane campus, eleven buildings are due to be demolished (two of which will be part-demolished, identified in Table 4) and four new buildings will come into operation (identified in Table 5) prior to 2050.

For the buildings to be demolished, no decarbonisation interventions have been considered and consumption attributable to these buildings has been removed at forecast the year of demolition.

UH currently have a £2.5M per annum budget for decarbonisation works. £350,000 is also available from the carbon budget, comprising a total of £2.85M.

To utilise the remaining decarbonisation budget for FY 2024/25, the following works are proposed:

- LED rollout
- Law Court Building heating system design works
- College Lane LRC heating system design works (partial, remainder in 2025/26)
- BMS Strategy review

Projects which have been prioritised for delivery in FY 2025 are:

- Todd Building – Replacement of the main heating and ventilation infrastructure and the remodelling of part of the first floor to provide new animation teaching facilities.
- Film, Media and Music Building - Replacement of the buildings main heating and cooling systems to address the overheating and ventilation issues.

Other major refurbishment projects across the UH estate include:

### Immediate (two years)

- Reconfiguration of Block R
- Feasibility study for the new Health Alliance Building
- Reconfiguration of the Health Research Building
- Relocation of Meridian House to College Lane Campus

### Short-Term (five years)

- Construction of the new Medical School building
- Construction of the new Health Alliance building
- Reconfiguration of Block M
- Major refurbishment of the MacLaurin building
- Major refurbishment of the Fielder Centre
- Refurbishment of the Refectory
- Redevelopment of the de Havilland public realm
- Other infrastructure works

**Long-term (twelve years)**

- Develop satellite locations (Angerland South, Angerland North and College Lane North)
- School of Creative Arts
- Expiry of PFI Agreement (de Havilland Campus)

## 3. Decarbonisation Approach

### 3.1 Determining the Whole Solution

#### 3.1.1 Whole Solution Approach

A whole solution approach has been adopted which is based on UH's three decarbonisation themes. The themes are described below.

The approach covers operational interventions, building control systems, electrical energy efficiency measures, thermal energy efficiency measures (building fabric improvements), renewable electricity generation and decarbonisation of heating systems.

The technologies considered are 'tried and tested'. New and emerging technologies could be considered in the future for incorporation into UH's 'Net Zero Programme'. For example, hydrogen boilers may become a feasible and viable option, but they are not included in the EDP at present as Hatfield is not close to an industrial cluster where hydrogen is set to be produced at scale.

#### 3.1.2 Decarbonisation Themes

The EDP is based on the following themes:

**Table 12 – Decarbonisation Themes**

| Decarbonisation Theme | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Control               | <ul style="list-style-type: none"><li>• Replace/upgrade Building Management Systems (BMS)</li><li>• Replace/upgrade lighting control systems</li><li>• Continue the roll-out of smart metering and sub-metering (AMR meters) to support Monitoring and Targeting and Measurement and Verification of savings from the Net Zero programme</li><li>• Implement active energy and carbon management by the FM providers to supplement the behaviour change programmes for UH staff and students</li></ul>                                                                                                             |
| Electrify             | <ul style="list-style-type: none"><li>• Switch from gas-fired heating and hot water systems to electrically driven systems</li><li>• Mitigate increase in demand for grid electricity from heat decarbonisation:<ul style="list-style-type: none"><li>○ Electrical Energy Efficiency Measures (EEMS), e.g. LED lighting, ventilation heat recovery</li><li>○ Renewable electricity generation (solar PV panels)</li><li>○ Energy storage (thermal and electricity, i.e. batteries)</li></ul></li><li>• Assess electrical loads and progressive impact of NZ programme on HV/LV electrical infrastructure</li></ul> |
| Insulate              | <ul style="list-style-type: none"><li>• Reduce annual demand and peak loads</li><li>• Improve the thermal performance of the building fabric (insulation and airtightness) to reduce peak loads and annual demand for thermal energy</li><li>• Improve thermal insulation of mechanical building services installations (pipework and ductwork systems)</li></ul>                                                                                                                                                                                                                                                  |

The themes are well-understood in UH and capture the EDP's requirements and the associated Net Zero retrofit measures described below.

### 3.1.3 Integration and Coordination

The design of the Net Zero measures in each building should achieve the optimum solution in terms of savings in operational carbon emissions relative to costs.

For example, for heat decarbonisation, consideration of the sequence in which the measures are considered is important. Reducing the building's peak heat load through fabric improvement measures and enhanced controls may result in smaller ASHP systems and lower peak electrical loads.

Therefore, investment in these measures may avoid the cost of larger plant and HV/LV upgrades. The trade-offs need to be carefully evaluated on case-by-case basis.

In addition, the designers and installers should consider the physical coordination and systems integration between the Net Zero retrofit measures and the existing building and its mechanical and electrical engineering systems. For example, the flow and return temperatures of ASHPs with a high Seasonal Coefficient of Performance (SCoP) are normally lower than those of LTHW heating boilers. To make the systems compatible, new or supplementary heat emitters may be required (if the building fabric measures do not reduce the peak heat load sufficiently).

## 4. Decarbonisation Opportunities on UH Campuses

In this Section of the Report, we outline the methodology for application of different measures across the estate.

The Net Zero retrofit measures considered for UH's estate are outlined below. Further details are provided in Appendix H.

1. Building Fabric Improvements (thermal insulation and airtightness)
2. LED Lighting and Controls Retrofit
3. Heat Decarbonisation - it should be noted that the decarbonisation of cooking appliances has been included in Decarbonisation of Heating and HWS.
4. Cooling Upgrades
5. Building Management System (BMS) and Active Energy & Carbon Management
6. Ventilation Upgrades
7. Solar PV

We outline below the Heat Decarbonisation options appraisal we were requested to undertake by UH and have detailed the application of Solar PV across the estate. We have also included a section on the capacity of the HV/LV electrical infrastructure as this is a key consideration in implementing the EDP.

### 4.1 Decarbonisation – Options Appraisal

Although connection to district heating network (DHN) could provide an opportunity for heat decarbonisation of the de Havilland campus, there are no current heat networks in the area. However, the size and layout of the campus presents an opportunity for the creation of a local network.

Although there are limited opportunities for energy generation from water sources, waste heat, heat recovery or energy from waste within the campus boundaries, the disused de Havilland Bowls Club may present a suitable site for the creation of an energy centre. Various low carbon solutions have been considered in determining suitable technologies for heating on the de Havilland (wholly or in part) campus including ASHP and ground source heat pump (GSHP) systems (open and closed loop).

In 2022, UH advised that several of the artificial turf pitches adjacent to the Bowls Club are due to be replaced or upgraded presenting a potential opportunity for the installation of GSHPs. A comparison of the costs of a 'Centralised GSHP System' and 'Decentralised ASHP Systems' on the de Havilland campus is provided below in Table 14, and detailed in Appendix A. Note the capital expenditure is in 2022 costs. The reductions in carbon emissions from the two scenarios are broadly similar. However, the estimated capital cost and risks of the centralised scenario are significantly higher. Therefore, a decentralised approach is recommended.

**Table 13 – de Havilland Heat Decarbonisation Options Appraisal: Cost Comparison**

|                              | <b>Academic Buildings Only</b> | <b>Academic Buildings and PFI Buildings</b> |
|------------------------------|--------------------------------|---------------------------------------------|
| Decentralised (ASHP systems) | £9.0m                          | £19.3m                                      |
| Centralised (GSHP system)    | £17.2m                         | £34.3m                                      |

Considering UH's current annual budget in relation to the total capital expenditure for recommended measures, the decarbonisation of heating systems has been prioritised.

## 4.2 Solar PV

The reduction in the carbon factor for grid electricity and the increase in estimated capital costs have weakened the case for solar PV panels. The savings in operational carbon emissions due to solar PV panels will continue to reduce over time. The financial business case will depend on the capital expenditure and the financial savings from reduced consumption of grid electricity. The price of grid electricity (p/kWh) may well reduce as the international market for gas is impacted by policies pursued by the OPEC+ countries following the presidential election in the USA.

The following buildings have been identified to have existing rooftop solar PV installations:

- Art & Design
- Automotive Centre
- Film, Music and Media Facilities Building
- Hutton Hub
- LRC (Buxton Centre for Learning)
- Lindop
- Mercer
- New Science Building
- Todd
- MacLaurin Building

Of these buildings, only the MacLaurin Building and Automotive Centre have been identified to not have available area for further solar PV to be installed. Where roof insulation works are also taking place, it is recommended that Solar PV installation follows the integration of roof insulation.

Across all in-scope buildings, it is estimated that a total of 3.5 MWh per annum of electricity could be generated through on-site solar PV installations. This is based on PV being installed on all buildings where it has been deemed feasible. However, the only recommended PV arrays within UH's current budget are located on the roofs at the Law Court Building and Titan Court.

Off-site solar PV arrays have not been proposed as part of this EDP following discussion with UH.

The EDP assumes that all the electricity generated at both locations will be consumed in UH's buildings. This will make a significant contribution to the Net Zero trajectory in the early years by substituting for grid electricity. However, as the UK's grid continues to decarbonise, their contribution to decarbonisation will reduce.

If the renewable electricity generated by these solar PV arrays is not consumed in UH's buildings, the impact on the decarbonisation trajectory would have to be evaluated. An alternative use may be electric vehicle charging. This could also contribute to the decarbonisation of UH's operations, though not from its estate.

Despite seasonal variations in electrical output from solar panels, all generation from solar PV has been assumed to be used by buildings across the UH estate. Therefore, no electrical storage systems have been included as part of this EDP. Similarly, no export of electricity has been considered, which could act as a source of income for UH.

It is recommended that building specific feasibility studies are carried out to assess the potential for electricity generation by solar PV panels during the design stage of projects. Additionally, for the installation on rooftop solar PV systems, an assumption has been made that all roofs have sufficient structural loading capacity. It is recommended that roof structural assessments are conducted.

The installation of solar PV panels will also require engagement with the Distribution Network Operator (DNO) for the Hertfordshire area, UK Power Networks.

## 4.3 HV/LV Electrical Infrastructure

### 4.3.1 ASHP Loads

Whilst the switch from boilers to heat pumps reduces or eliminates gas consumption, electricity consumption will increase. This has been reflected in Figures 1 and 8, 'Decarbonisation Trajectory and Energy Supply Mix'.

The increase the demand for grid electricity would be mitigated by electrical energy efficiency measures (e.g. retrofit of LED lighting), energy storage and the generation of renewable electricity by UH (e.g. solar PV panels), provided the electricity generated this way substituted for grid electricity.

### 4.3.2 Other changes in electrical Loads

UH's 'Estate Vision 2035' includes the demolition of eleven buildings on the College Lane Campus and the construction of four new buildings to replace them. The net effect of these plans is likely to be a significant increase in electrical peak demand. The implications of this are considered in Figures 1 and 8, 'Decarbonisation Trajectory and Energy Supply Mix'.

The projected increase in electric vehicles is likely to increase demand for Electric Vehicle Charging Points nationally and in Hatfield. UH is in dialogue with the local authority on local provision and an EVCP provider in relation to Angerland. Consequently, it is expected that there will be no increase in the number of EVCPs on the campuses.

### 4.3.3 Energy Storage

In relation to energy storage for heating, this could be either electrical storage (batteries) or thermal storage (stored hot water). Batteries would allow the fluctuations in the demand for electricity and supply from the grid to be decoupled.

The batteries could be charged when demand (and tariffs) is low (e.g. overnight), and discharge when the ASHP systems need to operate to heat the buildings. The thermal store would operate in a similar way, except that the peak heat demand would be met by the thermal store rather than the heat pumps. This would reduce the duty and, therefore, the cost of the heat pumps.

The optimum combination of electrical and thermal storage should be considered at the design stage for each building. However, thermal storage is likely to be the more cost-effective solution, with much lower embodied carbon.

### 4.3.4 Electrical Capacity/Availability

UH has reserved 60MVA of electrical capacity (availability) in its electricity supply arrangements. This should be sufficient for the initial 'electrify'/heat decarbonisation projects, subject to detailed design of the retrofit measures and an assessment of the local HV/LV electrical infrastructure.

An allowance has been made in the indicative costs to upgrade the existing electrical low voltage (LV) infrastructure. However, storage of electricity has not been included in the EDP or the indicative costs for the reasons explained above.

If additional capacity is required to facilitate the electrification of heating systems, the local District Network Operator (DNO) would have to be approached for a technical proposal, programme and costs for the required upgrade works.

## 5. The Estate Decarbonisation Plan (EDP)

In establishing the EDP we have undertaken a review of the available funding per year (Table 17), and the optimised measures for each building (Appendix B). The measures have been prioritised based on the age and condition of existing assets (anticipated life-cycle replacement) and the projected carbon savings. In this section we outline the modelling we have used to establish the trajectory for carbon emissions for the applied measures.

### 5.1 Costs and Funding

#### 5.1.1 Indicative Costs

Details the programme of interventions for each building, along with indicative project costs and operational carbon savings, is shown in Appendix B and the Delivery Plan. This groups works into 5-year tranches.

Indicative project costs of the decarbonisation measures are summarised in Table 15. The total cost of all recommended interventions is £143.1million at current period pricing (Q1 2025). Factoring in 3.5% per annum inflation into UH's current budget of £2.85million per annum, UH has a total budget of £118.3million available up to 2050.

Therefore, it is not possible to implement all recommended measures within UH's current budget allocation. Heat decarbonisation measures which remove the usage of fossil fuels have been prioritised, along with BMS upgrades. The total capital cost of interventions within UH's current budget is £74.7million (Q1 2025). The remaining budget has primarily been forecast for building fabric improvements, with a minority of buildings having LED lighting, ventilation upgrades, cooling upgrades and solar PV scheduled.

Indicative costs are based on rates in Q1/2025 and exclude VAT. They include:

- The elemental costs of each intervention
- Main Contractor's Preliminaries (17%)
- Overheads and Profit (8%)
- Fees and contingency (15%)

Allowances have also been made for M&E interventions, comprising testing and commissioning (5%), builder's work in connection (BWIC) (5%) and M&E preliminaries (15%).

The following exceptional items are not included in the indicative capital costs:

- Asbestos Refurbishment and Demolition (R&D) Surveys and asbestos removal
- Temporary works and hire of heat generation plant
- Redecorations/making good (dependent on extent)
- Disruption to UH operations
- Decanting and reoccupation of buildings
- UH Management Costs and overheads

Maintenance costs have not been considered as part of the financial analysis.

**Table 15 – Indicative Costs by Measure**

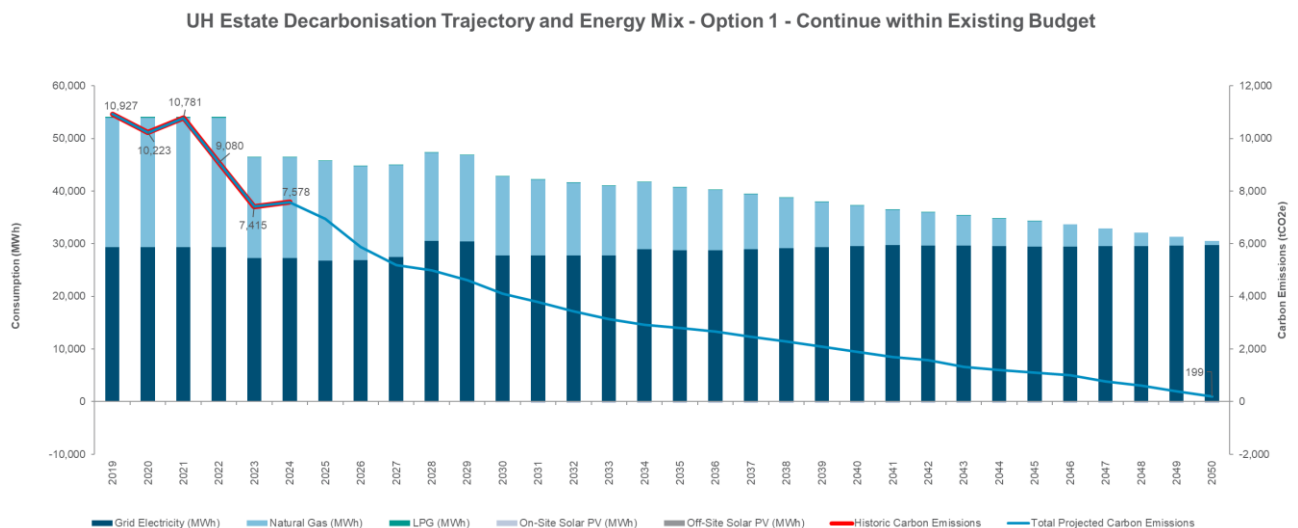
| NZ Measure                                                         | Cost (£million, Q1, 2025) | Percentage of Total Cost (%) |
|--------------------------------------------------------------------|---------------------------|------------------------------|
| Fabric Improvements                                                | 3.4                       | 4                            |
| Heating and DHWS Retrofit                                          | 48.2                      | 65                           |
| LED Lighting and Controls Retrofit                                 | 6.5                       | 9                            |
| Ventilation Upgrades                                               | 2.3                       | 3                            |
| Cooling Upgrades                                                   | 4.0                       | 5                            |
| Building Management System and Active Energy and Carbon Management | 8.8                       | 12                           |
| Solar PV (on-site)                                                 | 1.5                       | 2                            |
| Solar PV (off-site)                                                | 0.0                       | 0                            |
| <b>Total</b>                                                       | <b>74.7</b>               | <b>100</b>                   |

There are risks and uncertainties delivery of the EDP measures. The sources of uncertainty include the rate at which the UK's electricity grid decarbonises and future climate scenarios (potentially milder winters). The risks (Appendix C) include technical obsolescence, industry capacity, supply-chain bottlenecks, funding (including the availability of grants from government) and planning risk.

## 5.2 Modelling

Benchmark data from the British Energy Efficiency Survey 2014-2015 have been used to model energy and associated carbon savings from each scheduled measure, through calculation of the energy end-use formed of total energy consumption benchmark from the Higher Education sub-sector.

Following the implementation of all measures in Appendix B, Figure 6 shows carbon emissions are projected to reduce from 7,579 tCO<sub>2</sub>e currently to 199 tCO<sub>2</sub>e. In relation to the Baseline, this represents a 97% reduction.



**Figure 6 - Decarbonisation Trajectory and Energy Supply Mix**

By 2050, residual carbon emissions from the UH estate of approximately 199 tCO<sub>2</sub>e are projected. This is comprised of emissions associated to grid electricity consumption and fossil fuel usage in catering. To achieve Net Zero Carbon, these will have to be offset. UH could consider internal budget reviews, implementing PFI arrangements or off-balance sheet pricing to install the recommended measures which have not been incorporated in the above trajectory due to the prioritisation of other measures within the current budget. For offsetting, procuring additional land and installing

more solar PV arrays could be considered. There are also many offsetting schemes available - using the DESNZ Green Book guidance<sup>4</sup> it is estimated that offsetting this amount of carbon emissions will cost £75,000 per annum (Central series at £378/ tCO<sub>2</sub>e). Alternatively, 'green electricity' could be procured, although it is likely to have a higher unit price.

The modelling of solar PV panels assumes that all the electricity generated by them will be consumed in UH's estate. Seasonal variations in generation and demand from buildings may mean that supply outweighs demand in summer months.

The percentage of total carbon savings attributable to each measure over the period up to 2050 are shown below in Table 16. Whilst there is net saving from the decarbonisation of Heating and HWS, the installation of ASHP systems results in an increase in electricity consumption. Note that the savings associated with the BMS intervention are comprised of savings from both equipment upgrades and implementation of the BMS Strategy and Energy Bureau Service.

An Outline Scope of Works document has been produced for each building with Net Zero retrofit measures in the 2025-2026 period (Appendix M). This describes the rationale for implementing the measures and provides detail of what the intervention comprises.

**Table 16 – Estimated Carbon Emission Savings by Measure**

| <b>NZ Measure</b>                  | <b>Percentage of Total (%)</b> |
|------------------------------------|--------------------------------|
| Fabric Improvements                | 2                              |
| Heating and HWS Retrofit           | 75                             |
| LED Lighting and Controls Retrofit | 1                              |
| Ventilation Upgrades               | 1                              |
| Cooling Upgrades                   | 0                              |
| Building Management System         | 20                             |
| Solar PV (on-site)                 | 1                              |
| <b>Total</b>                       | <b>100</b>                     |

A second option for UH's decarbonisation trajectory has been considered, which has unlimited budget. The capital cost for this option is £143.1m (Q1 2025). This achieves a 99% reduction in annual carbon emissions compared to the Baseline. The additional cost to reduce annual emissions by a further 2% is £68.4million. This does not represent good value for money, with offsetting costs a more favourable option. AtkinsRéalis recommend that UH continue with their current budget as this follows a pragmatic and value-based approach.

<sup>4</sup> [Valuation of greenhouse gas emissions: for policy appraisal and evaluation - GOV.UK](#)

## 6. The Delivery Plan

The Delivery Plan outlines the measures bundled into the current and next financial years (2024-25 and 2025-26) and five-year tranches (Appendix B). The Delivery Plan is based on the EDP (set out above). The Delivery Plan is based on:

1. Availability of funding (see section 5.1 above)
2. Incremental heat decarbonisation using a decentralised approach
3. Age and condition of the existing buildings and their M&E installations, particularly boilers
4. Prioritisation of projects to maintain Net Zero trajectory
5. Assessment of programme level risks and uncertainties
6. Capacity of UH Estates and their consultants and contractors to manage multiple projects

### 6.1 Programme and Governance

UH's Director of Estates will be responsible for monitoring the EDP and Delivery Plan. A programme approach is recommended based on a secure funding environment, with a dedicated programme team.

The projects in the Net Zero Programme will be subject to UH's governance processes and procedures. The Annual Carbon Reduction Plan will be submitted in good time to meet UH's Financial Planning Round.

UH's Sustainability Steering Group will oversee the programme. The Executive Working Group will agree priorities and recommend the works to be implemented on an annual basis to meet UH's Financial Planning Round.

### 6.2 Procurement

The method of procurement of each project or package of projects will be considered as part of UH's governance process. This is a well-established process that is overseen by the Director of Estates.

### 6.3 Planning

Some of the Net Zero retrofit measures will require planning consent, including the Air Source Heat Pumps compounds. It is likely that screening will be required around the compounds for visual amenity. In addition, the Local Planning Authority (LPA) may require an acoustic survey and evidence of acoustic treatment. This is to protect the acoustic environment, particularly at night near bedrooms.

Of the sixty-seven buildings included in the scope of the EDP, none has been identified as listed.

UH's planning consultants can advise on the planning policies which affect the Net Zero measures and the approach for the planning applications.

## 7. Resources

### 7.1 UH Management

The resources required to monitor the EDP and deliver the Net Zero Programme are identified in Appendix I. UH Estates will be responsible for:

- Monitoring and annually updating the EDP, including:
  - Oversee the production of Measurement and Verification Reports (benefits realisation, based on the M&V Plan)
  - Agree annual adjustments to the EDP to maintain the decarbonisation trajectory
  - Recommending annual budgets in line with UH's Financial Planning Round
- Implementing the agreed projects in the 'Net Zero Programme', including:
  - Internal UH Stakeholder Management
  - Appoint consultants
  - Agree the procurement method for each project/batch of projects
  - Fulfil the role of Client under the works contracts
  - Fulfil the duties of Client under the CDM Regulations 2015

UH Estates' management team has extensive experience of major projects and programmes, including refurbishment and retrofit projects in existing buildings. The capacity of the team has been considered in the proposed EDP where an incremental approach has been adopted.

However, additional resources may be required for Monitoring and Targeting (CONTROL) and Measurement and Verification (benefits realisation). These resources could be available in-house (through recruitment) or from external suppliers (consultants or contractors).

#### 7.1.1 Consultants

The ad hoc input of Net Zero Consultants would provide the specialist advice to UH Estates on the EDP and Delivery Plan. Competent, experienced consultants in the field of Net Zero Retrofit projects would manage the design and delivery of the projects. They would provide the designs, administer the contracts and manage the project risks. It is important to appoint consultants with recent relevant experience and skills. As the NZ retrofit market gathers pace in response to the government's commitment to net Zero 2050, skills shortages may appear.

#### 7.1.2 Contractors

Contractors with recent, relevant experience of working in occupied university buildings should be preferred. They should have robust processes for testing, commissioning, and handover of works, including M&E works, and be responsive when latent defects become apparent during the Defects Period.

As with consultants, it is important to appoint contractors with recent, relevant experience and skills. As the NZ retrofit market gathers pace in response to the government's commitment to net Zero 2050, skills shortages among contractors may appear.

#### 7.1.3 Supply Chain

Manufacturers and suppliers with reliable delivery periods and acceptable warranties should be preferred.



The balance between cost and quality will need to be carefully judged, along with the extent to which UH Estates or their design consultants influence the choice of products and systems (through specifications and the tender/appointment process).

## 8. Supporting Information

### 8.1 Building Information

The 'UH Estate Decarbonisation Plan' is based on information provided by UH Estates and from site surveys undertaken by engineers and NZ consultants. The site surveys were visual and non-intrusive. The survey team also interrogated the BMS systems through their user interfaces (head-ends).

Relevant information on the in-scope buildings is provided in Appendix D (de Havilland campus) and Appendix E (College Lane campus and other buildings).

As the generation of renewable electricity on the campuses is a key component of the EDP (under ELECTRIFY), the likely extent of solar PV panels was assessed as part of the site investigations and surveys. The indicative areas of potential solar PV panels are provided in Appendix L. They are subject to detailed evaluation on a building-by-building basis, including the assessment of the condition of the roof and its structural load bearing capacity.

### 8.2 Energy Meters and Consumption Data

UH Estates provided consumption data for both campuses. Following analysis of several years' data, the baseline consumption for each building has been set (Appendix F). These baselines enable the designers to evaluate the impact of the proposed measures and to implement Measurement and Verification of the savings following installation of the measures.

The metering arrangements for both campuses are provided in Appendix G. There is ongoing work to upgrade meters and to ensure that significant end-uses are sub-metered.

The unit prices of energy (grid electricity and gas) have been provided in Appendix J. Given the recent volatility in international energy markets, the impact on energy bills should be evaluated during the detailed design process.

### 8.3 Outline Scopes of Works

The outline scope of works for each building with works proposed in 2025/26 is provided in Appendix M. These scopes provide an indication of the works to be designed and installed under the Net Zero Programme. However, detailed design and cost management is required before the works can be procured.

## 9. Key Challenges

### 9.1 Resources and Funding

The EDP (Appendix B) is based on funding of £2.85M for the life of the programme, increased by 3.5% per annum in line with inflation. However, there are risks to this level of funding being secured over this period due to changing priorities or funding constraints.

The resources required to monitor the EDP and to deliver the programme are covered in Section 7 and Appendix I. It is important to maintain the programme team to maintain momentum. Therefore, it would prove very challenging from a resourcing perspective if funding was not consistent.

### 9.2 Uncertainties and Risks

There are uncertainties that could impact the EDP and risks associated with the Net Zero Programme. The sources of uncertainty include the rate at which the UK's electricity grid decarbonises and future climate scenarios (potentially milder winters), both of which could change the Net Zero trajectory to 2050.

The programme and project risks (Appendix C) include technical obsolescence, industry capacity, supply-chain bottlenecks, funding (including the availability of grants from government) and planning risk. A risk register relating to the deployment of the EDP is provided in Appendix C. It covers key financial, organisation and delivery risks.

The age and condition of the existing gas-fired boilers represent an increasing risk to UH. The risk of boiler failure and consequent interruptions to university operations increase as the boilers get older. In addition, their efficiency reduces, which increases their operational carbon emissions for each unit of heat output. Temporary boiler plant could restore operations, but a planned replacement programme would provide greater resilience (see Risk Number 14 in Appendix C).

### 9.3 Communications

Communications with key internal and external stakeholders is important to manage expectations. Disruption to UH's operations is inevitable. This is likely to have a negative impact on the student experience. A communications plan highlighting UH's commitment to tackling the climate and ecological emergencies would help to mitigate this impact. The communications plan for Estates Decarbonisation could link to UH's 'Net Zero Action Plan'.

However, the works are likely to cause disruption to UH's operations and impact on the student experience. Managing expectations around the adverse impacts of implementing the programme will be required to protect UH's reputation, particularly with prospective students and staff.

### 9.4 Whole Life Carbon

The Net Zero retrofit measures aim to significantly reduce operational carbon emissions. However, the embodied carbon of materials, equipment and plant to be included in the works should also be minimised.

Whole Life carbon Assessments can be undertaken in accordance with the latest guidance from the Royal Institute of Chartered Surveyors (RICS). This is normally done at the design stage, with verification during the procurement and construction stages from Environmental Product Declarations (EPDs).

EPDs that comply with BS EN 15804:2012 + A2 2019 should be provided. If an EDP is not available, provide a carbon calculation as set out in 'CIBSE TM65 2022: Embodied Carbon of Building Services Equipment- calculation methodology and guidance ('mid-level' assessment)'. Further information can be found in UH's Sustainable Construction Policy.

# 10. Conclusion and Recommendations

## 10.1 Conclusions

AtkinsRéalis were appointed to produce this EDP in response to UH's commitment to reducing operational carbon emissions from its buildings, as stated in its Climate Change Vision which was published in 2021.

The EDP is based on the following decarbonisation themes:

- **ELECTRIFY** – switch from burning fossil fuel to electrically-driven heating and hot water systems
- **CONTROL** – active energy and carbon management and enhanced building control systems
- **INSULATE** – reduce peak loads and annual demand for thermal energy

The EDP is the basis for developing the Delivery Plan, unlocking the delivery multiple retrofit projects to maintain the trajectory to Net Zero 2050 (Figure 1).

## 10.2 The Role of UH Estates

The Director of Estates, Ian Grimes, is responsible for monitoring and updating the EDP and for implementing the Delivery Plan through a programme of retrofit measures.

UH's Sustainability Steering Group will oversee the programme. The Executive Working Group will agree priorities and recommend the measures to be implemented on an annual basis. The timing of this activity should be planned to meet UH's Financial Planning Round.

The resources required to monitor and deliver the Delivery Plan have been considered. It is important to keep a dedicated core team of internal and external resources to maintain momentum.

## 10.3 Recommendations

The key recommendations to progress and successfully implement UH's EDP and Delivery Plan are:

1. **Produce 'Annual Carbon Reduction Plan' to meet UH's Financial Planning Round**  
This EDP is dependent on a consistent level of funding over many years. Therefore, an 'Annual Carbon Reduction Plan' will be required for UH's annual Financial Planning Round to make the case for regular funding.
2. **Incorporate the EDP into 'UH 2035 Estates Vision'**  
UH's '2035 Estates Vision' responds to the business needs of a successful and growing university. It sets out plans to replace several buildings with new, purpose-built buildings on the College Lane Campus. This will have an impact on the Net Zero trajectory. Therefore, it is important to incorporate the EDP into 'UH 2035 Estates Vision' to ensure they are coordinated and integrated.
3. **Review Service Levels for Facilities Management prior procurement of FM contract in 2026**  
The CONTROL decarbonisation theme includes active energy and carbon management. The Facilities Management (FM) contractors have a key role to play as they operate the BMS and lighting control systems. The contract for the academic estate is due for renewal in 2026. This presents an opportunity to reset the contract requirements to incentivise the FM contractor to manage the buildings efficiently, thereby minimising operational carbon emissions.



**4. Initiate Net Zero projects for 2024/25 and 2025/26**

Initiating short to medium term projects would demonstrate UH's commitment to delivering on its Net Zero goal and continue progress towards the EDP's intended trajectory. Any delay would make it more difficult to follow the trajectory in future years.

**5. Establish project team to plan and deliver Net Zero projects**

Subject to adopting recommendation 5. above, a dedicated Net Zero delivery team will be required. It is likely to comprise internal and external resources. The sooner they are in place, the more likely that the projects will be driven forward, and the benefits realised.

**6. Agree the process for evaluating and reporting the operational carbon savings and other benefits, and for comparing the actual decarbonisation trajectory against the EDP**

Annual evaluation of the Net Zero retrofit projects will inform decision-making on the measures to be included in the programme in future years, their benefits, and costs. The reporting of the evaluation should include comparison with the decarbonisation trajectory. This should be done on a fair and reasonable basis, ideally applying best practice in Measurement and Verification (e.g. IPMVP published by EVO). This would also comply with the funding conditions of the Public Sector Decarbonisation Scheme (PSDS) administered by Salix Finance Limited.

# APPENDICES

# Appendix A. Cost Estimate for Centralised and Decentralised Heating System

|               | Heat Source Type        | Scope                                           | Proposed System                                                                                                                                                                                                                                                                                                                                                                                                      | Capital Cost (excluding VAT, Q4 2022) | Installation Period (days) |
|---------------|-------------------------|-------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|----------------------------|
| Centralised   | Ground Source Heat Pump | Academic Buildings(3.5MW)                       | GSHP and thermal store located in an energy centre, based on vertical closed ground loop. Heat is provided to the buildings through a District Heat Network. If the demand for domestic hot water can be met through other means in the summer (e.g. electric immersion heaters or solar thermal), it would be possible to make the centralised heating system seasonal (i.e. heating season from September to May). | £17,246,000                           | 900                        |
|               | Ground Source Heat Pump | Academic buildings and Residential Halls(4.5MW) |                                                                                                                                                                                                                                                                                                                                                                                                                      | £34,331,000                           | 952                        |
| Decentralised | Air Source Heat Pump    | Academic Buildings(3.5MW)                       | ASHP and thermal stores would replace the existing gas-fired boilers and water heaters in each building. A programme based on this approach could be implemented progressively as the existing boilers come to the end of their life and as funding becomes available.                                                                                                                                               | £9,003,000                            | 240                        |
|               | Air Source Heat Pump    | Academic buildings and Residential Halls(4.5MW) |                                                                                                                                                                                                                                                                                                                                                                                                                      | £19,321,000                           | 330                        |



# Appendix B. UH Estate Delivery Plan

The supplementary 'UH Estate Delivery Plan' spreadsheet details the phasing of interventions per building, with capital cost, carbon saving and operational cost savings.



## Appendix C. Risk Register

| Risk Number | Risk Classification | Risk Title              | Risk Description                                                                                                                                      | Probability of Occurrence | Level of Consequence | Current Risk Status | Mitigation Plan                                                                                                                                                                                                 |
|-------------|---------------------|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|----------------------|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1           | Financial           | Availability of Funding | The availability of funding and budgets to undertake feasibility studies, bid for funding, the capital cost elements of work (including design fees). | 2                         | 4                    | 8                   | Determining that funding will be available throughout the Decarbonisation Plan.                                                                                                                                 |
| 2           | Financial           | Price security          | Price security, risk of overspending, unforeseen costs (particularly when working in existing buildings), introducing new technologies.               | 3                         | 4                    | 12                  | Costs in this report should be regularly reviewed and increased in-line with inflation and up-to-date energy costs. Secure cost with suppliers by placing order ASAP and seek extensions of quotation validity. |
| 3           | Financial           | Expenditure             | Expenditure outside of project for consultancy, securing additional internal resources to deliver the projects.                                       | 2                         | 3                    | 6                   | Secure resource and fees with professional consultants.                                                                                                                                                         |
| 4           | Financial           | Operational costs       | Increased operational costs for implementing low carbon technologies (caused by gas and electricity pricing structure)                                | 2                         | 4                    | 8                   | Review design proposal with the Estates team and agree preliminary Design works.                                                                                                                                |



| Risk Number | Risk Classification | Risk Title                           | Risk Description                                                                                                        | Probability of Occurrence | Level of Consequence | Current Risk Status | Mitigation Plan                                                                                                                                          |
|-------------|---------------------|--------------------------------------|-------------------------------------------------------------------------------------------------------------------------|---------------------------|----------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
|             |                     |                                      | and higher servicing & maintenance costs)                                                                               |                           |                      |                     |                                                                                                                                                          |
| 5           | Organisational      | Resource Availability                | Availability of resource to deliver, manage and monitor the performance of the Decarbonisation Plan.                    | 1                         | 5                    | 5                   | Early engagement with the Estates team and wider stakeholders to establish a resourcing plan.                                                            |
| 6           | Organisational      | Decision making                      | Complex decision chains and routes to sign off proposals and timings to respond/bid for external funding opportunities. | 1                         | 5                    | 5                   | Engagement with governance structure to maintain communications and proactive approach to resolving issues                                               |
| 7           | Organisational      | Implementation of behavioural change | Resistance to change when implementing behavioural change policies (top management support required).                   | 1                         | 5                    | 5                   | Early engagement with the Estates team and wider stakeholders to establish a communication plan and on-going reporting of all site works from both sides |
| 8           | Organisational      | Training                             | Lack of internal capability for implementation of works                                                                 | 1                         | 2                    | 2                   | Training requirements to be identified and supported (time/funding).                                                                                     |

| Risk Number | Risk Classification | Risk Title              | Risk Description                                                                                                                                                                                                                                            | Probability of Occurrence | Level of Consequence | Current Risk Status | Mitigation Plan                                                                                                                  |
|-------------|---------------------|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|----------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------|
| 9           | Delivery            | Planning permission     | Time to obtain required planning permission for heat decarbonisation works will need to be secured (e.g. the citing of external air source heat pumps, windows replacement, external wall insulation). Possible planning implications for listed buildings. | 1                         | 5                    | 5                   | Engagement with planning department to maintain communications and proactive approach to resolving issues/                       |
| 11          | Delivery            | Long lead in time       | Possible delivery issues for proposed technologies (lack of available equipment due to COVID-19/Brexit/emerging industry/conflict).                                                                                                                         | 4                         | 4                    | 16                  | Prompt completion of design & specification to raise POs as early as possible.                                                   |
| 12          | Delivery            | Contractor Experience   | Lack of contractor knowledge in delivering low carbon heating projects (emerging technology).                                                                                                                                                               | 3                         | 5                    | 15                  | Ensure established contractor is appointed with previous experience in low carbon heating projects and appropriate case studies/ |
| 13          | Delivery            | Monitoring and Metering | Lack of time/funding to facilitate monitoring and metering to provide ongoing feedback to secure the successful implementation of the                                                                                                                       | 2                         | 2                    | 4                   | Adequate Monitoring and Verification Plan (M&V) Plan must be in place, with robust reporting schedules/                          |

| Risk Number | Risk Classification   | Risk Title     | Risk Description                                                                  | Probability of Occurrence | Level of Consequence | Current Risk Status | Mitigation Plan                                                                                                                                                           |
|-------------|-----------------------|----------------|-----------------------------------------------------------------------------------|---------------------------|----------------------|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|             |                       |                | Decarbonisation Plan. Feedback is vital to develop successful building solutions. |                           |                      |                     |                                                                                                                                                                           |
| 14          | University Operations | Boiler Failure | Interruptions to university operations due to boiler failure                      | 4                         | 2                    | 8                   | <ol style="list-style-type: none"> <li>1. Temporary boilers.</li> <li>2. Planned programme of boiler replacement (with ASHP systems where feasible and viable)</li> </ol> |

## Appendix D. de Havilland Campus Building Information

| Reference | Name                   | GIFA (m <sup>2</sup> ) | Year of Construction | Building Type | DEC Rating | Lead Heat Source | PFI or Academic |
|-----------|------------------------|------------------------|----------------------|---------------|------------|------------------|-----------------|
| P802M     | Block M                | 13,861                 | 2004                 | Teaching      | D          | Gas              | Academic        |
| P802N     | Block N                |                        |                      |               |            |                  |                 |
| P802R     | Block R                |                        |                      |               |            |                  |                 |
| P803      | de Havilland Reception | 152                    | 2012                 | Office        | D          | Gas              | Academic        |
| P806      | Enterprise Hub         | 2,683                  | 2020                 | Hub           | A          | Gas              | Academic        |
| P808      | LRC                    | 9,936                  | 2004                 | LRC           | D          | Gas              | Academic        |
| P839      | Law Court Building     | 2,404                  | 2011                 | Teaching      | B          | Gas              | Academic        |
| P840      | Gatehouse              | 201                    | 2004                 | Office        | N/A        | Electric         | Academic        |
| P825      | The Street             | 936                    | 2004                 | Circulation   | D          | Gas              | Academic        |
| P805      | The Weston Auditorium  | 2,118                  | 2004                 | Auditorium    | E          | Electric         | Academic        |
| P810A     | Sports Village         | 8,959                  | 2004                 | Sports        | D          | Gas              | PFI             |
| P810A     | Refectory              | 1,548                  | 2004                 | Refectory     | E          | Gas              | PFI             |
|           | Outdoor Change         | 710                    | 2003                 | Sports        | N/A        | Gas              | PFI             |
|           | RSO                    | 386                    | 2017                 | Office        | N/A        | Gas              | PFI             |
| P838      | Institute of Sport     | 2,065                  | 2003                 | Laboratory    | B          | Gas              | PFI             |
| P670F     | Aldenham               | 3,436                  | 1990s                | Residence     | C          | Electric         | PFI             |
| P670E     | Ashwell                | 1,552                  | 1990s                | Residence     | C          | Electric         | PFI             |
| P670I     | Hadham                 | 2,423                  | 1990s                | Residence     | C          | Electric         | PFI             |
| P670K     | Kimpton                | 2,243                  | 1990s                | Residence     | C          | Electric         | PFI             |
| P670L     | Lemsford               | 1,584                  | 1990s                | Residence     | C          | Electric         | PFI             |



| Reference                                                   | Name      | GIFA<br>(m <sup>2</sup> ) | Year of<br>Construction | Building<br>Type | DEC<br>Rating | Lead Heat<br>Source | PFI or<br>Academic |
|-------------------------------------------------------------|-----------|---------------------------|-------------------------|------------------|---------------|---------------------|--------------------|
| P670C                                                       | Redbourn  | 3,215                     | 1990s                   | Residence        | C             | Electric            | PFI                |
| P670H                                                       | Sandridge | 1,627                     | 1990s                   | Residence        | C             | Electric            | PFI                |
| P670A                                                       | Sarrat    | 1,629                     | 1990s                   | Residence        | C             | Electric            | PFI                |
| P670D                                                       | Shenley   | 2,380                     | 1990s                   | Residence        | C             | Electric            | PFI                |
| P670B                                                       | Watton    | 4,780                     | 1990s                   | Residence        | C             | Electric            | PFI                |
| P670G                                                       | Welwyn    | 3,086                     | 1990s                   | Residence        | C             | Electric            | PFI                |
| Total Area (m <sup>2</sup> )                                |           | <b>73,914</b>             |                         |                  |               |                     |                    |
| Sub-Total Sports and Residential<br>– PFI (m <sup>2</sup> ) |           | <b>39,558</b>             |                         |                  |               |                     |                    |
| Sub- Total Academic Buildings<br>(m <sup>2</sup> )          |           | <b>34,356</b>             |                         |                  |               |                     |                    |



## Appendix E. College Lane Campus Building Information

| Reference | Name                                    | GIFA (m <sup>2</sup> ) | Year of Construction | DEC Rating | Lead Heat Source |
|-----------|-----------------------------------------|------------------------|----------------------|------------|------------------|
| P157      | Art & Design                            | 5,262                  | 1995                 | D          | Gas              |
| P142      | Automotive Centre                       | 575                    | 2001                 | G          | Gas              |
| P106      | Boiler House                            | 769                    | 1955                 | N/A        | Gas              |
| P109A     | C.P. Snow Psychology*                   | 1,799                  | 1975                 | F          | Gas              |
| P181      | Document Services Building              | 213                    | 1975                 | E          | Gas              |
| P140      | Ele House                               | 1,068                  | 1985                 | E          | Gas              |
| P103      | Film, Music & Media Facilities Building | 5,587                  | 2006                 | E          | Gas              |
| P117      | H.I.C*                                  | 448                    | 1965                 |            | Gas              |
| P108      | Health Research Building                | 2,187                  | 2006                 | E          | Gas              |
| P124      | Hillside House                          | 460                    | 1990                 | D          | Gas              |
| P125/E    | Hut E*                                  | 252                    | 2000                 | F          | Gas              |
| P125/Q    | Hut Q Research Centre*                  | 392                    | 1980                 | D          | Gas              |
| P126      | Hutton**                                | 5,284                  | 1955                 | E          | Gas              |
| P126A     | Hutton Hub                              | 3,188                  | 2014                 | E          | Gas              |
| P110      | Innovation Centre                       | 1,561                  | 2004                 | E          | Gas              |
| P165      | Key Centre                              | 465                    | 1999                 | E          | Gas              |
| P127      | LRC College Lane Classroom Annexe       | 1,096                  | 2021                 | E          | Electric         |
| P128      | LRC (Buxton Centre for Learning)        | 11,760                 | 1995                 | E          | Gas              |
| P129      | Lindop                                  | 2,390                  | 1985                 | F          | Gas              |
| P130      | Main**                                  | 14,404                 | 1955                 | E          | Gas              |
| P132      | Mercer                                  | 2,395                  | 1985                 | E          | Electric         |
| P192      | Multi-Storey Car Park 1                 | 10,251                 | 2008                 |            | Not heated       |
| P170      | New Science Building                    | 8,614                  | 2015                 | C          | Gas              |
| P193      | Nursery                                 | 675                    | 2008                 |            | Gas              |
| P137      | Science Building                        | 2,191                  | 1970                 | E          | Gas              |
| P138      | Services Building (ASE)                 | 952                    | 1990                 | E          | Gas              |
| P120      | Spectra                                 | 14,774                 | 2024                 |            | Electric         |

| Reference                         | Name                             | GIFA (m <sup>2</sup> ) | Year of Construction | DEC Rating | Lead Heat Source |
|-----------------------------------|----------------------------------|------------------------|----------------------|------------|------------------|
| P191                              | Student Forum                    | 8,673                  | 2009                 | C          | Gas              |
| P145                              | The Barn*                        | 315                    | 1970                 | F          | Gas              |
| P146                              | Todd                             | 5,754                  | 1985                 | E          | Gas              |
| P163                              | VRS                              | 143                    | 1970                 | N/A        | Gas              |
| P149                              | Wright*                          | 6,540                  | 1975                 | E          | Gas              |
| P149A                             | Wright Extension*                | 1,475                  | 1999                 | E          | Gas              |
| P701                              | Bayfordbury Science Block        | 1,249                  | 1975                 | E          | LPG              |
| P708                              | Patrick Moore Building (Rotunda) | 89                     | 2000                 | N/A        | Electric         |
| P121                              | Fielder Centre                   | 2,724                  | 1980                 | D          | Gas              |
| P133                              | Meridian House*                  | 1,640                  | 1990                 | A          | Gas              |
| P189                              | MacLaurin Building               | 5,004                  | 2006                 | G          | Gas              |
| P500                              | University Bus                   | 1,728                  | 2003                 | G          | Gas              |
| P188                              | Titan Court                      | 7,949                  | 1997                 | N/A        | Gas              |
| P653(Y)                           | 49 Chantry Lane                  | 105                    | No details           | N/A        | Gas              |
| <b>Total Area (m<sup>2</sup>)</b> |                                  | <b>142,400</b>         |                      |            |                  |

\*To be demolished

\*\*To be part-demolished



# Appendix F. Baseline Energy Consumption

| de Havilland |                                    |                                              |          |                                                        |                                              |          |                                                                |                                              |
|--------------|------------------------------------|----------------------------------------------|----------|--------------------------------------------------------|----------------------------------------------|----------|----------------------------------------------------------------|----------------------------------------------|
| Site         | Name                               | Baseline Fossil Fuel Consumption (kWh/annum) | Source   | Carbon Emissions from Baseline Gas Consumption (tCO2e) | Baseline Electricity Consumption (kWh/annum) | Source   | Carbon Emissions from Baseline Electricity Consumption (tCO2e) | Total Carbon Emissions from Baseline (tCO2e) |
| P802M        | Block M (Sir Brian Corby Building) |                                              |          |                                                        |                                              |          |                                                                |                                              |
| P802N        | Block N (Teaching Block)           | 912,077                                      | Residual | 167                                                    | 1,333,075                                    | HH       | 199                                                            | 365                                          |
| P802R        | Block R (Humanities & Education)   |                                              |          |                                                        |                                              |          |                                                                |                                              |
| P803         | deHaviland Reception               | 10,002                                       | Residual | 2                                                      | 7,502                                        | HH       | 1                                                              | 3                                            |
| P806         | Enterprise Hub                     | 431,664                                      | HH       | 79                                                     | 191,306                                      | HH       | 29                                                             | 107                                          |
| P808         | LRC                                | 653,806                                      | Residual | 120                                                    | 1,947,240                                    | HH       | 290                                                            | 410                                          |
| P839         | Law Court Building                 | 158,187                                      | Residual | 29                                                     | 168,280                                      | HH       | 25                                                             | 54                                           |
| P840         | Gatehouse                          | -                                            | N/A      | -                                                      | 13,175                                       | Residual | 2                                                              | 2                                            |
| P825         | The Street                         | 61,590                                       | Residual | 11                                                     | 61,352                                       | Residual | 9                                                              | 20                                           |
| P805         | The Weston Auditorium              | 139,368                                      | Residual | 25                                                     | 138,829                                      | Residual | 21                                                             | 46                                           |
| P810A        | Sports Village                     | 3,613,987                                    | Monthly  | 661                                                    | 2,605,422                                    | Monthly  | 388                                                            | 1,049                                        |
| P810A        | Refectory (Kitchen only gas)       | 259,135                                      | Residual | 47                                                     | 786,465                                      | Monthly  | 117                                                            | 165                                          |



|       |                           |                  |          |              |                   |          |              |              |
|-------|---------------------------|------------------|----------|--------------|-------------------|----------|--------------|--------------|
| 0     | Outdoor Change            | 77,915           | Residual | 14           | 141,598           | Monthly  | 21           | 35           |
| 0     | RSO                       | 64,616           | Residual | 12           | 135,963           | Monthly  | 20           | 32           |
| P838  | Institute of Sport        | 183,627          | HH       | 34           | 148,349           | HH       | 22           | 56           |
| P670F | Aldenham                  | -                | N/A      | -            | 335,677           | Residual | 50           | 50           |
| P670E | Ashwell                   | -                | N/A      | -            | 151,621           | Residual | 23           | 23           |
| P670J | Hadham                    | -                | N/A      | -            | 236,713           | Residual | 35           | 35           |
| P670K | Kimpton                   | -                | N/A      | -            | 219,128           | Residual | 33           | 33           |
| P670L | Lemsford                  | -                | N/A      | -            | 154,748           | Residual | 23           | 23           |
| P670C | Redbourn                  | -                | N/A      | -            | 314,087           | Residual | 47           | 47           |
| P670H | Sandridge                 | -                | N/A      | -            | 158,949           | Residual | 24           | 24           |
| P670A | Sarrat                    | -                | N/A      | -            | 159,144           | Residual | 24           | 24           |
| P670D | Shenley                   | -                | N/A      | -            | 232,512           | Residual | 35           | 35           |
| P670B | Watton                    | -                | N/A      | -            | 466,978           | Residual | 70           | 70           |
| P670G | Welwyn                    | -                | N/A      | -            | 301,484           | Residual | 45           | 45           |
|       | <b>de Havilland Total</b> | <b>6,565,975</b> |          | <b>1,201</b> | <b>10,409,598</b> |          | <b>1,551</b> | <b>2,752</b> |



| College Lane |                                         |                                              |              |                                                        |                                              |              |                                                                |                                              |
|--------------|-----------------------------------------|----------------------------------------------|--------------|--------------------------------------------------------|----------------------------------------------|--------------|----------------------------------------------------------------|----------------------------------------------|
| Site         | Name                                    | Baseline Fossil Fuel Consumption (kWh/annum) | Source       | Carbon Emissions from Baseline Gas Consumption (tCO2e) | Baseline Electricity Consumption (kWh/annum) | Source       | Carbon Emissions from Baseline Electricity Consumption (tCO2e) | Total Carbon Emissions from Baseline (tCO2e) |
| P157         | Art & Design                            | 603,755                                      | HH           | 110                                                    | 461,858                                      | Monthly      | 69                                                             | 179                                          |
| P142         | Automotive Centre                       | 30,483                                       | Proportioned | 6                                                      | 13,724                                       | HH           | 2                                                              | 8                                            |
| P109A        | C.P. Snow Psychology (going)            | 278,877                                      | HH           | 51                                                     | 17,466                                       | HH           | 3                                                              | 54                                           |
| P181         | Document Services Building              | 11,289                                       | HH           | 2                                                      | 28,131                                       | Monthly      | 4                                                              | 6                                            |
| P140         | Ele House                               | 17,096                                       | HH           | 3                                                      | 17,598                                       | HH           | 3                                                              | 6                                            |
| P103         | Film, Music & Media Facilities Building | 296,184                                      | Proportioned | 54                                                     | 646,819                                      | HH           | 96                                                             | 151                                          |
| P117         | H.I.C (going)                           | 23,750                                       | Proportioned | 4                                                      | 10,234                                       | HH           | 2                                                              | 6                                            |
| P108         | Health Research Building                | 115,940                                      | Proportioned | 21                                                     | 256,917                                      | HH           | 38                                                             | 59                                           |
| P124         | Hillside House (going)                  | 24,386                                       | Proportioned | 4                                                      | 20,804                                       | HH           | 3                                                              | 8                                            |
| P125/E       | Hut E (going)                           | 13,359                                       | Proportioned | 2                                                      | 20,160                                       | Proportioned | 3                                                              | 5                                            |
| P125/Q       | Hut Q Research Centre (going)           | 20,781                                       | Proportioned | 4                                                      | 31,360                                       | Proportioned | 5                                                              | 8                                            |
| P126         | Hutton (part going)                     | 280,121                                      | Proportioned | 51                                                     | 501,980                                      | Proportioned | 75                                                             | 126                                          |



|       |                                   |           |              |     |           |                               |     |     |
|-------|-----------------------------------|-----------|--------------|-----|-----------|-------------------------------|-----|-----|
| P126A | Hutton Hub                        | 0         | N/A          | 0   | 255,040   | Proportioned                  | 38  | 38  |
| P110  | Innovation Centre                 | 82,753    | Proportioned | 15  | 131,829   | HH                            | 20  | 35  |
| P165  | Key Centre                        | 24,651    | Proportioned | 5   | 15,237    | HH                            | 2   | 7   |
| P127  | LRC College Lane Classroom Annexe | 0         | N/A          | 0   | 87,680    | Proportioned                  | 13  | 13  |
| P128  | LRC (Buxton Centre for Learning)  | 2,352,000 | Proportioned | 430 | 1,533,899 | HH                            | 229 | 659 |
| P129  | Lindop                            | 192,108   | HH           | 35  | 392,826   | HH                            | 59  | 94  |
| P130  | Main (majority going)             | 763,412   | HH           | 140 | 2,160,600 | Adjusted                      | 322 | 462 |
| P132  | Mercer                            | 288,122   | HH           | 53  | 152,665   | HH                            | 23  | 75  |
| P192  | Multi-Storey Car Park 1           | 0         | N/A          | 0   | 205,020   | Benchmarked                   | 31  | 31  |
| P170  | New Science Building              | 2,584,200 | HH           | 473 | 1,722,800 | Adjusted                      | 257 | 729 |
| P193  | Nursery                           | 65,420    | HH           | 12  | 27,000    | Proportioned                  | 4   | 16  |
| P137  | Science Building                  | 116,152   | Proportioned | 21  | 219,100   | Adjusted                      | 33  | 54  |
| P138  | Services Building (ASE)           | 50,468    | Proportioned | 9   | 98,628    | HH                            | 15  | 24  |
| P120  | Spectra                           | -         | N/A          | -   | 1,916,928 | Seasonal Commissioning Report | 286 | 286 |
| P191  | Student Forum                     | 1,364,024 | Monthly      | 250 | 1,218,302 | HH                            | 182 | 431 |
| P145  | The Barn (going)                  | 16,699    | Proportioned | 3   | 11,025    | Proportioned                  | 2   | 5   |
| P146  | Todd                              | 279,588   | HH           | 51  | 495,131   | HH                            | 74  | 125 |
| P163  | VRS                               | 7,579     | Monthly      | 1   | 5,005     | Benchmarked                   | 1   | 2   |

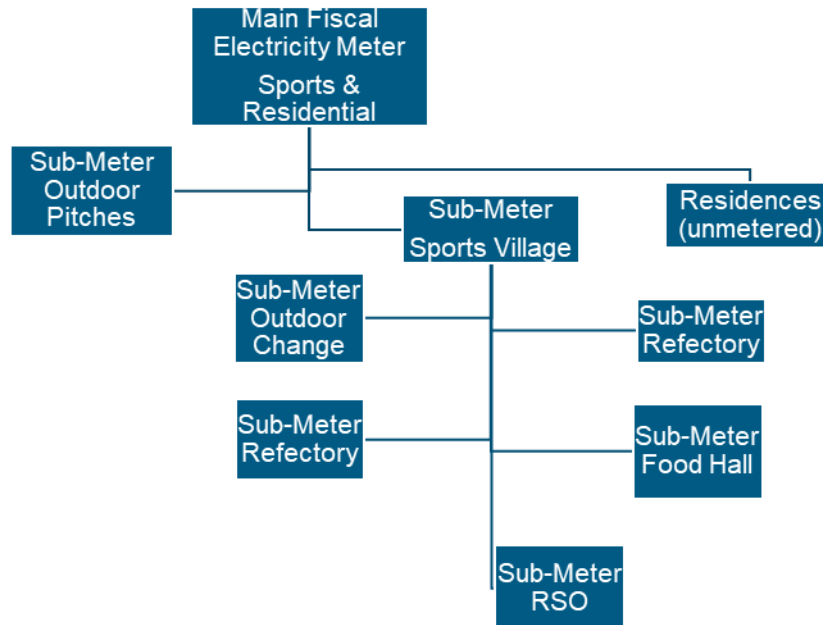


|         |                                           |                   |              |              |                   |              |              |              |
|---------|-------------------------------------------|-------------------|--------------|--------------|-------------------|--------------|--------------|--------------|
| P149    | Wright<br>(going)                         | 346,705           | Proportioned | 63           | 2,029,654         | HH           | 302          | 366          |
| P149A   | Wright<br>Extension<br>(going)            | 78,194            | Proportioned | 14           | 118,000           | Proportioned | 18           | 32           |
| P701    | Bayfordbury<br>Science<br>Block           | 101,138           | N/A          | 22           | 185,870           | Monthly      | 28           | 49           |
| P708    | Patrick<br>Moore<br>Building<br>(Rotunda) | 0                 | N/A          | 0            | 7,120             | Benchmarked  | 1            | 1            |
| P121    | Fielder<br>Centre                         | 414,202           | Monthly      | 76           | 208,940           | Monthly      | 31           | 107          |
| P133    | Meridian<br>House<br>(going)              | 149,336           | Monthly      | 27           | 71,973            | Monthly      | 11           | 38           |
| P189    | MacLaurin<br>Building                     | 199,449           | HH           | 36           | 584,254           | HH           | 87           | 124          |
| P500    | University<br>Bus                         | 253,331           | HH           | 46           | 285,090           | Monthly      | 42           | 89           |
| P188    | Titan Court                               | 1,171,029         | HH           | 214          | 667,444           | HH           | 99           | 314          |
| P653(Y) | 49 Chantry<br>Lane                        | 21,333            | Monthly      | 4            | 6,222             | Monthly      | 1            | 5            |
|         | <b>College<br/>Lane Total</b>             | <b>12,637,915</b> |              | <b>2,315</b> | <b>16,855,975</b> |              | <b>2,512</b> | <b>4,825</b> |

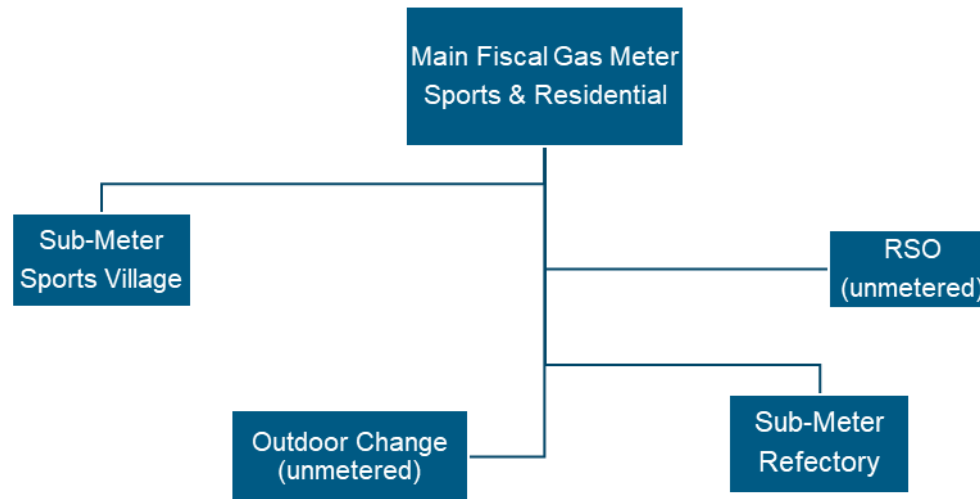


# Appendix G. Estate Metering

## G.1 de Havilland Sports and Residential Electricity Metering

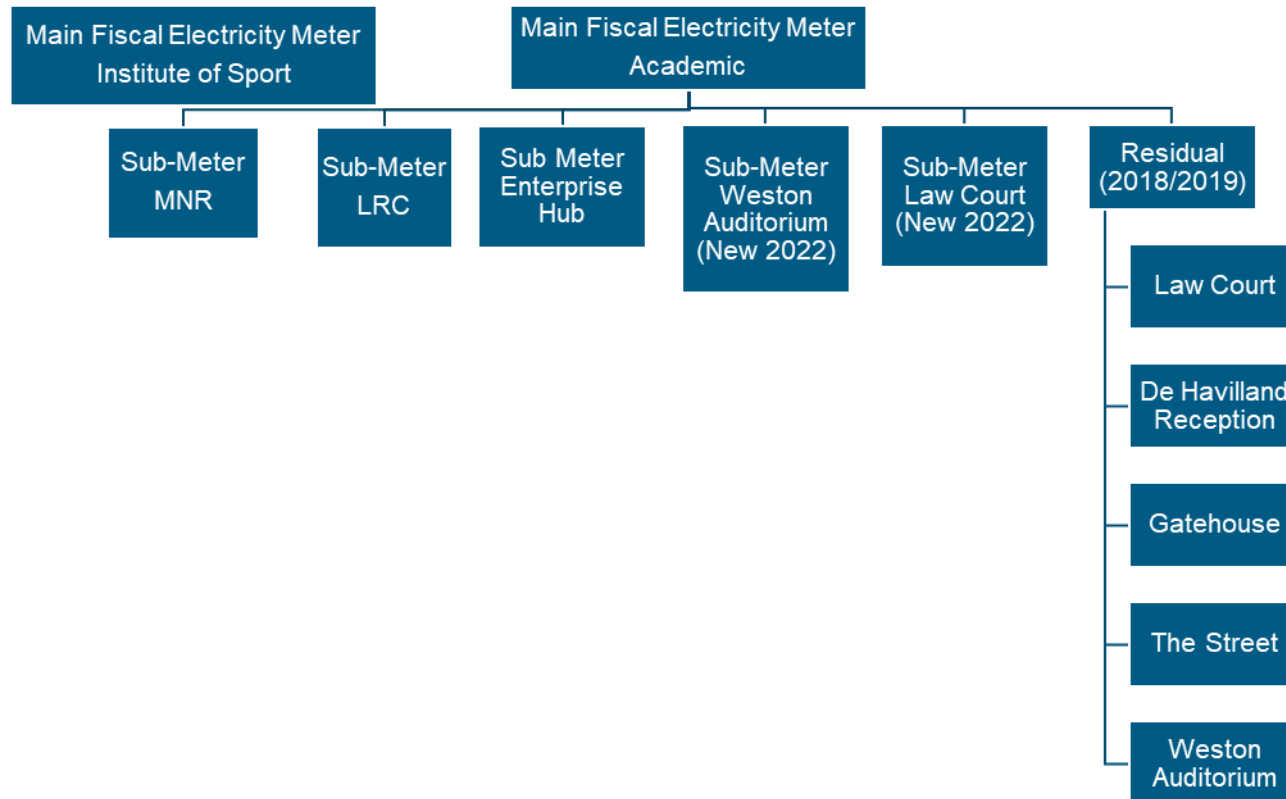


## G.2 de Havilland Sports and Residential Gas Metering



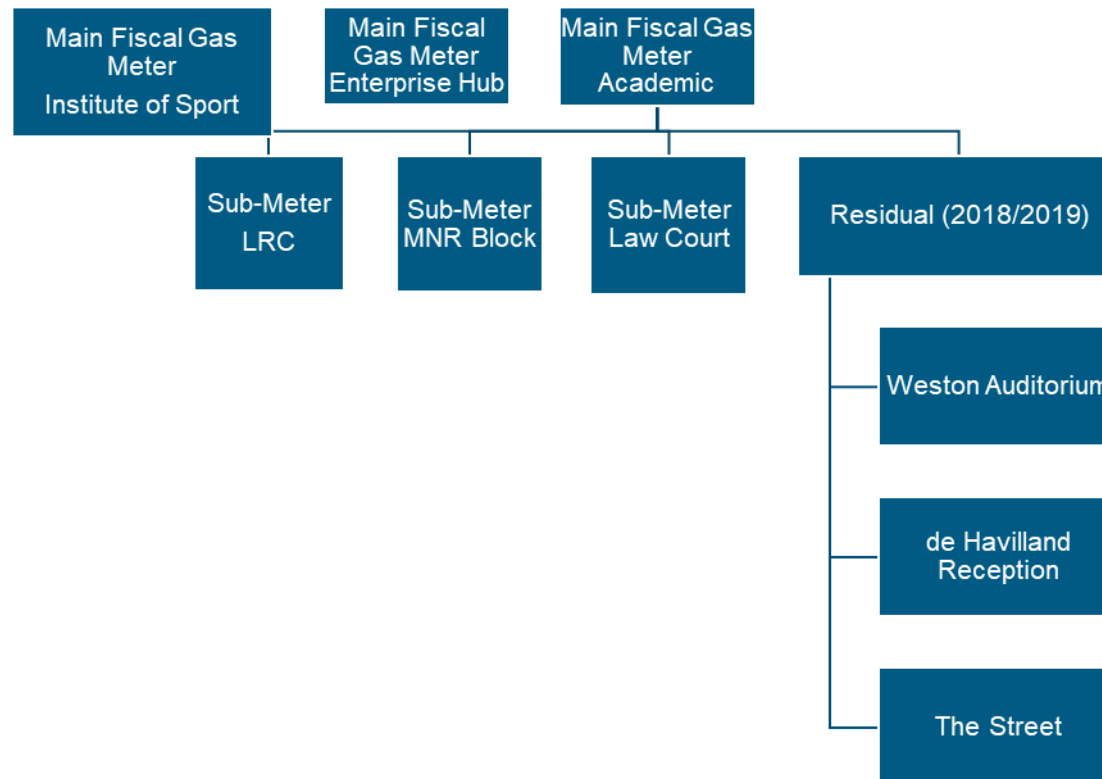
## G.3 de Havilland Academic Electricity Metering

The sub-meters within the Law Court and Weston Auditorium were installed in 2022. However, as the electricity consumption figures for 2018-2019 have been used in this report, the Law Court and Weston Auditorium have been included in residual electricity and apportioned using benchmarks for this report.

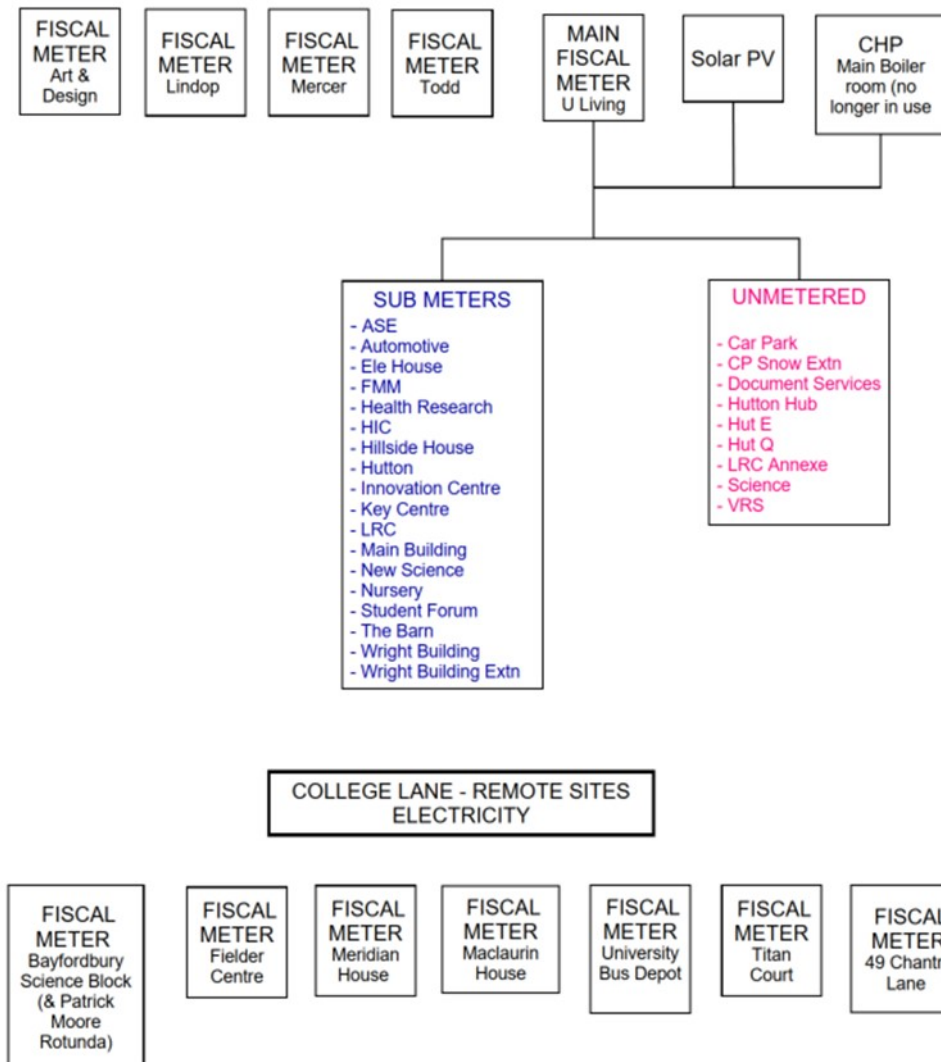


## G.4 de Havilland Academic Gas Metering

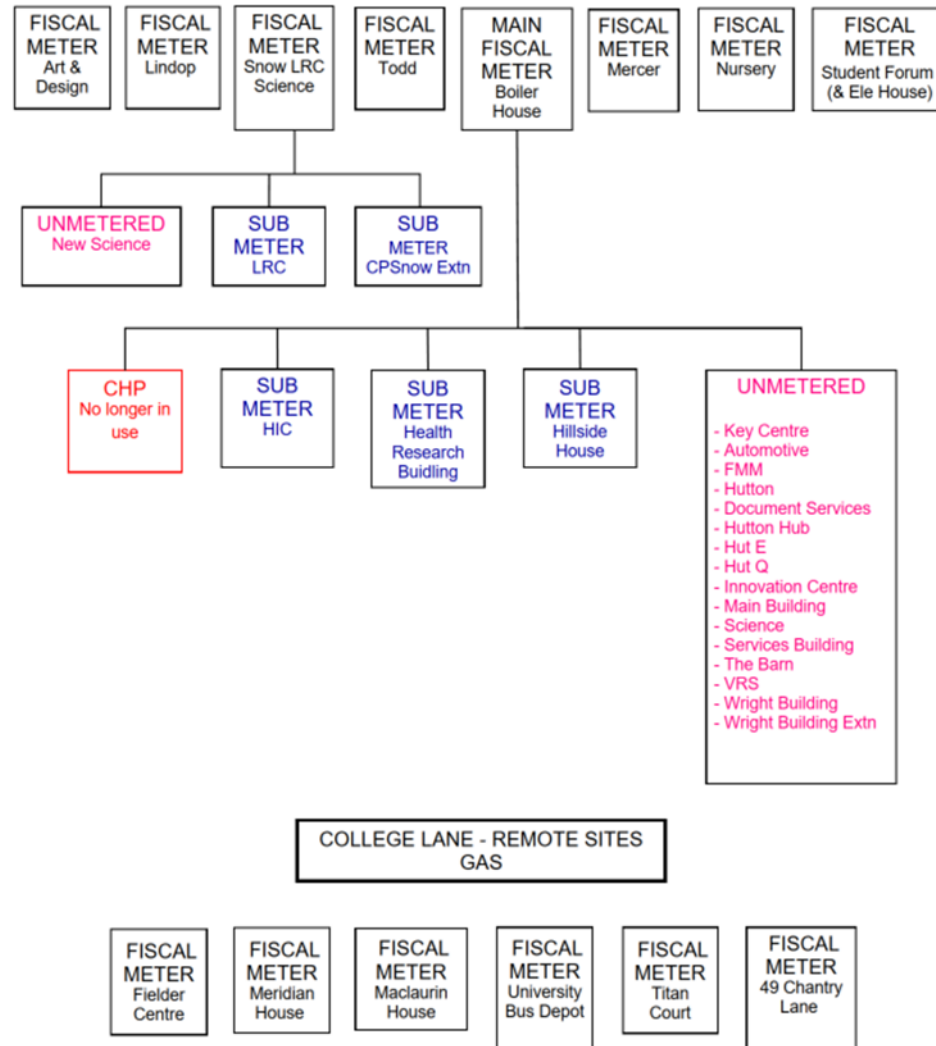
The Western Auditorium does not have any sub-metering present, the gas consumption can be calculated from the residual Main Fiscal gas metering.



## G.5 College Lane Electricity Metering



## G.6 College Lane Gas Metering



# Appendix H. Interventions

## BMS and Controls

A Building Management Systems (BMS) is an integrated system for monitoring and controlling energy-related building services and can provide enhanced control of buildings' mechanical and electrical engineering installations.

A behavioural change programme is recommended for the Facilities Management (FM) teams who are responsible for the operation and maintenance of the buildings. It is recommended that technical requirements in the Hard FM specifications are updated following the installation of the Net Zero retrofit measures.

Metering, Monitoring and Targeting (MM&T) and Measurement and Verification (M&V) is recommended for comparing energy and carbon performance before and after implementation of measures on a fair and reasonable basis. Behavioural change from training FM staff in Energy Management (ISO 50001), MM&T and M&V is likely to lead to more efficient operation and maintenance, and result in reduced carbon emissions. Both MM&T and M&V are facilitated by Automatic Meter Reading (AMR) technology and advanced BMS systems and lighting controls.

UH advised that re-procurement of the FM contract for the academic buildings will commence in 2024. This presents an opportunity to negotiate payment mechanisms with the FM contractor to incentivise them to improve the operational carbon performance of the buildings. It is recommended that requirements for energy efficiency and low carbon operation of buildings and associated M&E systems is included within the scope of the new contract. It is proposed that savings from proactive energy and carbon management are built into the contract requirements from 2026 under a new contract (with associated behavioural changes).

Any behavioural change programmes should be informed by the enhanced reporting addressed in the BMS intervention and AMR meter roll-out. The cost of energy should be made visible to the FM teams, emphasising the importance of energy efficiency, and encouraging the use of renewable energy sources to deliver UH's Net Zero target.

UH advised that there are several behavioural change programmes currently in operation across. This includes staff participation in 'Green Impact', an external programme encouraging environmentally and socially sustainable practices within organisations. Fifteen teams of academic and professional staff participated in the 2021-22 programme and the 2022-23 programme includes energy related actions to reduce demand and increase energy efficiency.

Additional carbon literacy training has been deployed to support the programme. An Annual Sustainability Advocates programme offers students opportunities to volunteer across various environmental and sustainability campaigns. Previous programmes have included waste audits with future energy related initiatives planned to embed an energy efficient mindset. However, the impact of these is currently not measured.



For the purpose of this plan, any savings resulting from these behavioural change programmes are deemed to be included in the BMS savings under the CONTROL decarbonisation theme.

## **Lighting**

Light-Emitting Diode (LED) lighting delivers significant energy savings over older models. A LED lighting retrofit programme across the de Havilland campus would be a cost-effective way to reduce energy consumption, bills and carbon emissions attributable to lighting. This involves replacement of less efficient light sources with high efficiency LEDs and incorporating improved controls, such as presence detection.

During the site surveys, manual switches were identified as the dominant lighting control, with limited instances of presence detection. These enhanced lighting controls can reduce lighting power demand during periods of low occupancy.

## **Heating**

It is recommended that fossil fuel heat sources are replaced by electrically driven heating systems. Due to the requirements for heat emitting systems to be compatible with low temperature systems, replacement of emitters or installation for supplementary heat emitters is required to compensate for the lower outputs. Additionally, it is recommended that exposed heating pipework and valves in both plant rooms and distribution routes are insulated to improve energy efficiency of the buildings.

The decarbonisation of catering facilities has been included within the modelling outputs for heating. Any remaining gas-fired cookers should be replaced with similar electric appliances.

## **Cooling**

Recommissioning or replacing of cooling plant for a more efficient alternative and improvement of time controls is recommended. Split Direct Expansion (DX) and Variable Refrigerant Volume (VRV) systems have been considered, along with replacement chillers where these have been identified.

## **Ventilation**

Developments in heating, ventilation, and air conditioning (HVAC) technologies has resulted in increased energy-efficient technology and improved control systems to reduce electricity consumption in buildings, including variable speed drives (VSDs). It is recommended that motor and pumps are appropriately sized to optimise energy efficiency.

## **Solar PV Panels**



Solar Photovoltaic (PV) is a key technology for renewable energy generation. Suitable sites have been identified during site surveys and desktop surveys. The potential annual output (kWh) for possible solar PV panel scenarios have been calculated. It is recommended that a structural assessment and condition survey of the roofs of each building considered for solar PV are undertaken.

### **Building Fabric Energy Efficiency Measures (EEMs)**

Building insulation reduces heat loss from a building, improving thermal comfort, reducing the risk of condensation, avoiding energy consumption, and reducing operational carbon emissions. Insulation reduces the required capacity of heating systems and subsequently installation capital costs. Draughts in a building result in heat loss and cause discomfort for occupants. Draught proofing is an inexpensive energy efficiency improvement method and louvres can also be upgraded to incorporate natural ventilation with heat recovery (NVHR) units, which utilise internal heat gains to temper incoming controlled fresh air.

Whilst the replacement of existing glazing with triple glazing would reduce heat loss, the payback periods associated with this intervention are significant and would result in considerable disruption to the university. Therefore, this intervention is not recommended. However, the implementation of reflective solar film for windows should be explored, with the dual benefit of reduction of heat gains due to solar radiation and reduction of glare.

# Appendix I. Delivery Resources

The following resources are required to deliver UH's Net Zero Programme:

| Required                                       | Role                                                                                                                                                                                                                                                          |
|------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Net Zero Consultant                            | Advise UH Estates on the UH Estate Decarbonisation Plan and provide annual updates on benefits realisation (Measurement and Verification) and adjustments to the programme to maintain the Net Zero trajectory.<br><br>Advise on funding applications (Salix) |
| Project Management/Programme Management        | Support UH Estates with the development Net Zero Programme and delivery of projects                                                                                                                                                                           |
| Principal Designer                             | Compliance with the CDM Regulations 2015                                                                                                                                                                                                                      |
| Building Services (MEP) Engineers              | Design – M&E systems, including compatibility, coordination and integration                                                                                                                                                                                   |
| Structural Engineers                           | Design, including load bearing capacity of roofs nominated for solar PV panels                                                                                                                                                                                |
| Quantity Surveyors                             | Cost Management and Life cycle costs/benefits                                                                                                                                                                                                                 |
| Building Surveyors                             | Design – building fabric improvements                                                                                                                                                                                                                         |
| Planning Consultant                            | Planning advice                                                                                                                                                                                                                                               |
| Acoustician                                    | To support planning applications, if required by LPA                                                                                                                                                                                                          |
| Environmental Impact Assessment Specialists    | To support planning applications, if required by LPA                                                                                                                                                                                                          |
| HV/LV Infrastructure and Renewable Consultants | Design – including HV/LV capacity, electrical infrastructure upgrades and solar PV panel arrays                                                                                                                                                               |



Contractor/Principal Contractor

Managing the works, including working drawings, installation, testing, commissioning, handover, O&M Manuals and 'As Installed' drawings.

Compliance with the CDM Regulations 2015

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Supply Chain

Supply equipment and materials that comply with the specifications. Warranties

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## Appendix J. Fuel Unit Prices

| Fuel Type   | Campus       | Building Type                                         | Price (p/kWh) |
|-------------|--------------|-------------------------------------------------------|---------------|
| Gas         | de Havilland | Academic                                              | 7.89          |
| Gas         | de Havilland | Sports & Residential                                  | 7.50          |
| Gas         | de Havilland | Laboratory (Institute of Sport)                       | 8.26          |
| Gas         | de Havilland | Enterprise Hub                                        | 7.54          |
| Electricity | de Havilland | Academic                                              | 22.78         |
| Electricity | de Havilland | Sports & Residential                                  | 13.86         |
| Electricity | de Havilland | Laboratory                                            | 22.78         |
| Gas         | College Lane | Art & Design                                          | 7.14          |
| Gas         | College Lane | All College Lane (minus Art & Design and Bayfordbury) | 9.28          |
| LPG         | College Lane | Bayfordbury Science Block                             | 8.35          |
| Electricity | College Lane | Art & Design                                          | 23.20         |
| Electricity | College Lane | All Other College Lane Buildings                      | 27.49         |
| Electricity | College Lane | Lindop                                                | 24.43         |



| Fuel Type   | Campus       | Building Type                    | Price (p/kWh) |
|-------------|--------------|----------------------------------|---------------|
| Electricity | College Lane | Mercer                           | 25.77         |
| Electricity | College Lane | Todd                             | 25.09         |
| Electricity | College Lane | Bayfordbury Science Block        | 24.96         |
| Electricity | College Lane | Patrick Moore Building (Rotunda) | 27.49         |
| Electricity | College Lane | Fielder Centre                   | 24.69         |
| Electricity | College Lane | Meridian House                   | 26.69         |
| Electricity | College Lane | MacLaurin Building               | 23.35         |
| Electricity | College Lane | University Bus                   | 24.81         |
| Electricity | College Lane | Titan Court                      | 21.17         |
| Electricity | College Lane | 49 Chantry Lane                  | 26.79         |



## Appendix K. Carbon Emissions Ranking

| Rank | Building Name                    | Normalised Carbon Emissions (2024) by     | Magnitude                                                            |
|------|----------------------------------|-------------------------------------------|----------------------------------------------------------------------|
|      |                                  | GIFA (tCO <sub>2</sub> e/m <sup>2</sup> ) | (Total Carbon Emissions (2024) – tCO <sub>2</sub> e/m <sup>2</sup> ) |
| 1    | Sports Village                   | 0.117                                     | 1,049                                                                |
| 2    | Refectory (Kitchen only gas)     | 0.106                                     | 165                                                                  |
| 3    | New Science Building             | 0.085                                     | 729                                                                  |
| 4    | RSO                              | 0.083                                     | 32                                                                   |
| 5    | LRC (Buxton Centre for Learning) | 0.056                                     | 659                                                                  |
| 6    | Wright (going)                   | 0.056                                     | 366                                                                  |
| 7    | University Bus                   | 0.051                                     | 89                                                                   |
| 8    | Outdoor Change                   | 0.050                                     | 35                                                                   |
| 9    | Student Forum                    | 0.050                                     | 431                                                                  |
| 10   | 49 Chantry Lane                  | 0.046                                     | 5                                                                    |
| 12   | Enterprise Hub                   | 0.040                                     | 107                                                                  |
| 13   | Bayfordbury Science Block        | 0.040                                     | 49                                                                   |
| 14   | Titan Court                      | 0.039                                     | 314                                                                  |
| 15   | Fielder Centre                   | 0.039                                     | 107                                                                  |



| Rank | Building Name                           | Normalised Carbon Emissions (2024) by     |  | Magnitude                                                            |
|------|-----------------------------------------|-------------------------------------------|--|----------------------------------------------------------------------|
|      |                                         | GIFA (tCO <sub>2</sub> e/m <sup>2</sup> ) |  | (Total Carbon Emissions (2024) – tCO <sub>2</sub> e/m <sup>2</sup> ) |
| 16   | Lindop                                  | 0.039                                     |  | 94                                                                   |
| 17   | Art & Design                            | 0.034                                     |  | 179                                                                  |
| 18   | Main (majority going)                   | 0.032                                     |  | 462                                                                  |
| 19   | Mercer                                  | 0.032                                     |  | 75                                                                   |
| 20   | C.P. Snow Psychology (going)            | 0.030                                     |  | 54                                                                   |
| 21   | Document Services Building              | 0.029                                     |  | 6                                                                    |
| 22   | Health Research Building                | 0.027                                     |  | 59                                                                   |
| 23   | Institute of Sport                      | 0.027                                     |  | 56                                                                   |
| 24   | Film, Music & Media Facilities Building | 0.027                                     |  | 151                                                                  |
| 25   | MNR Block                               | 0.026                                     |  | 365                                                                  |
| 26   | Services Building (ASE)                 | 0.025                                     |  | 24                                                                   |
| 27   | MacLaurin Building                      | 0.025                                     |  | 124                                                                  |
| 28   | Science Building                        | 0.025                                     |  | 54                                                                   |
| 29   | Hutton (part going)                     | 0.024                                     |  | 126                                                                  |
| 30   | Nursery                                 | 0.024                                     |  | 16                                                                   |



| Rank | Building Name                 | Normalised Carbon Emissions (2024) by     | Magnitude                                                            |
|------|-------------------------------|-------------------------------------------|----------------------------------------------------------------------|
|      |                               | GIFA (tCO <sub>2</sub> e/m <sup>2</sup> ) | (Total Carbon Emissions (2024) – tCO <sub>2</sub> e/m <sup>2</sup> ) |
| 31   | Meridian House (going)        | 0.023                                     | 38                                                                   |
| 32   | Law Court Building            | 0.022                                     | 54                                                                   |
| 33   | Innovation Centre             | 0.022                                     | 35                                                                   |
| 34   | The Street                    | 0.022                                     | 20                                                                   |
| 34   | The Weston Auditorium         | 0.022                                     | 46                                                                   |
| 36   | Todd                          | 0.022                                     | 125                                                                  |
| 37   | Hut E (going)                 | 0.022                                     | 5                                                                    |
| 37   | Hut Q Research Centre (going) | 0.022                                     | 8                                                                    |
| 37   | Wright Extension (going)      | 0.022                                     | 32                                                                   |
| 40   | De Havilland Reception        | 0.019                                     | 3                                                                    |
| 41   | Spectra                       | 0.019                                     | 286                                                                  |
| 42   | Hillside House (going)        | 0.016                                     | 8                                                                    |
| 43   | The Barn (going)              | 0.015                                     | 5                                                                    |
| 44   | VRS                           | 0.015                                     | 2                                                                    |
| 45   | Key Centre                    | 0.015                                     | 7                                                                    |



| Rank | Building Name                        | Normalised Carbon Emissions (2024) by     | Magnitude                                                            |
|------|--------------------------------------|-------------------------------------------|----------------------------------------------------------------------|
|      |                                      | GIFA (tCO <sub>2</sub> e/m <sup>2</sup> ) | (Total Carbon Emissions (2024) – tCO <sub>2</sub> e/m <sup>2</sup> ) |
| 46   | Aldenham                             | 0.015                                     | 50                                                                   |
| 46   | Ashwell                              | 0.015                                     | 23                                                                   |
| 46   | Redbourn                             | 0.015                                     | 47                                                                   |
| 46   | Sarrat                               | 0.015                                     | 24                                                                   |
| 50   | Hadham                               | 0.015                                     | 35                                                                   |
| 50   | Lemsford                             | 0.015                                     | 23                                                                   |
| 50   | Sandridge                            | 0.015                                     | 24                                                                   |
| 50   | Watton                               | 0.015                                     | 70                                                                   |
| 50   | Welwyn                               | 0.015                                     | 45                                                                   |
| 55   | Kimpton                              | 0.015                                     | 33                                                                   |
| 55   | Shenley                              | 0.015                                     | 35                                                                   |
| 57   | Automotive Centre                    | 0.013                                     | 8                                                                    |
| 58   | H.I.C (going)                        | 0.013                                     | 6                                                                    |
| 59   | Hutton Hub                           | 0.012                                     | 38                                                                   |
| 60   | LRC College Lane Classroom<br>Annexe | 0.012                                     | 13                                                                   |



| Rank | Building Name                    | Normalised Carbon Emissions (2024) by     |                                                                      | Magnitude |
|------|----------------------------------|-------------------------------------------|----------------------------------------------------------------------|-----------|
|      |                                  | GIFA (tCO <sub>2</sub> e/m <sup>2</sup> ) | (Total Carbon Emissions (2024) – tCO <sub>2</sub> e/m <sup>2</sup> ) |           |
| 60   | Patrick Moore Building (Rotunda) | 0.012                                     |                                                                      | 1         |
| 62   | Gatehouse                        | 0.010                                     |                                                                      | 2         |
| 63   | Ele House                        | 0.005                                     |                                                                      | 6         |
| 64   | Multi-Storey Car Park 1          | 0.003                                     |                                                                      | 31        |

## Appendix L. Solar PV Areas

This table outlines the available roof areas for the installation of Solar PV panels. Note that not all buildings have PV proposed as part of the EDP Delivery Plan due to the prioritisation of other measures within the current budget. Only the Law Court Building and Titan Court have PV proposed as part of the EDP update.

| Status                                        | Building                           | Solar PV Installed | Further PV Possible | Area Available for Additional/New Solar PV (m <sup>2</sup> ) | Rating (kWp) | Estimated Electrical Generation (kWh) |
|-----------------------------------------------|------------------------------------|--------------------|---------------------|--------------------------------------------------------------|--------------|---------------------------------------|
| Proposed                                      | Law Court Building                 | N                  | Y                   | 481                                                          | 96.20        | 81,770                                |
| Proposed                                      | Titan Court                        | N                  | Y                   | 789                                                          | 157.80       | 134,130                               |
| Not proposed within current budget allocation | Block M (Sir Brian Corby Building) | N                  | Y                   | 1,036                                                        | 207.20       | 176,120                               |
| Not proposed within current budget allocation | Block N (Teaching Block)           | N                  | Y                   | 545                                                          | 109.00       | 92,650                                |
| Not proposed within current budget allocation | Block R (Humanities & Education)   | N                  | Y                   | 1,019                                                        | 203.80       | 173,230                               |
| Not proposed within current budget allocation | de Havilland Reception             | N                  | Y                   | 114                                                          | 22.80        | 19,380                                |
| Not proposed within current budget allocation | Enterprise Hub                     | N                  | Y                   | 89                                                           | 17.80        | 15,130                                |



| Status                                        | Building                     | Solar PV Installed | Further PV Possible | Area Available for Additional/New Solar PV (m <sup>2</sup> ) | Rating (kWp) | Estimated Electrical Generation (kWh) |
|-----------------------------------------------|------------------------------|--------------------|---------------------|--------------------------------------------------------------|--------------|---------------------------------------|
| Not proposed within current budget allocation | LRC                          | N                  | Y                   | 1,863                                                        | 372.60       | 316,710                               |
| Not proposed within current budget allocation | Gatehouse                    | N                  | Y                   | 151                                                          | 30.20        | 25,670                                |
| Not proposed within current budget allocation | The Street                   | N                  | Y                   | 702                                                          | 140.40       | 119,340                               |
| Not proposed due to feasibility               | The Weston Auditorium        | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed - PFI                            | Sports Village               | N                  | Y                   | 3,360                                                        | 672.00       | 571,200                               |
| Not proposed within current budget allocation | Refectory (Kitchen only gas) | N                  | Y                   | 1,161                                                        | 232.20       | 197,370                               |
| Not proposed - PFI                            | Outdoor Change               | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed - PFI                            | RSO                          | N                  | Y                   | 290                                                          | 58.00        | 49,300                                |
| Not proposed due to feasibility               | Institute of Sport           | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed - PFI                            | Aldenham                     | N                  | Y                   | 349                                                          | 69.75        | 59,288                                |
| Not proposed - PFI                            | Ashwell                      | N                  | Y                   | 237                                                          | 47.40        | 40,290                                |
| Not proposed - PFI                            | Hadham                       | N                  | Y                   | 750                                                          | 150.00       | 127,500                               |
| Not proposed - PFI                            | Kimpton                      | N                  | Y                   | 376                                                          | 75.15        | 63,878                                |
| Not proposed - PFI                            | Lemsford                     | N                  | Y                   | 297                                                          | 59.40        | 50,490                                |
| Not proposed - PFI                            | Redbourn                     | N                  | Y                   | 585                                                          | 117.00       | 99,450                                |
| Not proposed - PFI                            | Sandridge                    | N                  | Y                   | 309                                                          | 61.80        | 52,530                                |



| Status                                        | Building                                | Solar PV Installed | Further PV Possible | Area Available for Additional/New Solar PV (m <sup>2</sup> ) | Rating (kWp) | Estimated Electrical Generation (kWh) |
|-----------------------------------------------|-----------------------------------------|--------------------|---------------------|--------------------------------------------------------------|--------------|---------------------------------------|
| Not proposed - PFI                            | Sarrat                                  | N                  | Y                   | 225                                                          | 45.00        | 38,250                                |
| Not proposed - PFI                            | Shenley                                 | N                  | Y                   | 413                                                          | 82.50        | 70,125                                |
| Not proposed - PFI                            | Watton                                  | N                  | Y                   | 812                                                          | 162.30       | 137,955                               |
| Not proposed - PFI                            | Welwyn                                  | N                  | Y                   | 436                                                          | 87.15        | 74,078                                |
| Not proposed within current budget allocation | Art & Design                            | Y                  | Y                   | 475                                                          | 95.00        | 80,750                                |
| Not proposed within current budget allocation | Automotive Centre                       | N                  | Y                   | 108                                                          | 21.60        | 18,360                                |
| Not proposed due to feasibility               | Boiler House                            | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed – building to be demolished      | C.P. Snow Psychology (going)            | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed within current budget allocation | Document Services Building              | N                  | Y                   | 130                                                          | 25.92        | 22,032                                |
| Not feasible – pitched roof                   | Ele House                               | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed within current budget allocation | Film, Music & Media Facilities Building | Y                  | Y                   | 89                                                           | 17.80        | 15,130                                |
| Not proposed – building to be demolished      | H.I.C (going)                           | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed within current budget allocation | Health Research Building                | N                  | Y                   | 397                                                          | 79.35        | 67,448                                |
| Not proposed – building to be demolished      | Hillside House (going)                  | N                  | N                   | 0                                                            | -            | 0                                     |

| Status                                        | Building                                | Solar PV Installed | Further PV Possible | Area Available for Additional/New Solar PV (m <sup>2</sup> ) | Rating (kWp) | Estimated Electrical Generation (kWh) |
|-----------------------------------------------|-----------------------------------------|--------------------|---------------------|--------------------------------------------------------------|--------------|---------------------------------------|
| Not proposed – building to be demolished      | Hut E (going)                           | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed – building to be demolished      | Hut Q<br>Research Centre (going)        | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed within current budget allocation | Hutton (part going)                     | N                  | Y                   | 702                                                          | 140.36       | 119,308                               |
| Not proposed due to green roof                | Hutton Hub                              | Y                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed within current budget allocation | Innovation Centre                       | N                  | Y                   | 377                                                          | 75.45        | 64,133                                |
| Not proposed due to feasibility               | Key Centre                              | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed – temporary building             | LRC<br>College Lane<br>Classroom Annexe | N                  | Y                   | 410                                                          | 81.90        | 69,615                                |
| Not proposed within current budget allocation | LRC<br>(Buxton Centre for Learning)     | Y                  | Y                   | 1,356                                                        | 271.20       | 230,520                               |
| Not proposed – no further PV possible         | Lindop                                  | Y                  | N                   | 0                                                            | -            | 0                                     |
| Not feasible – pitched roof                   | Main (majority going)                   | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed – no further PV possible         | Mercer                                  | Y                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed due to feasibility               | Multi-Storey Car Park 1                 | N                  | N                   | 0                                                            | -            | 0                                     |

| Status                                        | Building                         | Solar PV Installed | Further PV Possible | Area Available for Additional/New Solar PV (m <sup>2</sup> ) | Rating (kWp) | Estimated Electrical Generation (kWh) |
|-----------------------------------------------|----------------------------------|--------------------|---------------------|--------------------------------------------------------------|--------------|---------------------------------------|
| Not proposed within current budget allocation | New Science Building             | Y                  | Y                   | 1,265                                                        | 252.98       | 215,033                               |
| Not proposed within current budget allocation | Nursery                          | N                  | Y                   | 504                                                          | 100.80       | 85,680                                |
| Not proposed due to feasibility               | Science Building                 | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed due to feasibility               | Services Building (ASE)          | N                  | N                   | 0                                                            | -            | 0                                     |
| Not feasible – pitched roof                   | Student Forum                    | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed – building to be demolished      | The Barn (going)                 | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed – no further PV possible         | Todd                             | Y                  | N                   | 0                                                            | -            | 0                                     |
| Not feasible – pitched roof                   | VRS                              | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed – building to be demolished      | Wright (going)                   | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed – building to be demolished      | Wright Extension (going)         | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed due to feasibility               | Bayfordbury Science Block        | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed due to feasibility               | Patrick Moore Building (Rotunda) | N                  | N                   | 0                                                            | -            | 0                                     |
| Not feasible – pitched roof                   | Fielder Centre                   | N                  | N                   | 0                                                            | -            | 0                                     |



| Status                                   | Building               | Solar PV Installed | Further PV Possible | Area Available for Additional/New Solar PV (m <sup>2</sup> ) | Rating (kWp) | Estimated Electrical Generation (kWh) |
|------------------------------------------|------------------------|--------------------|---------------------|--------------------------------------------------------------|--------------|---------------------------------------|
| Not proposed – building to be demolished | Meridian House (going) | N                  | N                   | 0                                                            | -            | 0                                     |
| Not proposed – no further PV possible    | MacLaurin Building     | Y                  | N                   | 0                                                            | -            | 0                                     |
| Not feasible – pitched roof              | University Bus         | N                  | N                   | 0                                                            | -            | 0                                     |
| Not feasible – pitched roof              | 49 Chantry Lane        | N                  | N                   | 0                                                            | -            | 0                                     |

# Appendix M. Outline Scope of Works

Issued alongside this report.



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