TM54 Operational Energy Assessment

Britannia Street Car Park

January 2025

ensphere

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This document has been prepared and checked in accordance with Ensphere Group Ltd.'s Quality Management System.

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Final	V1	Kizzy O'Sullivan	Aura Tache	Pete Jeavons	January 2025

Report Outline

Contents

Executive Summary

This assessment presents the anticipated operational energy performance for a proposed development at Britannia Street Car Park, London, WC1X 9BP.

The proposals are for a purpose-built student accommodation building, with associated cycle parking, waste/recycling storage, landscaping and other ancillary works.

CIBSE TM54 methodology has been applied to estimate operational energy consumption, helping to identify and quantify factors influencing energy use within the building incorporating standard parameters and energy loads from preset profiles and industry database. Where specific data was unavailable, reasonable assumptions have been made.

The energy modelling employs a dynamic simulation approach with advanced HVAC system and control capabilities, enabling it to:

- Calculate 8,760 hours of building operation to simulate annual energy use.
- Model hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation.
- Model thermal mass effects, part load performance curves for mechanical equipment, capacity and efficiency correction curves for mechanical heating and cooling equipment and air side economisers with integrated control.
- Be able to take account of lighting controls linked to lighting levels from daylight.

The model considers both regulated and unregulated energy consumption and generates scenarios around central prediction to explore how the building will perform under different operating conditions.

The proposed development comprises the following:

- High-performance building fabric and energy-efficient lighting, services, and equipment.
- Passive design measures to reduce energy demand for heating, cooling, ventilation, and lighting.
- ASHPs for hot water and space heating
- Extent of roof mounted PV

As part of the sensitivity analysis, various scenarios have been examined by changing key parameters such as weather conditions, heating setpoints, occupancy density, and operational schedules. Tests indicate that occupancy-related factors, particularly density and schedules, have the most significant impact on energy consumption.

Overall, the scenario analysis suggests that annual electricity consumption for the proposed development could range from 527 MWh ("LOW") to 913 MWh ("HIGH") depending on occupant behaviour and energy management practices for the development. Figure ES.1 summarises the energy breakdown for the baseline scenario, considered the most likely, with estimated annual consumption of 648 MWh for the whole development.

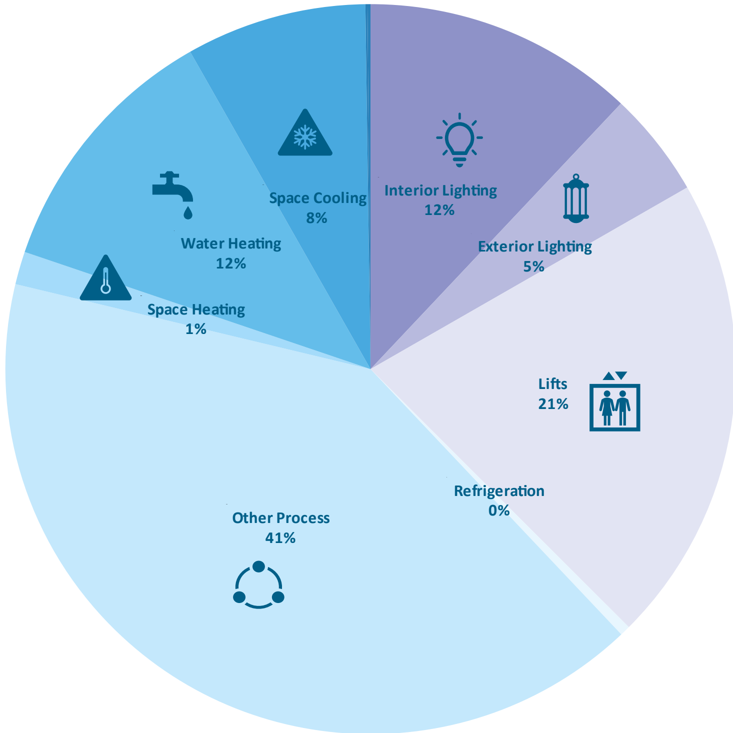


Figure ES.1 – Energy Consumption Breakdown for Baseline Scenario

The energy breakdown by end-use indicates that equipment loads are the primary contributors to operational energy consumption, followed by lifts, internal lighting, and domestic hot water. The proposed operational energy strategy adheres to best practice methodologies and aligns with industry benchmarks. The proposed scheme design is expected to deliver an energy-efficient and low-carbon building.

1. Introduction

Ensphere Group Ltd was commissioned by Curlew Developments London Limited to evaluate the anticipated operational energy for a proposed development at Britannia Street Car Park, London, WC1X 9BP.

Site and Surroundings

The application site (the 'Site'), which is 0.1 hectares in size, is located in the Kings Cross Ward of the London Borough of Camden, bounded by Britannia Street to the north; the three storey 'Help Musicians Building' and six storey Derby Lodge buildings to the east; Wicklow Street to the south; and by London Underground railway lines (in a cutting) to the west. The Thames Link railway line also runs in a shallow tunnel beneath the western half of the Site.

The Site comprises undeveloped hardstanding in use as a public car park and includes a ventilation shaft linked to the Thames Link railway tunnel running below the Site.

The area surrounding the Site was historically industrial and residential in nature with the Site itself having previously been occupied by a 3-storey warehouse. While the area generally retains its historic built from, forming part of the Kings Cross St Pancras Conservation Area, over time the areas industrial uses have been replaced by office, creative and additional residential uses (including student accommodation).

Building heights in the area generally range from two to six storeys, while the consented redevelopment of the nearby Royal National Throat, Nose and Ear Hospital (located to the south-west of the Site) permits the delivery of building up to 13 storeys tall.

The Site benefits from a high PTAL rating of 6b ('Excellent'), Kings Cross and St Pancras Railway and Underground Stations are located within 370 metres / 7-minute walk from the Site. There are also a number of bus stops within close proximity, with bus stops located at Grays Inn Road and Kings Cross Road.

Given the Sites proximity to various Universities including Central Saint Martins, Aga Khan University Institute, University of London & UCL within short walking and cycling distance of the Site, and its location within the 'Knowledge Quarter', the Site is an ideal location for students.

Proposed Development

The proposals are for the redevelopment of an existing brownfield site for Purpose-Built Student Accommodation in addition to community floorspace.

Report Objective

The objective of this assessment is to demonstrate the operational energy use of the proposed development.

One notable limitation in the existing Part L calculation methodology is its failure to account for unregulated energy loads. The proportion of unregulated energy, though varying significantly across different building types, can constitute over half of the overall operational energy. Disregarding unregulated energy at the regulatory level may result in significantly divergent consumption levels compared to those initially estimated during the design phase.

The operational energy consumption is categorised into two primary components. The first is 'regulated' energy consumption, which arises from controlled and fixed building services like heating, cooling, hot water, ventilation, and lighting. The second is 'unregulated' energy consumption, which is attributed to processes not subject to building regulations, including IT equipment, lifts, refrigeration systems, cooking equipment, and other types of 'small power'.

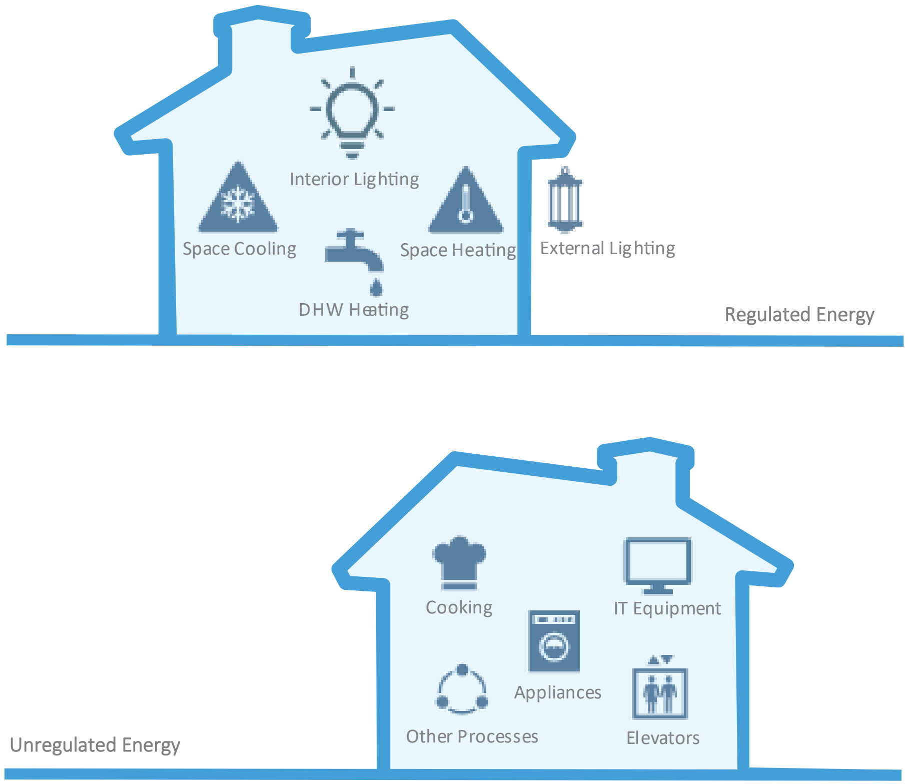


Figure 1.2 – Regulated and Unregulated Energy Categories

The TM54 analysis provides a more accurate understanding of energy demand during the design stage, as outlined in the CIBSE TM54 Technical Memorandum: *Evaluating Operational Energy Use at the Design Stage* (2022).

This methodology will help bridge the performance gap between the regulated energy use from Part L compliance and actual operational energy consumption.

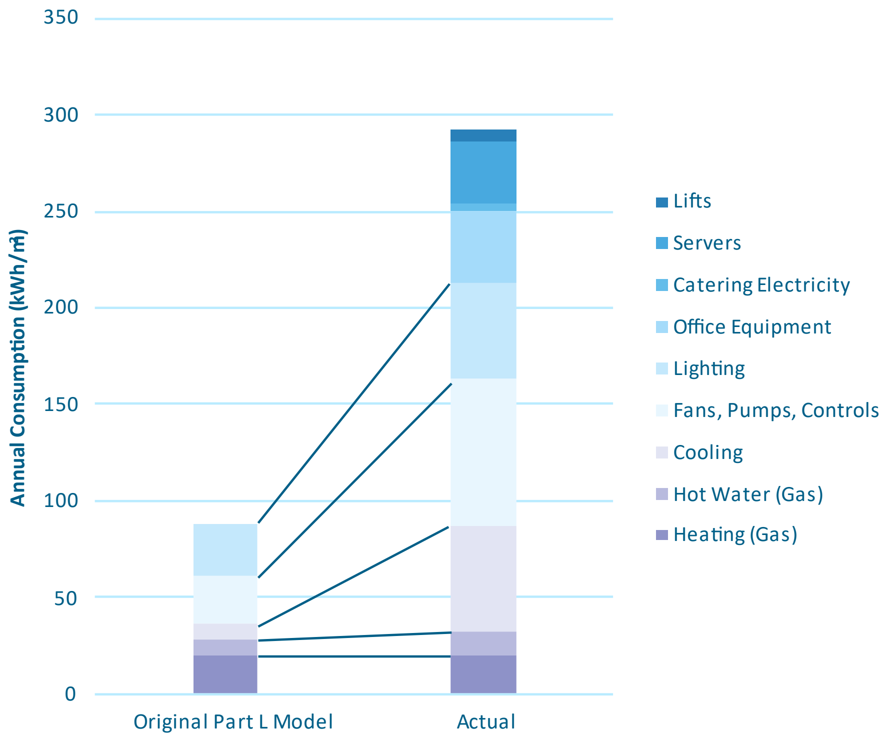


Figure 1.3 - Comparison of Building Regulations Approved Document L2A (HM Government, 2010) Calculations and Monitored Energy Use After Five Years of Operation, for an Example Building (Reproduced from CIBSE TM54)

2. Assessment Methodology

CIBSE TM54 (2022)

Evaluating Operational Energy Use at the Design Stage

BRREAM UK New Construction (2024)

Version 6.1

CIBSE TM54 Methodology: Evaluating Operational Energy Use at the Design Stage (2022)

The CIBSE TM54:2022 methodology offers a comprehensive framework for evaluating operational energy use at the design stage, helping to predict energy consumption more accurately compared to compliance modelling approaches. It consists of a 17-step process that systematically identifies and assesses both regulated and unregulated energy demands, enabling designers to gain a realistic understanding of how the building is likely to perform in practice, bridging the performance gap that often arises between predicted and actual energy use.

The methodology considers factors influencing energy use, including building fabric, systems, occupancy patterns, and unregulated loads. It encourages the use of dynamic simulation modelling to calculate operational energy usage across a typical year, considering key parameters like weather conditions, plant efficiencies, and user behaviour.

Step 0: Choosing the modelling approach

Modelling type: Dynamic Thermal
Modelling software: IES VE
HVAC modelling detail: HVAC Thermal Template

Step 1: Constructing and building the model

- Constructing and zoning the model
- Establishing floor areas
- Include external/internal shading devices
- Defining building's fabric & thermal mass
- Defining air permeability as infiltration rate (ACH @ 50Pa)

Step 2: Estimating operating hours and occupancy factors

- Operating hours
- Occupancy profile and gains

Steps 3-9: Internal gains and associated energy uses*

- Step 3: Lighting
- Step 7: Server rooms
- Step 4: Lifts and escalators
- Step 8: Additional plant and equipment
- Step 5: Small power
- Step 9: Domestic hot water (DHW)
- Step 6: Catering

Step 10: Adding internal heat gains in the model

These are calculated automatically by the software based on the inputs from steps 3-9.

Step 11: Modelling HVAC systems and their controls

This step includes the defining the domestic hot water and the HVAC system for space heating, space cooling, and ventilation strategies within the software.

Steps 13-17: Producing, analysing, reporting, and reviewing results

- Step 13: Sensitivity analysis
- Step 16: Reporting and implementation matrix
- Step 14: Scenario testing
- Step 17: Quality assurance (QA)
- Step 15: Review against targets & benchmarks

BREEAM Ene01: Prediction of Operational Energy Consumption

Consideration has been given to the BREAM UK New Construction (2024) technical guide. This section considers the requirements of BREEAM's Ene 01: Reduction of Energy Use and Carbon Emissions. Further detail is provided in Guidance Note GN32: BREEAM New Construction Guidance Note - Energy Prediction and Post Occupancy Assessment.

The BREEAM criteria include reference to the following:

- Energy design workshop focusing on operational energy performance.
- Undertake energy modelling during the design and post-construction stage to generate predicted operational energy consumption figures.
- Report predicted energy consumption targets by end use, design assumptions and input data, including justifications.
- Carry out sensitivity and scenario modelling to inform energy performance targets and operational strategies.
- Energy modelling to be undertaken by a suitably qualified expert to ensure the accuracy and compliance of the energy predictions.

Other Considerations

London Plan (2021)

The London Plan is the overall strategic plan for London, it sets out an integrated economic, environmental, transport and social framework for development of London over the next 20-25 years. The London Plan is part of the Development Plan and covers a range of planning issues. The presented policies provide a vision for how London should sustainably grow and develop in the future. Policies considered pertinent to this report are presented below:

- Policy SI 2 (Minimising greenhouse gas emissions) – Major development should be net zero-carbon and minimise emissions in accordance with the following energy hierarchy: be lean, be clean, be green, be seen. A minimum on site reduction of 35% beyond Building Regulations will be required for major development. Residential development should achieve 10 per cent, and non-residential development should achieve 15 per cent through energy efficiency measures. Any short fall with the zero-carbon target should be addressed through a carbon offset payment. Development referable to the GLA should also calculate whole life-cycle carbon emissions.
- Policy SI 5 (Water infrastructure) – Development proposals should be achieving mains water consumption of 105 litres or less per head per day; and achieve at least the BREEAM excellent standard for the 'Wat 01' water category. Smart metering, water saving, and recycling measures should also be incorporated.
- Policy SI 7 (Reducing waste and supporting the circular economy) – Referable applications should promote circular economy outcomes and aim to be net zero-waste.

Whole life carbon refers to the total carbon emissions associated with a building throughout its entire lifecycle, including production, construction, operation, and end-of-life disposal. These emissions are typically categorized into two types: embodied carbon and operational carbon.

The CIBSE TM54 Operational Energy Assessment supports whole life carbon assessments by helping to estimate potential operational energy consumption and its associated carbon emissions..

London Plan Guidance – Whole Life-Cycle Carbon Assessments (2022)

The guidance document explains how to prepare a WLC assessment which should accompany all referable planning applications in line with the London Plan Policy SI 2. The guidance follows BS EN 15978 using the RICS Professional Statement (1*st* Edition) as the methodology for assessment.

The document references the requirement for using the CIBSE TM54 reporting methodology for the operational carbon emissions in non-domestic developments, providing a breakdown for regulated and unregulated energy consumption.

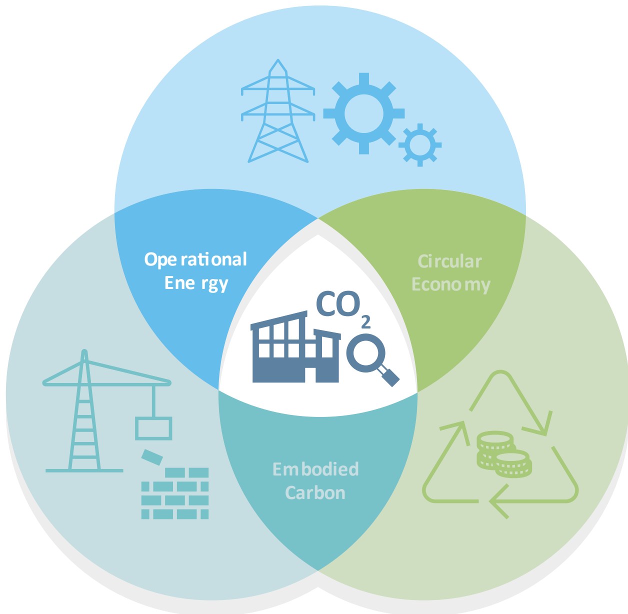


Figure 2.1 – Diagram Showing Whole Life Carbon Components and the Relationship with the CIBSE TM54 Operational Energy Consumption Assessment

3. Reference Technical Guides

CIBSE Guidance

CIBSE Guide A: Environmental Design (2015, updated 2021)

CIBSE Guide A provides a comprehensive guidance on design criteria and calculation methodologies, including fabric performance, HVAC system design and sizing, methods for thermal comfort evaluation and energy demand.

Consideration is given to *Table 1.5 Recommended comfort criteria for specific applications* of the *Environmental criteria for design* section to define the comfort parameters such as optimum summer and winter operative temperatures assisting in setting the cooling and heating setpoints.

Table 3.1– Benchmark Operative Temperature Benchmarks as per Table 1.5 of CIBSE Guide A

Type of use of space	Customary winter operative temperatures	Customary summer operative temperature (in air-conditioned buildings)
Bathroom	20-22	23-25
Bedrooms	17-19	23-25
Hall/ Stairs/ Landings	19-24	21-25
Kitchen	17-19	21-25
Living Rooms	22-23	23-25
Toilets	19-21	21-25

CIBSE (2016) Ventilation and ductwork CIBSE Guide B

CIBSE Guide B (2016) provided information on the design, installation, and performance of ventilation systems, including the prediction of airflow.

The Approved Document Part F (2021) may assist as well in defining the ventilation strategies as well as providing standard numeric data inputs for the dynamic model.

CIBSE Guide D: Transportation systems in buildings (2020e)

Guide D focuses on the design, installation, and maintenance of transportation systems in buildings, such as lifts (elevators), escalators, moving walkways, and other vertical and horizontal transport mechanisms.

The document details calculation methodologies and assumptions for estimating the energy consumption of transportation systems in a variety of building types.

CIBSE Guide F (2012)

The guide provides examples of average power consumption as well as sleep mode for typical equipment, as well as HVAC and ventilation elements design and sizing.

The Approved Document Part L (2021) should be utilised in conjunction with the above mentioned CIBSE Guide to ensure that the proposed systems comply with Building Regulations.

CIBSE Guide G: Public health and plumbing engineering (2014)

Guide G is utilized to estimate the design and daily domestic hot water (DHW) demands based on building typologies. Alternatively, existing usage data from clients or end-users for similar buildings may be employed. Other references, such as average daily DHW consumption outlined in the London Plan (GLA, 2021), may also be consulted.

CIBSE (2020f) Sustainability CIBSE Guide L

CIBSE Guide L assists with defining renewable systems and ensuring standard assumptions are input into the model.

CIBSE TM48 (2009a)

CIBSE TM48 (2009a) provides guidance on the use of climate change scenarios. TRY (Test Reference Year) files are recommended for evaluating energy performance, including future climates, such as 2050s and 2080s projections. DSY weather files are also applied to assess the overheating risks and estimating cooling energy demand during hot periods of time.

CIBSE TM59: Design Methodology for the Assessment of Overheating Risk in Homes (2017)

This CIBSE Technical Memorandum focuses on predicting overheating in buildings and serves as a resource for designers, developers, and other stakeholders responsible for defining indoor environmental conditions.

The document serves as a reference for defining thermal templates for baseline scenarios by utilizing the standard occupancy profiles, lighting gains, and heating gains for residential living spaces.

CIBSE AM11: Building performance modelling (2015a)

CIBSE AM11 (2015a) offers information on how to generate a dynamic simulation model DSMs as well as representing the HVAC systems and their associated controls as well as plant and renewable energy systems.

Other Industry Guidance

SLL Code for Lighting (2022)

The *SLL Code for Lighting* (2022) is an authoritative guidance on best practices for designing, implementing, and maintaining effective, efficient, and sustainable lighting systems. The document outlines examples of different types of internal and external lighting with their associated illuminance, gains, and power consumptions.

BSRIA Rule of Thumb: Useful Information Guide (BG 87/2024)

Rule of Thumb: Useful Information Guide (BG 87/2024) is a practical reference offering quick, essential guidance and standard benchmarks for building services design and operation.

4. Steps 0 – 1 Modelling Approach & Construction

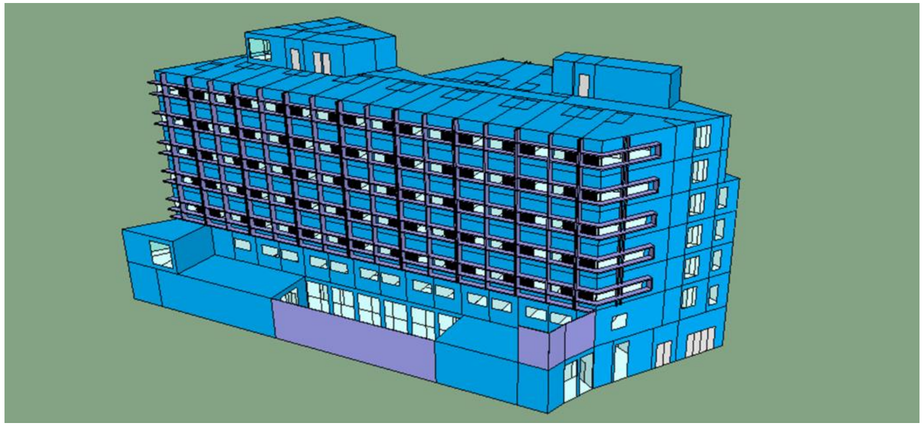


Figure 4.1 – IES VE Indicative Energy Model

Step 0: Choosing the Modelling Approach

The modelling process involves selecting the most appropriate tool and approach to match the required level of complexity and detail for the proposed development. This selection also considers future uses and applications in subsequent project stages, ensuring efficiency and supporting the project's lifespan.

Dynamic Simulation Models (DSMs) provide a better estimate of energy use compared to steady state calculations as they consider more of the complexities of the variation in energy use across time, and interactions between different parts of a building system (i.e. its dynamic nature). DSM tools are designed to simulate the dynamic relationship between the building form, fabric, external weather, occupants, usage patterns and HVAC plant, lighting, and its controls. They require significant input data and experienced and knowledgeable users but provide detailed outputs and insights into building performance.

The software used for the development TM54 assessment is IESVE 2024. This is a DSM tool with a high level of functionality, enabling control over a significant range of modelling variables.

The HVAC modelling detail level uses the Apache Template approach suitable for the early-stage design of the project. The modelling strategy has been limited by the availability of detailed information of the HVAC system specifications at the time of this report.

Step 1: Constructing and Building the Model

Geometry

Generating the model geometry is one of the first steps in undertaking building modelling and forms the basis from which all future calculations are undertaken. Its accuracy and quality determine the future model outputs.

The location was set to Central London within the software, and the development's orientation from true north was established at 25°, based on drawings provided by Sheppard Robson architects.

The model construction was based on the architectural design drawings available at the time. It should be noted that, after the initial modelling of the building geometry, updated drawings with minor amendments to the building layout were issued. These amendments were reviewed and deemed to have no significant impact on the TM54 assessment.

The project geometry contains a high level of detail including any building elements that could potentially impact the solar gains and act as shading devices. Thus, the architectural elements such projected architectural grid, vertical fins and fences were included in the model as local shading. *Figure 4.1* depicts the geometry of the indicative energy model, with shading elements shown in purple.

Table 4.1 –Architectural Drawings Considered for Building Geometries

Drawing	Revision	Date
6910-SRA-ZZ-00-DR-A-20210	P10	27/11/2024
6910-SRA-ZZ-00-DR-A-20211	P07	27/11/2024
6910-SRA-ZZ-00-DR-A-20212	P09	27/11/2024
6910-SRA-ZZ-00-DR-A-20213	P07	27/11/2024
6910-SRA-ZZ-00-DR-A-20214	P08	27/11/2024
6910-SRA-ZZ-00-DR-A-20215	P06	27/11/2024
6910-SRA-ZZ-00-DR-A-20216	P06	27/11/2024
6910-SRA-ZZ-00-DR-A-20217	P10	27/11/2024
6910-SRA-ZZ-ZZ-DR-A-20401	P05	29/11/2024
6910-SRA-ZZ-ZZ-DR-A-20402	P04	29/11/2024
6910-SRA-ZZ-ZZ-DR-A-20403	P03	29/11/2024

Building Fabric

The building fabric is set in line with the energy strategy established in the Energy Statement Report (Document reference: 23-E049-009-V00-01 Britannia Street - Energy Statement).

The following table summarises the thermal properties (U-values and air permeability) of the building elements applied in the model. The windows are modelled as double-glazed with a G-Value of 0.4 and a frame factor of circa 0.8. The reduced G-Value of 0.4 ensures minimising the solar gain levels through the windows.

The air permeability of 3 $m^3/(h \cdot m^2)$ @50Pa is input as infiltration rate in the air exchange section of the IES VE thermal template for all modelled spaces (AP = ~ 0.15ACH @50Pa).

Table 4.2 - Proposed Building Fabric U-Values and Air Permeability

Fabric Element	Part L2 (W/m^2K)	Proposed (W/m^2K)
External Wall	0.26	0.15
Floor	0.18	0.10
Roof	0.18	0.10
Windows	1.60 (including frame)	1.40
Doors	1.60	1.40
Air Permeability	8 $m^3/(h \cdot m^2)$ @50Pa	3 $m^3/(h \cdot m^2)$ @50Pa

Zoning and Establishing Floor Areas

Zoning has been based on several factors, including the function of each room, construction type, and activity patterns. It also takes into account the HVAC systems to ensure accurate energy modelling.

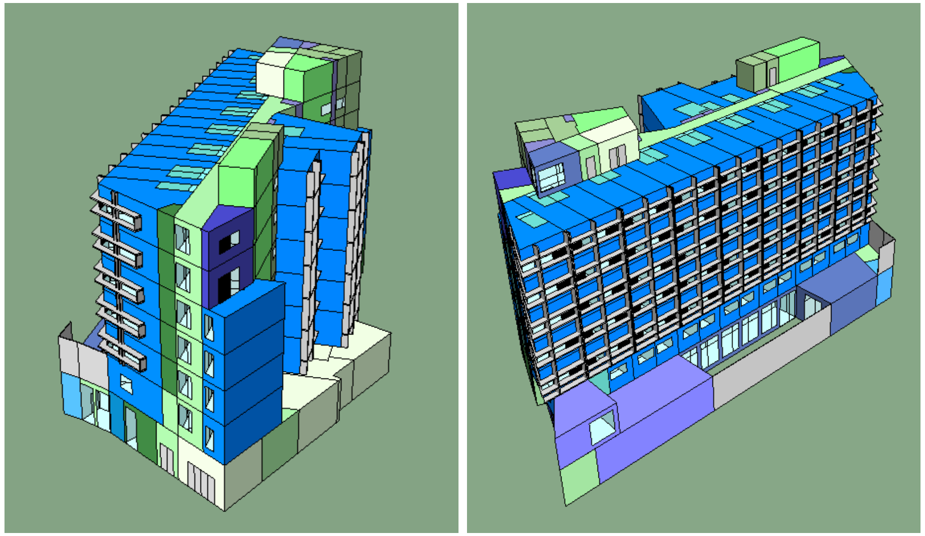
The zoning and grouping scheme have been established based on the thermal template categories associated with various activity uses, as illustrated in *Figure 4.2*. Reporting the gross internal area, as detailed in *Table 4.3* assists with potential energy consumption calculations performed outside the model.

The modelled floor areas align with the scaled architectural drawings provided and considers the Gross Internal Area (GIA); the total building area measured inside external walls. However, when creating energy models in IESVE, internal walls are typically represented as two-dimensional planes. This approach affects the reported floor area by excluding the thickness of internal walls. As a result, the modelled area is approximately 4,773 m^2.

Table 4.3 - Table of Floor Areas for Building Uses

Space Type (Theraml Template Category)	GIA (m2)
Circulation	765
Communal Areas	210
Ensuites	410
Kitchenette	5
Laundry	6
Lifts	133
Office	38
Plant	196
Reception	112
Risers	166
Staff Shower Room	9
Stairs	281
Storage	150
Studios	2,241
Study Space	39
WC	12

The thermal templates were defined based on activity type, in accordance with the CIBSE TM59 methodology for living spaces within the residential areas, and by applying the NCM Activity Database for the associated amenity spaces.



Studios	Riser (No Heat Gains)	Amenity Space	Light Plant
Ensuite	Riser (With Heat Gains)	Office/ Study Area	WC
Kitchenette	Reception	Laundry	Stairs
Living	Corridors	Store	Lifts
Shading Device Elements			

Figure 4.2 – Image Showing the Thermal Templates Defined within the Model as per Specific Activity Uses

Weather Data

Weather files include information on external air temperature, relative humidity, solar radiation, wind speed and direction and cloud cover. In the UK, the CIBSE offers a wide range of weather resources for 14 locations, which include:

- Design Summer Years (DSY1, DSY2, DSY3) that represent different types of hot summer weather and are intended for overheating risk assessments.
- Future weather based on UKCP09 with projections based on several emission scenarios for 2020 (current) and 2050.

The HVAC design and cooling strategies have been proposed in line with the results of a simulation-based overheating analysis carried out by Ensphere (Document reference: 23-E049-012 Britannia Street Thermal Comfort Analysis). As the overheating risk assessment plays a significant role in the design proposal application.

Therefore, the model uses the CIBSE weather files for London Weather Centre assuming more intense summers specific to the central urban London. The weather files used in the model consider several summer-scenarios:

- London_LWC_DSY1_2020 – a year with a moderately warm summer
- London_LWC_DSY2_2020 – a year with a very intense single warm spell
- London_LWC_DSY3_2020 – a year with a prolonged period of sustained warmth

The weather files DSY2 and DSY3 are tested for the purposes of assessing more extreme scenarios under Step 13: Sensitivity Analysis section of this report.

Different weather file scenarios have an impact indirectly on the heating and cooling demands of the buildings based on the solar gains levels variations. The solar gains are calculated within the software through the SunCast tool which considers a full solar shading analysis.

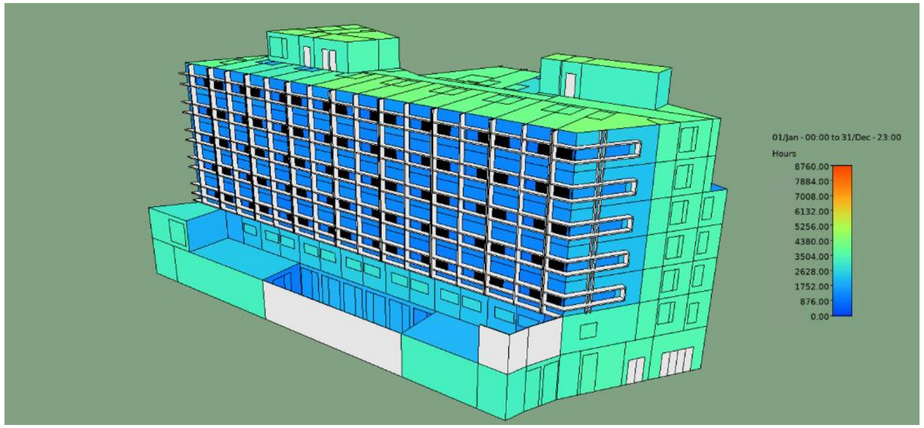


Figure 4.3 - SunCast Solar Shading Calculations

5. Step 2: Operating Hours & Occupancy

The operating hours for the Baseline simulation have been designed based on a combination of NCM predefined profiles as well as CIBSE TM59, CIBSE Part A, and BRE estimates.

The occupancy profiles and the equipment load for the typical scenario of the proposed development have been established as follows:

- Student Rooms: The occupancy profiles and equipment load for the student studios have been based on "*Table 2 Occupancy and equipment gain description*" of CIBSE: TM59 Design methodology for the assessment of overheating risk of homes (CIBSE, 2017). However, it should be noted that, while TM59 typically assumes a two-person occupancy for studio apartments, single occupancy was considered more realistic for the proposed development given the nature of PBSA. Nevertheless, the occupancy schedule and equipment load followed TM59 profiles.

- Other Non-Residential Spaces: For other areas, such as communal spaces, management areas, and all other non-residential spaces, the occupancy profiles and equipment loads have been established in line with the National Calculation Methodology (NCM) Modelling Guide for Buildings Other than Dwellings (2021). This provides standardised assumptions for occupancy and equipment load, tailored to each space type and reflective of typical usage patterns.

Where occupancy is intermittent, diversity factors are applied to approximate the average. Occupants' location within a building vary throughout the day and this distribution is valuable information when evaluating energy demand. Diversity factor is a number between zero and one that is used to multiply the peak value which is the actual peak occupancy at a given time.

The full details of the occupancy profiles and operating hours for all spaces input in the IES VE simulation are displayed in Appendices. Table Appendix B.1 summarises a series of parameters for the maximum sensible gain (W/P) and Maximum latent gain (W/P), as well as the occupancy schedules. Occupancy Density can be found in Table Appendix B.4.

6. Steps 3-9: Internal Gains and Associated Energy Use

Steps 3 to 9 of the CIBSE TM54 methodology involve evaluating the internal gains and associated energy use within the building, including both regulated energy components (such as lighting demands, plant equipment, and systems related to heating, cooling, and distribution) and unregulated energy elements (such as small power, catering, lifts/escalators, and IT equipment).

The gains associated with the occupancy levels, equipment, and interior lighting are calculated automatically within the IES VE software based on the internal gain inputs set in each thermal template. These are detailed in Appendix Table B.1.

Step 3: Evaluating Lighting Energy Use

Interior Lighting

The interior lighting design is intended to be highly efficient and in excess of Building Standards requirements. It is intended that lighting efficacy shall be in excess of 110 lumens/circuit Watt, as outlined in the Energy Statement ensuring compliance with Approved Document L: Conservation of Fuel and Power Volume 2.

The energy consumption for interior lighting within the residential spaces is assumed to be proportional to floor area, with lighting loads measured in W/m², set from 6 pm to 11 pm. The standard power consumption input is 2 W/m², as specified in the CIBSE TM59 internal gains profiles default for an efficient new-build residential development.

For the associated amenities, the NCM preset power consumptions have been applied as well as the associated operational schedules (please refer to Appendix Table B.1).

External Lighting

The exterior lighting incorporated into this model is presumed to operate from 19:00 to 07:00. The external light is set in line with the recommended illuminance for each entrance providing 50 lux as per the guideline set in the "*Lighting Guide 9:Lighting for communal residential buildings*" (SLL, 2013, p. 20) and in "*Table 3.5 General circulation areas*" from the SLL Code for Lighting (CIBSE, 2012).

The model assumes two LED lamps per large entrance door and one per small entrance door as well as lamps in the courtyard, totalling 16 external LED lamps for the development. The total power consumption for the external lighting is 0.38 kW

Step 4: Evaluating Energy Use for Lifts and Escalators

Estimates of energy consumption of lifts and escalators are based on the following key reference documents:

- BS EN ISO 25745-1:2012: Energy performance of lifts, escalators and moving walks. Energy measurement and verification
- BS EN ISO 25745-2:2015: Energy performance of lifts, escalators and moving walks. Energy calculation and classification for lifts (elevators)
- BS EN ISO 25745-3:2015: Energy performance of lifts, escalators and moving walks. Energy calculation and classification of escalators and moving walks.

These standards (as ISO 25745 Parts 1, 2 and 3) are applied worldwide and are used to determine BREEAM credits as well.

Table 6.1 – Categorised Number of Trips per Day (nd

	Usage Category				
	1	2	3	4	5
Usage intensity	Very Low	Low	Medium	High	Very High
No. trips per day (nd)	50	125	300	750	1,500
Typical range	<75	75<200	200<500	500<1,000	1,000<2,000

The running energy consumption (E_{rc}) is the energy consumed to perform the ISO reference cycle. The running energy is measured (using the procedure given in ISO 25745-1) for an empty car travelling the distance between the terminal landings.

The running energy measurement is made between terminal landings. The distance actually travelled for an average trip (s_{av}) is less than the distance between the terminal landings. To correct for this the average distance (s_{av}) can be expressed as a ratio (k_{av}) of the terminal travel distance (s_{rc}).

Table 6.2 – Average Travel Distance Ratio (kav)

Number of Stops	Percentage Average Travel Distance for Stated Usage Category		
	1-3	4	5
2	-	1.00	-
3	-	0.67	-
>3	0.49	0.44	0.39

Table 6.3 – Average Car Load Factor (kL)

Rated Load (kg)	Car Load Factor for Stated Usage Category					
	1-3		**4**		**5**	
	Electric	**Hydraulic**	**Electric**	**Hydraulic**	**Electric**	**Hydraulic**
≤ 800	0.88	1.05	0.85	1.06	0.79	1.09
801 to ≤1,275	0.93	1.03	0.90	1.04	0.87	1.06
1,276 to ≤2,000	0.95	1.02	0.94	1.02	0.92	1.04
>2,000	0.97	1.01	0.96	1.02	0.95	1.02

ISO 25745-2 provides the energy performance classification for a single lift without the influence of traffic control. The estimated daily energy consumption (E_d) of a lift is the sum of the running consumption (E_{rd}) and the standing (idle/standby) consumption (E_{sd}):

$$E_d = E_{rd} + E_{sd}$$

The daily running consumption (E_{rd}) is dependent on the energy used for an average trip that the lift makes multiplied by the number of trips in a day (n_d). The daily running consumption (E_{rd}) in watt-hours (W·h) is given by:

$$E_{rd} = \frac{n_d \times E_{rc} \times k_{av} \times k_L}{2}$$

where n_d is the number of trips in a day, E_{rc} is the measured or estimated running energy consumption of the ISO reference cycle (two trips) (W·h), k_{av} is the average travel distance ratio and k_L is a load factor.

The number of trips per day (n_d) for a specific installation can, according to usage, be taken from Table 6.2. Usage categories are given in Table 6.3.

For the proposed development, lift usage is expected to peak during weekday mornings from 07:00 to 09:00 and evenings from 17:00 to 19:00, with extended usage over weekends and holidays. The maximum power consumption for the lifts is assumed to be 9 kW.

Escalators and Moving Walks

Where ecsalators and moving walks are preset calculations for energy use should follow the methodology outlined in ISO 25745-3 which provides the energy performance classification for a single escalator or moving walk where the powers (kW) during standby, in auto-start mode, in slow speed mode and in no load as well as the inclanation angle are considered.

Alternatively, if available, product specifications form the manufaturer may be referenced and implemented into the dynamic model.

There are no escalators or moving walks proposed for the development.

Step 5: Evaluating Energy Use for Small Power

The TM54 methodology aims to address the performance gap between estimated and actual energy consumption. Unregulated energy accounts for a significant portion of a building's overall energy use. Estimating small power (plug loads) can be challenging, as their impact arises not only from the power they consume but also from the fact that much of this power is converted into heat gains within the space, influencing heating and cooling loads.

This step in the methodology focuses on quantifying the additional small power gains associated with unregulated equipment and identifying the operational profiles most likely to be used.

Data for typical equipment/appliance loads have primarily been derived from predefined NCM profiles specific to each space activity type, while the equipment load for the studios has been based on the "*Table 2: Occupancy and Equipment Gain Descriptions*" from CIBSE TM59.

Step 6: Evaluating Energy Use for Catering

Cooking and catering facilities should be included in building energy calculations.

For homes in the UK, energy use can be estimated using PHPP assumptions of 0.20–0.25 kWh/meal depending on the source of fuel gas/ elctric. Another source that may be used for domestic developments is SAP10 - Appendix L, which provides equations for internal heat gains and energy use based on occupants and meals.

Non-domestic buildings without catering facilities can omit this step, but for those with catering, energy use can be estimated using benchamrks form *CIBSE TM50: Energy efficiency in commercial kitchens (2021)* or data from previously occupied buildings, adjusted for changes.

Scenario testing is recommended when future catering arrangements are uncertain, as catering equipment can significantly impact energy consumption.

For the PBSA development at Britannia Street, no catering facilities have been considered in line with the proposed deisgn, hence in line with CIBSE TM54 methodology this step has been omitted.

Step 7: Evaluating Energy Use for Server Rooms

Server rooms are specialized spaces designed to house computer servers, networking equipment, and data storage systems that manage and process digital information. They are normally included in non-domestic developments such as offices buildings, data centres, commericial units, and certain educational institutions.

Server rooms require continuous dedicated cooling systems separate from those serving occupied areas. to maintain operational temperatures and prevent overheating from constant IT equipment use. Cooling systems vary in efficiency, with chilled water systems typically requiring 70% of the peak server load and direct expansion systems needing 100%. While chilled water systems are generally more efficient, direct expansion systems can optimize building-level efficiency by operating independently of central plant schedules. Cooling needs can be modeled to reflect internal gains and heat exchange, or calculated externally using rules-of-thumb. If local cooling is absent, 24/7 internal heat gains from servers should be included in the dynamic simulation model (DSM) to account for their impact on building heating and cooling demands.

In line with CIBSE TM54 methodology, this step has been omitted as there are no server rooms or IT hubs proposed for the development.

Step 8: Evaluating Energy Use for Additional Plant and Equipment

As part of this section, additional energy consumption related to specific space activity types may be included when applicable, such as energy use from specialized plant and equipment, gym machinery, security systems, or chilled cabinets.

The data for plant room energy consumption has been derived from the NCM's pre-defined equipment use assumptions, which are specifically tailored to student accommodation plant rooms.

Step 9: Evaluating Energy use of Domestic Hot Water

Evaluating the energy used to provide domestic hot water (DHW) has several steps:

- Estimating how much water will be used and considering the daily profile for how the DHW will be used.
- Accounting for heat losses due to distribution through pipework and standing losses from storage cylinders.
- Modelling how the DHW will be generated and how the generation equipment will be controlled to meet the demand profile.

For this development, DHW consumption for the student rooms has been defined in accordance with the London Plan Policy SI 5 (Water Infrastructure), which includes a target of 105 litres or less of mains water consumption per person per day.

7. Step 10: Adding Internal Heat Gains to the Model

The internal heat gains from all equipment and processes in the building are included in the model when calculating energy use associated with heating, cooling, distribution systems, light, occupants, and appliances. Many of these gains are automatically calculated in the model based on the inputs from Steps 3-9 and Step 11.

The internal heat gain associated with energy uses calculated outside the model are added to the model. The internal heat gains have the potential to significantly impact the energy load on a heating or cooling system. The internal gain from occupants from have been included in the analysis to recreate a realistic scenario based on values provided by CIBSE guide A: Environmental Design and KS17 document. These values (maximum sensible gain and maximum latent gain) vary based on the expected activity within the space. The occupancy gains input in the model are shown in the Appendix Table B.1.

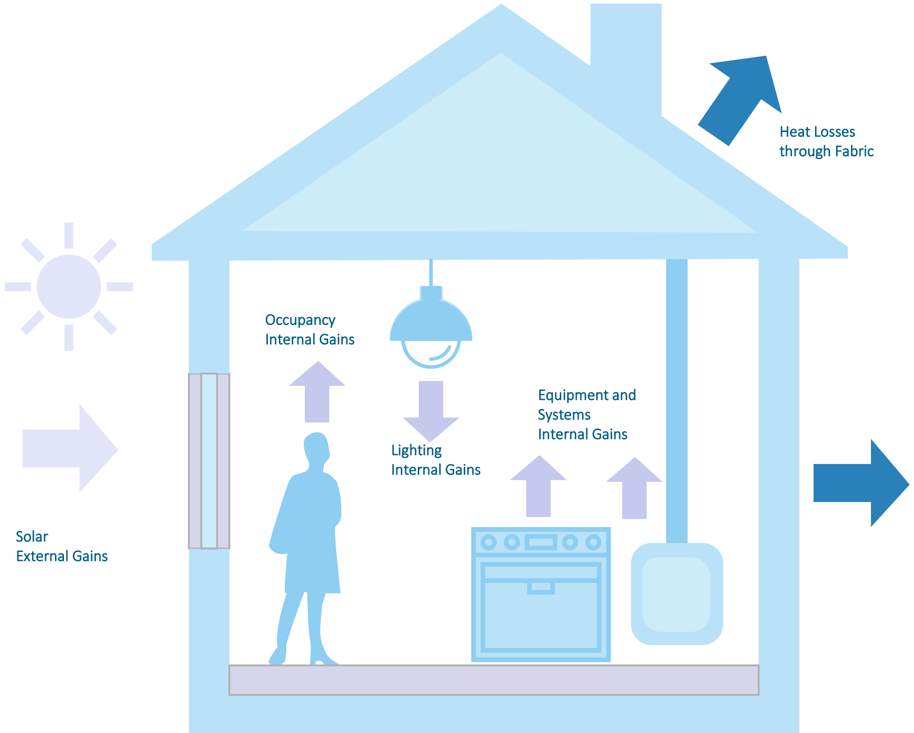


Figure 7.1– Internal Heat Gains vs Losses

8. Step 11: HVAC Systems & Control

The HVAC system strategies are defined in line with the proposed Energy Statement (reference document: 23-E049-009-V00-01 Britannia Street - Energy Statement) and taking in consideration the overheating strategy outlined in the Thermal Comfort report (reference document: 23-E049-012 Britannia Street Thermal Comfort Analysis_v2).

The energy use for HVAC systems and associated controls are calculated within the software based on the system typology defined within the NCM wizard tool within Apache. It takes into account the HVAC system design, individual equipment efficiencies and control strategy.

Defining Space Heating, Cooling Strategies

It is proposed to incorporate low-carbon and renewable technologies as the foundation of the heating strategy, in line with recommendations from the Energy Statement for the development. An air source heat pump (ASHP) system will be used for both space heating and hot water. The system is expected to achieve a Coefficient of Performance (COP) of 3.8 for space heating and a COP of 3.2 for water heating, ensuring efficiency while reducing carbon emissions.

Cooling systems have been implemented where necessary, in line with the findings from the Thermal Comfort Assessment. The cooling strategy is designed to meet the required conditions with a Seasonal Energy Efficiency Ratio (SEER) of 5.

Ventilation Strategy

Given that there are some acoustic considerations, it is anticipated that mechanical ventilation heat recovery will be included in the development to help maintain thermal comfort levels and air quality, particularly during cooler months when it is less desirable to open windows.

Appropriate ventilation rates for each of the space types throughout the proposed development have been determined in accordance with the Approved Document Part F (HM Gov, 2021), ensuring compliance with building regulations. Details of the applied flow rates can be found in the Appendix Table B.1.

Controls

The controls strategy is based on room temperature set points, which are directly linked to the occupancy and operational patterns of the building. Several important factors have been considered, including thermostat profiles (heating/cooling setpoints and setbacks), the implementation of variable temperature settings, hours of operation, and zoning.

The heating system and cooling strategies temperature setpoints have been set as per the recommended values from Table 1.5 CIBSE Guide A (CIBSE, 2017). For example, the heating system is set to activate when the room temperature drops below 21°C, but only when the space is occupied during the winter months. Similarly, mechanical ventilation and comfort cooling systems follow similar patterns, with their operation controlled to maintain the desired optimum room temperature via the thermostat.

Outside of the operational hours of the non-domestic areas, the heating system is set to turn back on if the temperature drops as low as 12°C, ensuring the space is maintained within acceptable temperature limits even when unoccupied.

On-Site Renewables

In line with the Part L compliance requirements outlined in the Energy Statement, approximately 80 m² of photovoltaic (PV) panels have been integrated into the development. This system is projected to deliver an output of around 13 kWp.

The on-site electrical generation is included in the model to emphasise the benefits of the PV panels implementation and its contribution to reducing energy demands and carbon emissions.

When presenting the outputs from IES VE, the “Total Electricity” output refers to the energy demand without accounting for the electricity displaced by the PV panels. Whereas “Total Energy” consumption refers to the total energy consumption accounting for the PV-generated electricity contribution.

9. Step 12: Management Considerations

Taking Management Considerations into Account

It is assumed that the building will be managed and well maintained at all times. This will include control calibration, implementation of energy saving features in lighting and equipment and energy will be monitored using smart meters and submeters.

TM54 methodology targets different possible scenarios where the reality of the situation would not be well managed or well controlled. The results section of the report presents possible results with management factors of 1, 1.05 and 1.1 simulated within varying weather scenario intensities. This exercise will explore likely ranges of operational energy usage and guide future decisions on how to lower energy consumption

10. Steps 13-15: Results analysis

Step 13: Sensitivity Analysis

Conducting basic sensitivity tests involves making adjustments to the baseline model one input at a time. This approach offers insights into the relative impact of each change on the overall outcome, helping identify influential parameters and informing scenario testing. The results will be presented and compared with the most plausible scenario identified in through Steps 0 to 12

The range of factors considered in one-parameter-at-a-time tests series may vary depending on the specific building typologies. The factors presented in the diagram below are generally of significant importance. Based on the project's applicability, requirements, and baseline scenario outputs, the most appropriate parameters may be selected for the sensitivity analyses.

Figure 10.1 – Figure Showing Sensitivity Analysis Parameters

Baseline Energy Consumption

Steps 0 to 12 detailed the baseline scenario, which represents the most likely energy usage pattern. Initial energy modelling indicates the annual energy consumption to be approximately 665 MWh. The breakdown of this energy use across various categories is illustrated in Figure 9.1 below.

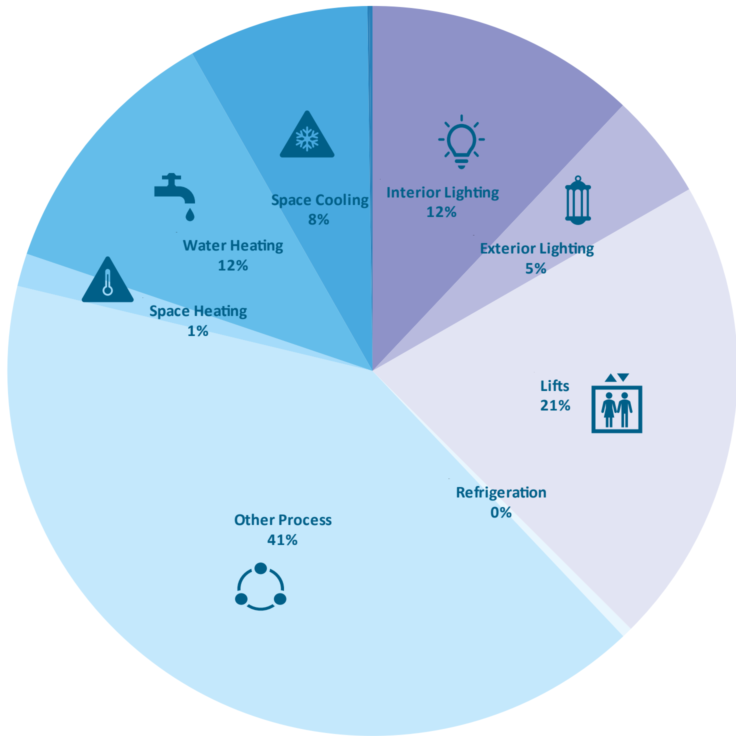


Figure 10.2 – Baseline Energy Use Breakdown

The most significant energy consumption is attributed to 'other processes,' which encompasses unregulated energy uses such as appliances and small power loads. Additional notable contributors include lifts, interior lighting, and domestic hot water heating.

It is important to note that Figure 10.2 does not account for energy generated by the onsite PV system. For the baseline scenario, PV production is estimated at approximately 17 MWh annually, reducing the projected electricity consumption from the national grid to 648 MWh.

Parameters Assessed in Sensitivity Analysis

The following parameters were varied relative to the baseline to assess their impact:

- Test Series 1: Weather Data
- Test Series 2: Heating Setpoint
- Test Series 3: Occupancy Density
- Test Series 4: Occupancy Schedule

Test 1: Weather Data

Typical weather conditions are expected to include moderately warm summers. However, the risk of heatwaves or extended periods of sustained warmth poses a potential risk for the proposed development. Therefore, it is important to understand how the building will perform under these conditions.

The potential impact of different weather conditions has been tested applying different weather files suitable for the project's location:

- London_LWC_DSY1_2020 – a year with a moderately warm summer.
- London_LWC_DSY2_2020 – a year with a very intense single warm spell.
- London_LWC_DSY3_2020 – a year with prolonged sustained warmth.

Initial simulations were carried out using the DSY1 dataset, reflecting the most likely summer scenario. Additional tests with the DSY2 and DSY3 datasets were conducted to assess the building's response to more extreme weather conditions.

The variations in energy consumption compared to the baseline are illustrated in Figure 10.3.

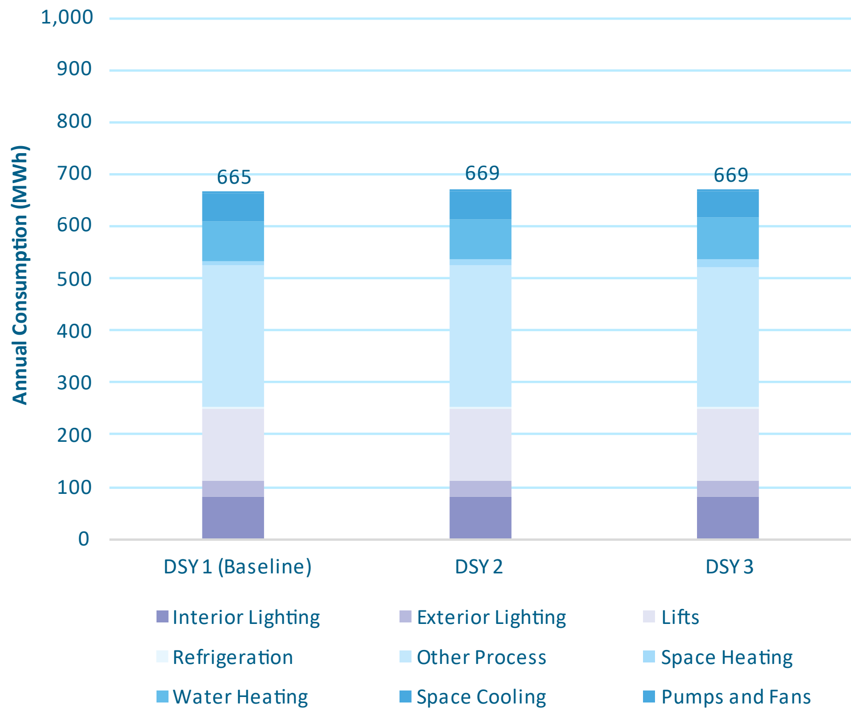


Figure 10.3 – Sensitivity Test 1 (Weather Data)

Test 2: Heating Setpoint

Another factor that has the potential to impact the operational energy performance of the building is an appropriate management of the systems and controls. For this case, heating followed profiles set out in TM59 guidance for studios and NCM guidance for other spaces, with all spaces assumed to have a heating setpoint of 21 degrees in the baseline scenario associated with typical use.

While improvements in the energy performance of the building can be made through adjusting the heating setpoint, and it is beneficial to understand the scale of the impact, it is important to also consider the comfort of the building. As, if proposed setpoints do not provide a comfortable environment, measures may not be adhered to in practice. Thermal comfort has been assessed in detail in overheating analysis carried out by Ensphere (Document reference: 23-E049-012 Britannia Street Thermal Comfort Analysis).

The following heating setpoints have been tested to assess the extent of the impact on the building energy performance:

- Heating setpoint: 20 °C
- Heating setpoint: 21 °C (Baseline)
- Heating setpoint: 22 °C

The results of the second sensitivity test are displayed below in *Figure 10.4*, illustrating the impact of varying heating setpoints on the building's energy performance.

The results indicate that the impact of varying the heating setpoint on annual energy consumption is relatively minor, with only a slight increase observed as the setpoint rises. This suggests that small adjustments to the heating setpoint have a limited effect on the overall energy performance of the building.

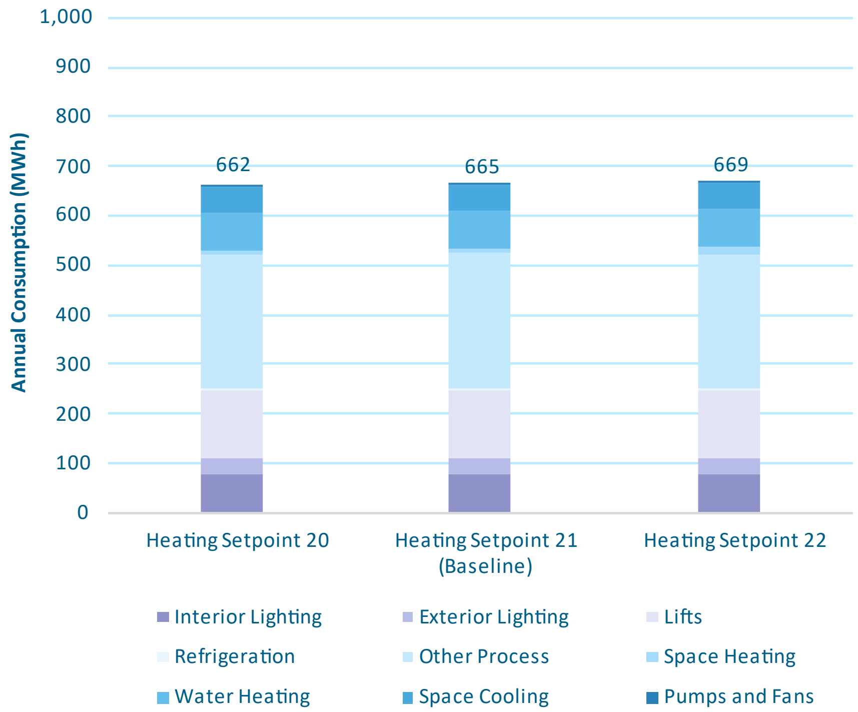


Figure 10.4 - Sensitivity Test 2 (Heating Setpoint)

Test 3: Occupancy Density

The third sensitivity test examined the impact of varying occupancy density on the building's energy performance. Occupancy density can influence energy consumption through its effects on a variety of factors including heating, cooling, and small power usage.

The baseline occupancy for studios was set at one person per studio. Since this could not be reduced further, the low-density scenario also assumed single occupancy. In the high-density scenario, studios were increased to dual occupancy.

For other spaces, the baseline occupancy density was derived from the predefined NCM profiles, expressed in m^2/person. In these spaces, the low-density scenario involved a 50% reduction in occupancy, while the high-density scenario reflected a 50% increase. Further details can be found in Appendix Table B.4.

The results of the occupancy density sensitivity test are presented in Figure 10.5 below.

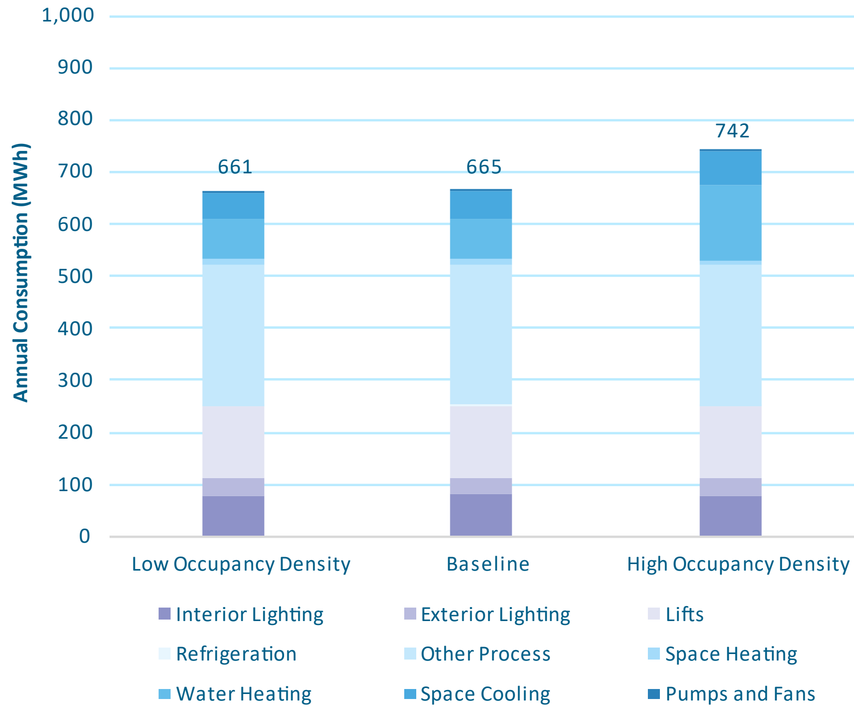


Figure 10.5 - Sensitivity Test 3 (Occupancy Density)

These results demonstrate that changes in occupancy density may have a more significant impact on annual energy consumption compared to the previous factors for the proposed development.

Test 4: Occupancy Schedule

The final sensitivity test focused on varying the operational schedule to evaluate its impact on the building's energy consumption. Occupancy schedules directly influence energy usage by affecting the operational periods of heating, cooling, lighting, and small power systems.

For this test, the baseline occupancy schedule for studios was based on TM59 profile, while other space types followed the schedules outlined in the NCM, specific to their use. Due to these variations, a blanket approach could not be applied to adjust the schedules uniformly. Instead, adjustments were tailored to each space type. Detailed information on the specific schedule variations can be found in the appendices.

The results of the occupancy schedule sensitivity test are illustrated in Figure 10.6 below.

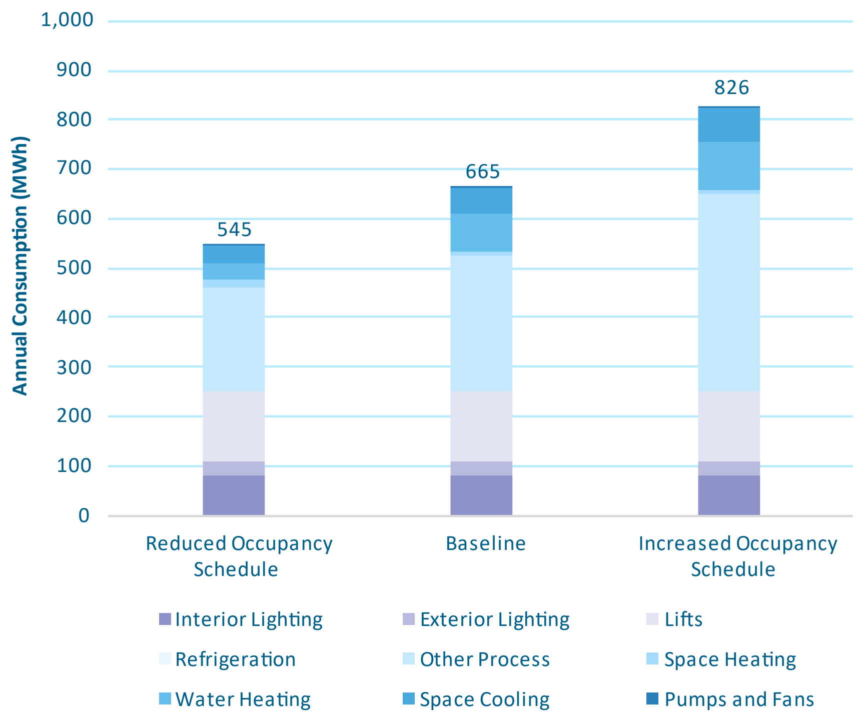


Figure 10.6 - Sensitivity Test 4 (Occupancy Schedule)

The results indicate that varying the occupancy schedule may have the most significant impact on the building's energy consumption among all the factors tested. This highlights the importance of accurately predicting and managing occupancy patterns to optimise energy performance.

Step 14: Scenario Testing

Following the sensitivity tests conducted in Step 13, which highlighted the significant impact of occupancy schedule and density on the building's energy consumption, further testing has been carried out to explore a range of potential operational scenarios. In line with the CIBSE TM54 guidance, scenario testing aims to quantify the uncertainties in the building's performance by considering a variety of realistic low, medium, and high energy performance scenarios. This process plays a role in understanding the potential variations in energy use, allowing for better-informed decisions regarding energy targets and building operation strategies.

Parameters Assessed in Scenario Analysis

For the purposes of this assessment, three distinct scenarios were developed by combining variations in occupancy density and operational hours, as these factors are considered to be the most significant drivers for the development:

- "LOW" Scenario – This scenario reflects good occupant behaviour and well-managed operational energy practices. It assumes lower occupancy levels and efficient use of plant and equipment, resulting in minimal energy consumption.
- "MEDIUM" Scenario – The medium scenario represents a more plausible real-world scenario, where occupant behaviour and energy management practices are typical, reflecting standard occupancy and operational hours.
- "HIGH" Scenario – The high scenario assumes irresponsible occupant behaviour and poor operational energy management. This includes extended operational hours and higher occupancy densities, contributing to a significant increase in energy consumption.

All scenarios were modelled using the London_LWC_DSY1 weather file and a heating setpoint of 21°C, which were held constant across all tests and were not varied. This allows for a focus on the impact of occupancy and operational as more significant factors.

Results

Figure 10.7 illustrates the energy consumption results for each scenario, highlighting variations in energy use under different management and occupancy conditions. The results show that energy consumption in the "LOW" scenario is notably lower than the baseline, while the "HIGH" scenario reflects a substantial increase, with operational energy consumption rising by more than 70%.

It should be noted that these results do not yet account for the benefits of the PV system and focus solely on the building's electricity consumption. The purpose of this approach is to isolate the impact of internal operations and occupancy behaviours on energy use. While including PV generation would offset a portion of the electricity demand, its exclusion at this stage provides a clearer understanding of the building's baseline energy performance and highlights the role of occupant behaviour and energy management practices. The impact of the PV system will be considered in the final results analysis to present a more comprehensive assessment.

A key finding from the analysis is the disproportionate impact of internal equipment loads, which contribute significantly to the variations in energy use. For example, energy consumption from equipment alone rises from approximately 208 MWh in the "LOW" scenario to 399 MWh in the "HIGH" scenario—an increase of over 90%. This highlights the importance of managing equipment usage and occupant behaviour to minimise energy demand.

The results of the scenario testing are shown in Figure 10.7 below.

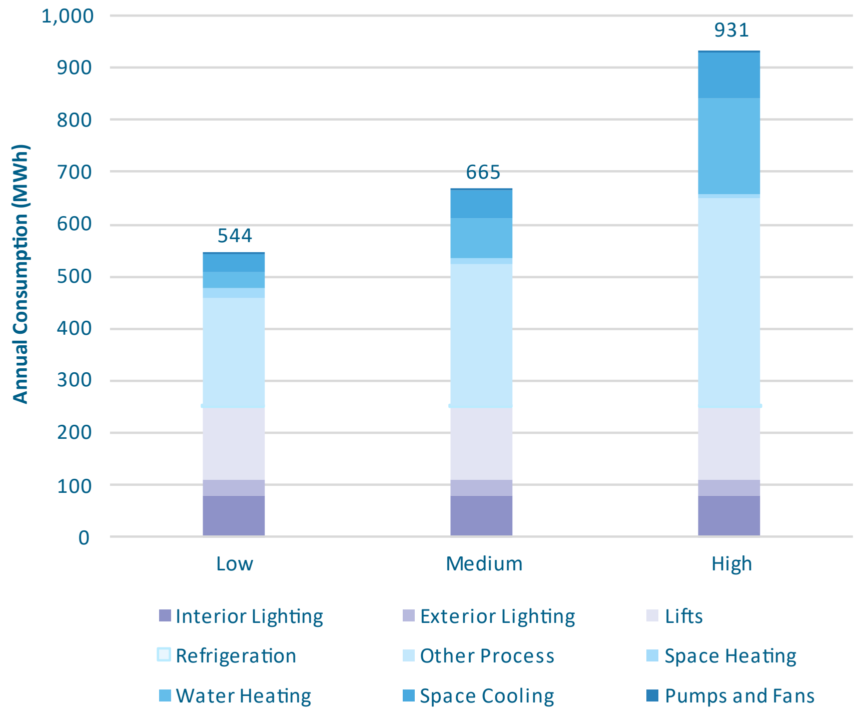


Figure 10.7 – Scenario Testing

The scenario testing, as outlined, underscores the importance of occupant behaviour and operational energy management in determining the building's energy consumption. It also serves to illustrate the range of performance that may be expected under different management practices and occupancy conditions, providing valuable insight for future energy use predictions and target setting, and the development of effective operational strategies that minimise energy consumption across the building's lifecycle.

Step 15: Review Against Targets & Benchmarks

The proposed design for the development does not have a specific set target to achieve apart from the standard Part L compliance assessment and related local planning policy targets. Compliance with these targets have been assessed separately in the Energy Statement.

Therefore, to evaluate the indicative performance, the simulation results were compared against published benchmarks from recognised industry sources, including CIBSE TM46: Energy Benchmarks (2008), CIBSE Guide F: Energy Efficiency in Buildings (2021), and guidance from RIBA.

Adjusting Outputs for Accurate Comparisons

It is important to note that published benchmarks exclude certain energy uses, such as external lighting and lifts, which are accounted for in the IES TM54 simulations. To enable a direct and accurate comparison, adjustments have been made to the simulation results to exclude these additional loads where necessary. This adjustment process helps to align the outputs of the simulation with the scope of the benchmarks and provides a clearer indication of how the building is expected to perform in comparison.

The comparison process also considers the variations between different scenarios: low, medium, and high energy consumption cases as assessed in Step 14. These scenarios reflect the sensitivity of the model to key building management factors such as occupancy levels and usage schedules. By doing so, the analysis captures the potential range of annual energy consumption for the building and highlights the importance of a properly managed building.

The table summarises the unadjusted and adjusted indicative annual energy consumption for the building in kWh/m^2 for the three scenarios.

Table 10.1 – Adjusted Energy Consumption for Comparison to Benchmarks

	"LOW" Scenario	"MEDIUM" Scenario	"HIGH" Scenario
Annual Energy Consumption from IES Simulations (kWh/m^2)	110	136	191
Adjusted for comparison to benchmarks (kWh/m^2)	75	100	156

The following Figure 10.8 illustrates the adjusted energy consumption results for the low, medium, and high scenarios, alongside the corresponding industry benchmarks. The graph highlights how the proposed design performs under different operational conditions compared to established energy performance standards.

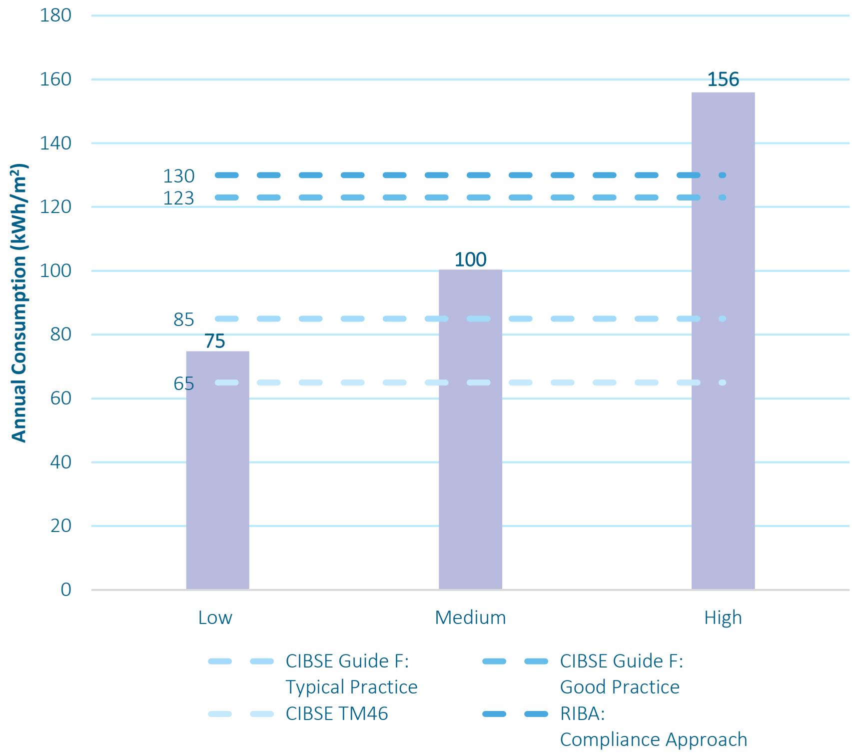


Figure 10.8 – Comparison to Industry Benchmarks

Reviewing the Results

Both the "LOW" and "MEDIUM" scenarios demonstrate a significant improvement over the CIBSE Guide F: Typical Practice and the RIBA: Compliance Approach benchmarks, with energy use well below these established thresholds. This indicates that the proposed design has strong potential to outperform typical industry practices, particularly in terms of energy efficiency, even under standard operational conditions.

The "LOW" scenario, in particular, showcases very good energy performance, exceeding the CIBSE Guide F: ‘good practice’ benchmark, reflecting the building's capacity to operate efficiently through effective occupant behaviour and energy management.

While the "HIGH" scenario shows a substantial increase in energy use, it is important to note that this is an outlier included to highlight more extreme cases. It is primarily intended to demonstrate the impact of poor energy management and inefficient occupant behaviour. Although the figures appear high in comparison, the inclusion of this scenario serves to emphasise the importance of a properly managed building. As proposed for this development, effective operational strategies and occupant engagement will help ensure that energy use remains closer to the "LOW" and "MEDIUM" scenarios, thus optimising the building’s overall energy performance.

Overall, the comparison indicates that, with effective management and adherence to energy-efficient practices, the development has the potential to align with or surpass industry benchmarks, thereby contributing to a measurable reduction in its environmental impact.

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11. Step 16: Quality Assurance

A review of the model, report, and associated design is essential for whichever level of modelling detail is adopted. The QA (Quality Assurance) involves the model itself and its consistency with the project information (design proposals, control strategy, project brief, etc) and modelling report. The QA considers both the quality of the model and that of the information provided to those who will utilise the report and modellers who may be responsible for the model in the future.

The energy model underwent regular checks to ensure that the simulations maintained an appropriate level of oversight and quality assurance (QA), thereby minimizing errors and misinterpretation of data.

Partial QA reviews were conducted at specific milestones, such as the conclusion of Step 1, to verify that the building geometry and envelope were accurately configured. These reviews involved cross-checking the 3D model with the architectural drawings available at the time of writing the report and running the ModelIT report model review tool within IES VE to c to identify and address any potential geometry errors.

Preliminary test simulations were conducted early in the modelling process for the weather file calculations within SunCast as a good practice to assess if the 3D model is correctly defined and prepared for dynamic simulations. Additional QA procedures were implemented during the Sensitivity Analysis and Scenario Testing stages (Steps 13 and 14) including the validation of output data against industry benchmarks.

Comprehensive QA was performed before reporting any modelling results to external parties, with detailed notes cross-referenced against the implementation matrix (presented in the following section).

Model Geometry Review

Regular report checks are carried out using the Model Report review tool within the ModelIT application of the IES VE software.

SunCast Simulation Test

Initial SunCast simulation test is run to identify early on in the modelling process potential geometry and thermal template errors.

Thermal Templates Adjustments

The thermal templates are derived from predefined standard profiles such as NCM and TM59 and refined to realistic scenarios.

Apache Dynamic Simulation Test

Initial dynamic simulation test is run in Apache IES tool to assess and check for potential simulation errors or output discrepancies.

Benchmarks Cross-checking

Consistent cross-checking with industry known benchmarks are carried regularly for every simulation to ensure high quality results.

12. Step 17: Reporting & Implementation Matrix

The implementation matrix summarises the TM54 process, the key inputs for each step of the methodology, and how each result has been calculated.

The ‘probable range’ column is filled-in to reflect the likely variability in the input. The ‘confidence level’ column is filled-in to reflect the modeller’s assessment of the level of certainty they have for the input.

‘Low confidence’ can indicate where values are taken from CIBSE guidance, benchmarks or standard databases, as well as data assumptions prior to a finalised detailed design of certain building components or spaces within the project.

‘Medium’ refers to values that are based on outline design information bespoke to the project, but that more detailed values are expected.

‘High’ indicates that detailed design information has been provided, with input from well informed future users, and is unlikely to change significantly through construction.

TM54 Step	Recommendation	Modelling Approach	Probable Range	Confidence Level	QA Check
Step 0: Choosing the right level of modelling	The project team should establish early in the project, in discussion with the client, the right level of modelling for the project. This should consider multiple factors including the complexity of the building and its systems, the resources available for the modelling, and the level of accuracy and certainty needed from the results.	A dynamic thermal modelling approach has been chosen as this enables the model to provide a very detailed energy consumption simulation. The HVAC was modelled starting from templates and tuned to more accurately reflect the design proposals. The energy use associated with hot water and lighting is calculated within the DSM.	N/A	N/A	Yes
Step 1: Constructing and building the model	Constructing and zoning: Consider the level of detail needed for the model to be accurate and robust. Always check the North arrow. Check the modelled envelope properties against information provided by design team members (engineer, façade consultant, architect etc). Carry out simple checks at the end of this stage, with default settings, to ensure the model operates as expected.	The model used information provided by the design team, including the architect and building services engineer. The North arrow was taken from the architectural site drawings. The development was set to a 25° angle from the true North. Neighbouring are not expected to affect the building through considerable height differences; therefore, they were omitted.	10%	Medium	Yes
	Establishing floor areas: Identify or estimate NIA, GIA, or TFA for the building, as required for the calculations and in line with the floor area used in targets and benchmarks for the project, and include this in the report	The GIA within the model is 4,773 m². As the volumes have been defined as per the NCM Guide using the lines from the inside of external walls and in the centre of partitions between rooms, there are some minor differences between the surface area shown in the architectural drawings and the areas defined in the IES VE model.	<1%	High	Yes
	The weather data used for the model should be clearly stated in the report, and appropriate for the purpose of the modelling. Where the site location is not close to any of the CIBSE weather file locations, the best match should be used based on the local climate.	The model uses the CIBSE weather files for London Weather Centre assuming more intense summers specific to the central urban London suitable for the project’s location. The weather files used in the model consider several summer scenarios including current DS1, DSY2 and DSY3.	N/A	N/A	Yes
Step 2: Estimating operating hours and occupancy factors	Request anticipated operational profiles from the client, for example through structured interview.	NCM profiles, as well as TM59 occupancy and equipment patterns, were used. Actual values are unknowable until post-occupancy. Sensible assumptions based on typical operational schedules were made where official data and benchmarks were not available. Where	50%	Low	Yes

		defaults were used, further analysis was carried out in sensitivity tests and in scenario testing.			
Step 3: Evaluating lighting energy use	Assess the energy use for each element, as per guidance provided in each step. Where steps are omitted, state and justify (e.g. Step 4 omitted if the building has no lifts). Make a note of instances where benchmarks or assumptions have been used, rather than project-specific	Model uses lighting efficacies recommended in line with their Part L compliance assessment. The target illuminance levels are defined as per CIBSE Guide A and The SLL Code for Lighting (Edition 2022). The detailed lighting parameters included in the model are enclosed in the report and in the Appendix B.	20%	High	Yes
Step 4: Evaluating energy use for lifts and escalators	Identify likely variability and uncertainty, to take account of it in the scenario testing and sensitivity analysis.	There are three lifts in the proposed development. Recommended reference documents have been used to estimate energy consumption.	10%	High	Yes
Step 5: Evaluating energy use for small power		Small power inputs were defined based on BRE estimated and pre-defined NCM profiles as well as calculation and estimates from CIBSE Guide F: Energy efficiency in buildings.	50%	Low	Yes
Step 6: Evaluating energy use for catering		This step has been omitted as there are no catering facilities proposed for the development.	N/A	N/A	N/A
Step 7: Evaluating energy use for server rooms		In line with CIBSE TM54 methodology, this step has been omitted as there are no server rooms or IT			
		hubs proposed for the development.			
Step 8: Evaluating energy use of additional plant and equipment		External lighting is proposed entrances and Courtyard. Internal lighting has been estimated using NCM and TM59 profiles.	10%	Low	Yes
Step 9: Evaluating energy use of domestic hot wate		DHW has been modelled as an ASHP system with SCOP of 3.2 in line with Energy Statement consultants. Water consumption has been taken from London Plan Policy.	30%	Medium	Yes
Step 10: Evaluating internal heat gains		Internal heat gains have been calculated automatically in the IES VE software based on the defined profiles and parameters for air exchange, infiltration rates, solar gains from various weather files, occupancy, equipment, and HVAC systems	20%	Medium	Yes
Step 11: Modelling HVAC systems and their controls	Assess the energy use with the appropriate modelling method, as determined in Step 0. Report separately for heating, hot water, cooling, and fans and pumps. Model controls carefully and use this to inform the control strategy and design.	HVAC systems and controls have been modelled in line with recommended systems outlined in the Energy Statement It is anticipated that space and water heating will be provided by a communal Air Source Heat Pump system. The proposed COP for space heating is 3.8 and proposed COP for water heating is 3.2. Comfort cooling has also been applied based on recommendations from the thermal	30%	Medium	Yes

		comfort assessment with an SEER of 5.			
Step 12: Taking management considerations into account	Review management considerations, ideally through structured interview/information request with future occupants. This should determine variability in the inputs due to management considerations. Blanket management factors should not be used.	Sensible assumptions have been made as noted in the current report.	N/A	N/A	N/A
Step 13: Sensitivity analysis	At the minimum, run basic sensitivity tests on the impact of individual inputs, to identify the most influential and inform scenario testing. The range of factors to include in the sensitivity tests will vary for different building types but typically would include weather and climate, heat gain scenarios, including occupancy density and hours, management and occupant behaviour. Discuss with the client whether a proper sensitivity analysis (beyond these basic tests) is required and	A series of sensitivity cases were run. The proposed tests including weather data, heating setpoint, occupancy density and occupancy schedules.	N/A	N/A	Yes
	record the justification and decision.				
Step 14: Scenario testing	Produce mid-range, low-end and high-end scenarios. As an additional option, a 'worst case' scenario can be run, with caveats as noted in section. This should take account of variability in inputs established in each of the previous steps.	Additional scenarios have been run with minimum and maximum equipment loads influenced by occupant behaviours, and extended hours for occupied spaces and services.	N/A	N/A	Yes
Step 15: Reviewing the results against benchmarks and targets	Compare results with the project targets and, if relevant, benchmarks. If using benchmarks, provide context on their relevance to the project. Use the comparison to check whether the design proposals are on track to achieve the target, and inform any change required.	Simulation results were compared against industry benchmarks, including those from CIBSE and RIBA, to evaluate the building's energy performance. Adjustments were made to account for differences in energy use, such as excluding external lighting and lifts, ensuring a direct comparison. The results were then assessed across low, medium, and high energy consumption scenarios to highlight potential performance variations.	N/A	N/A	Yes

13. Summary

This assessment presents the anticipated operational energy performance for a proposed development at Britannia Street Car Park, London, WC1X 9BP.

The proposals are for a purpose-built student accommodation building, with associated cycle parking, waste/recycling storage, landscaping and other ancillary works.

CIBSE TM54 methodology has been applied to estimate operational energy consumption, helping to identify and quantify factors influencing energy use within the building. Where specific data was unavailable, reasonable assumptions have been made.

The energy modelling employs a dynamic simulation approach with advanced HVAC system and control capabilities, enabling it to:

- Calculate 8,760 hours of building operation to simulate annual energy use.
- Model hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation.
- Model thermal mass effects, part load performance curves for mechanical equipment, capacity and efficiency correction curves for mechanical heating and cooling equipment and air side economisers with integrated control.
- Be able to take account of lighting controls linked to lighting levels from daylight.

The model considers both regulated and unregulated energy consumption and generates scenarios around central prediction to explore how the building will perform under different operating conditions.

The proposed development comprises the following:

- High-performance building fabric and energy-efficient lighting, services, and equipment.
- Passive design measures to reduce energy demand for heating, cooling, ventilation, and lighting.
- ASHPs for hot water and space heating
- Extent of roof mounted PV

As part of the sensitivity analysis, various scenarios have been examined by altering key parameters such as weather conditions, heating setpoints, occupancy density, and schedules. Tests indicate that occupancy-related factors, particularly density and schedules, have the greatest impact on energy consumption.

Overall, the scenario analysis suggests that annual electricity consumption for the proposed development could range from 527 MWh ("LOW") to 913 MWh ("HIGH") depending on occupant behaviour and energy management practices for the development. Figure ES.1 summarises the energy breakdown for the baseline scenario, considered the most likely, with estimated annual consumption of 648 MWh. This incorporates realistic assumptions for energy loads, commercial area functionality, and standard weather conditions.

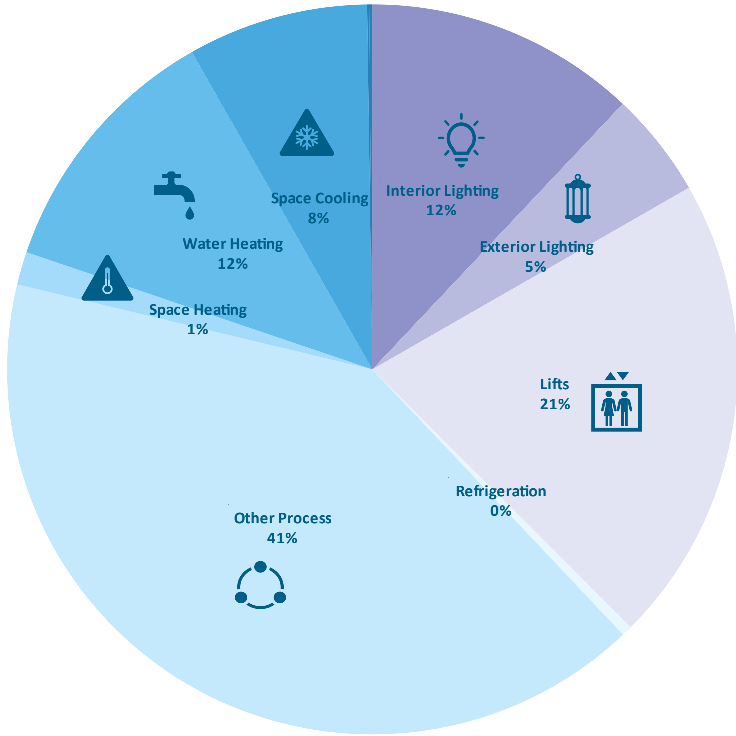


Figure 13.1 – Energy Consumption Breakdown for Baseline Scenario

When examining the energy breakdown by end-user, it appears that equipment loads is the primary contributor to operational energy consumption, followed by lifts, internal lighting, and domestic hot water.

The proposed operational energy strategy aligns with best practice methodologies and industry benchmarks. When implemented, the scheme will deliver an energy-efficient, low-carbon building.

14. Recommendations

In light of findings from the TM54 operational energy assessment for the proposed development Britannia Street Car Park, London, WC1X 9BP, the following recommendations are made to optimise the building's energy performance:

- Promote Responsible Occupancy and Equipment Use:
  - Encourage occupants to adopt responsible energy consumption habits, particularly when it comes to small power usage. This can be achieved through visible energy consumption feedback and incentives for energy-efficient behaviour, for example.
- Implement Advanced Control Systems:
  - Install smart controls for heating, cooling, and lighting systems, linked to occupancy patterns and internal temperature settings. This will ensure that energy is only used when necessary, optimising building performance and reducing energy consumption during periods of low occupancy.
  - Consider measures that reduce peak demand, particularly for heating and hot water. This could include the integration of thermal storage systems, which would allow energy to be stored during off-peak hours and used when demand is higher, thereby reducing strain on the building's energy systems.
- Post-Occupancy Evaluation and Ongoing Monitoring:
  - The London Plan 2021 mandates that developments monitor and disclose energy usage over a five-year period post-occupancy, comparing actual performance with design-stage modelling. This should be considered a key part of the building's operational strategy, with energy consumption tracked and reported annually.
  - It is recommended that the building undergo post-occupancy evaluations (POE). These evaluations will assess actual energy consumption against predicted usage, allowing for adjustments to be made as necessary. Future use of frameworks such as TM63 (Post-Occupancy Energy Evaluation) will provide guidance for these evaluations, helping identify discrepancies and root causes of any energy performance issues.
- Maximise Renewable Energy Generation
  - It is recommended to cover 30-70% of the roof with renewable technologies, such PV panels, which has the potential to generate up to 25%-50% of the building's overall energy consumption. However, it is acknowledged that this will need to be considered in the context of other roof demands.
  - To further enhance energy independence, consider integrating battery storage systems to store excess energy generated by the PV system. This would enable the building to maintain a more consistent energy supply, reduce reliance on grid energy during peak times.
- Maintenance and Operational Strategy
  - Ensure that all renewable energy systems, including the PV panels, are regularly maintained for optimal functionality. This will help avoid performance degradation over time and ensure that the building maximises the benefits from its renewable energy systems.
  - Consider establishing an energy performance management strategy that includes the continuous monitoring of energy systems, regular maintenance schedules, and periodic performance reviews to maintain high efficiency across the building's lifecycle.

Analysis highlights that implementing these recommended measures should be a priority to optimise the building's energy performance. If adopted, the proposed strategies will contribute to a more efficient, low-carbon development. Ultimately supporting both operational cost savings and sustainability objectives.

Appendices

A. Site Plan

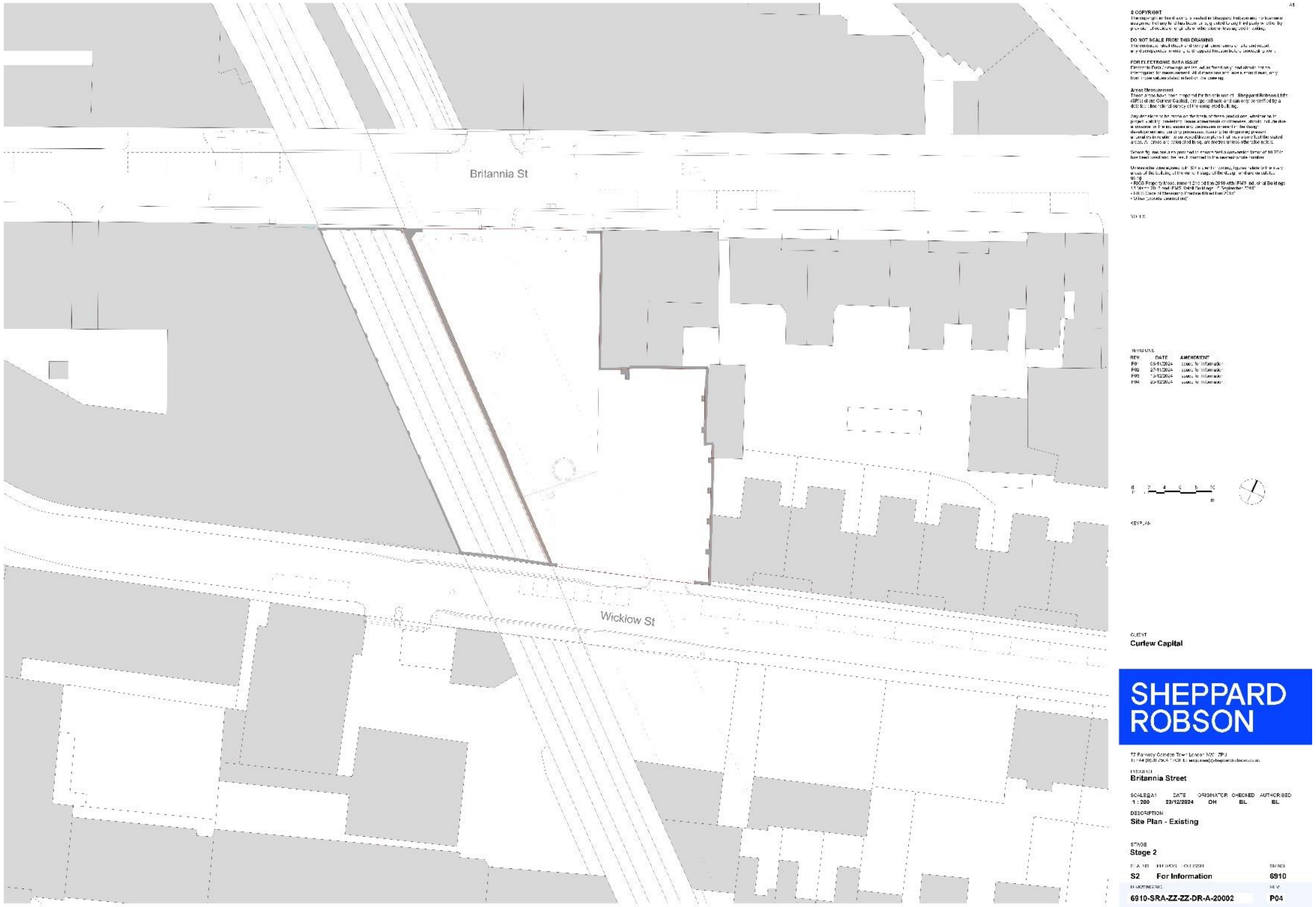
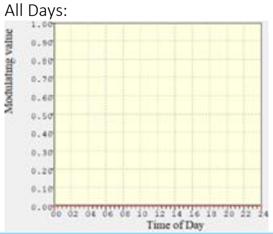
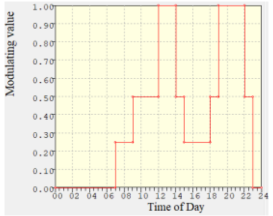
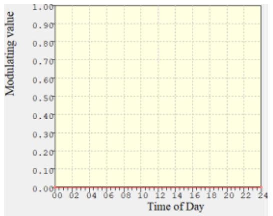
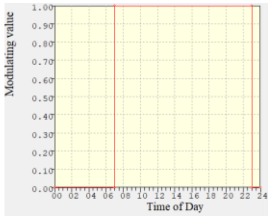
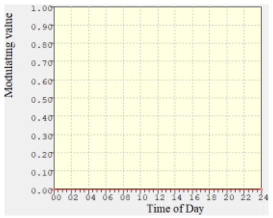
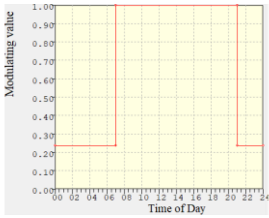
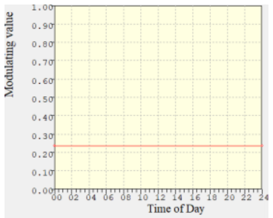


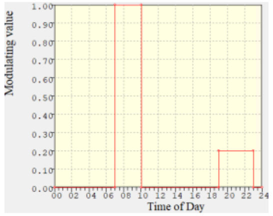
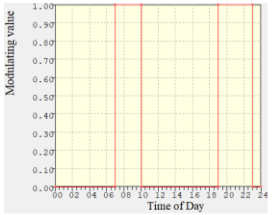
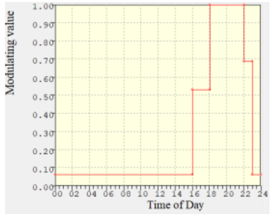
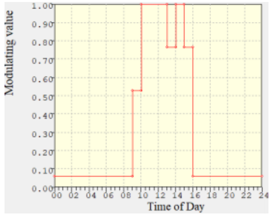
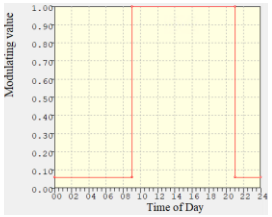
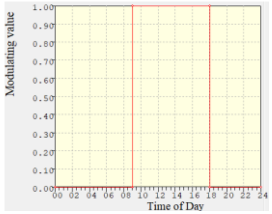
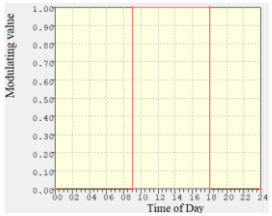
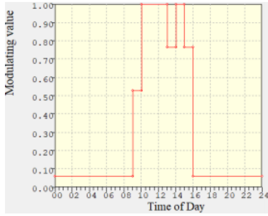
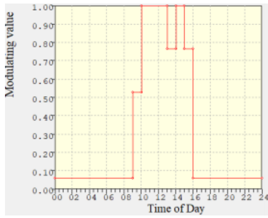
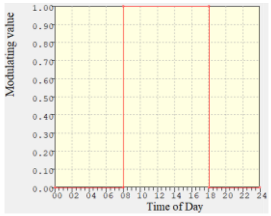
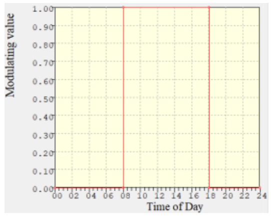
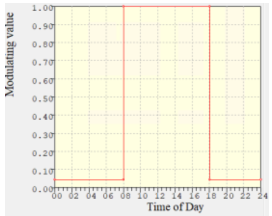
Figure A.1 – Site Plan (Provided by Sheppard Robson)

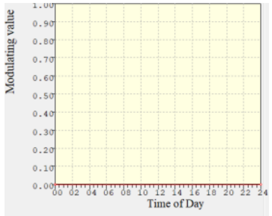
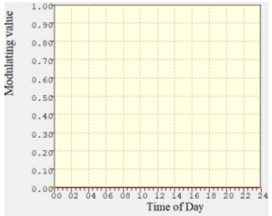
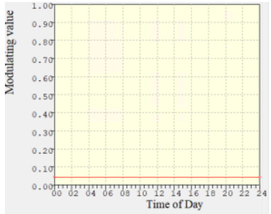
B. Data Inputs

Baseline Scenario

Table Appendix B.1 - Baseline Profiles

Space Type	Occupancy	Lighting	Equipment	Additional Information
Circulation	None	All Days: 	None	Lighting: Maximum Sensible Gain: 3.75 W/m² Maximum Power Consumption: 4.69 W/m²
Communal Area	Typical Day:  Holiday: 	Typical Day:  Holiday: 	Typical Day:  Holiday: 	Occupancy: Maximum Sensible Gain: 61.00 W/person Maximum Latent Gain: 39.00 W/person Lighting: Maximum Sensible Gain: 10.40 W/m² Maximum Power Consumption: 10.40 W/m² Equipment: Maximum Sensible Gain: 5.27 W/m² Maximum Latent Gain: 0.00 W/m²
Ensuite	All Days:	All Days:	All Days:	Occupancy: Maximum Sensible Gain: 60.00 W/person Maximum Latent Gain: 60.00 W/person Lighting: Maximum Sensible Gain: 10.40 W/m² Maximum Power Consumption: 10.40 W/m²

				Equipment: Maximum Sensible Gain: 1.56 W/m² Maximum Latent Gain: 0.00 W/m²
Kitchenette	Typical Day:  Holiday: 	Weekdays:  Weekend and Holiday: 	Weekdays:  Weekend and Holiday: 	Occupancy: Maximum Sensible Gain: 63.00 W/person Maximum Latent Gain: 117.00 W/person Lighting: Maximum Sensible Gain: 26.00 W/m² Maximum Power Consumption: 26.00 W/m² Equipment: Maximum Sensible Gain: 1.56 W/m² Maximum Latent Gain: 0.00 W/m²
Laundry	Typical Day:  Holiday:	Typical Day:  Holiday:	Typical Day:  Holiday:	Occupancy: Maximum Sensible Gain: 90.00 W/person Maximum Latent Gain: 90.00 W/person Lighting: Maximum Sensible Gain: 11.25 W/m² Maximum Power Consumption: 11.25 W/m² Equipment: Maximum Sensible Gain: 1.56 W/m² Maximum Latent Gain: 0.00 W/m²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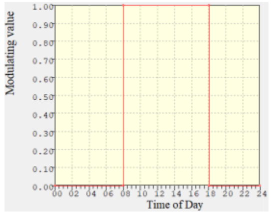
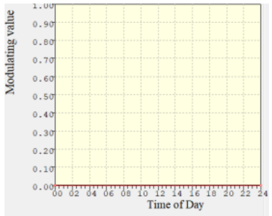
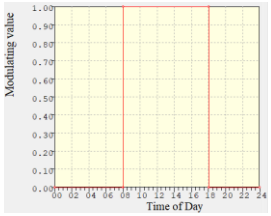
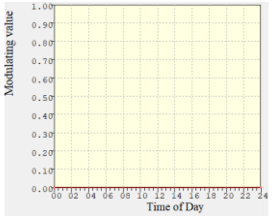
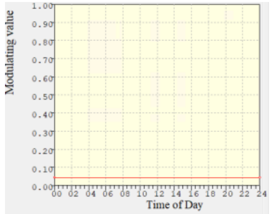
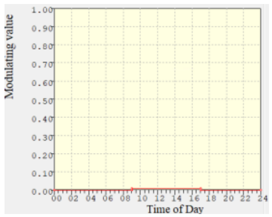
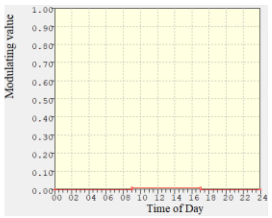
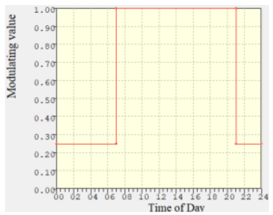
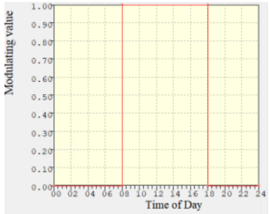
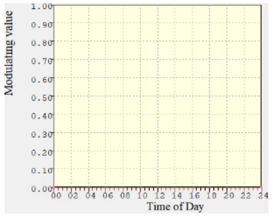
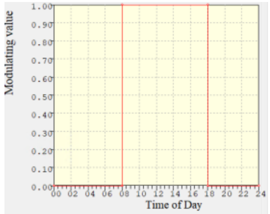
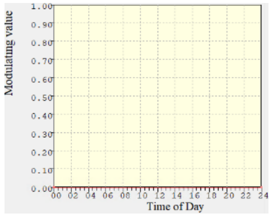
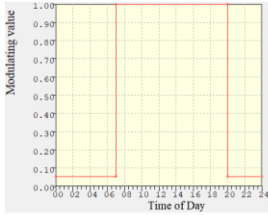
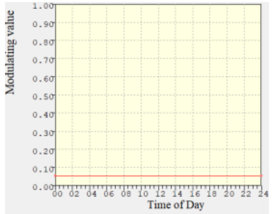
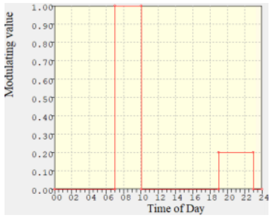
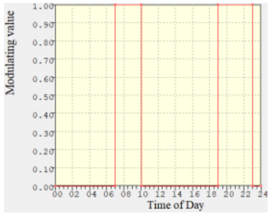
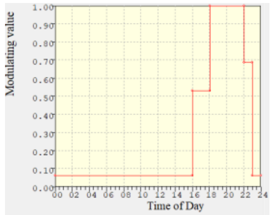
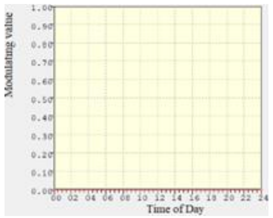
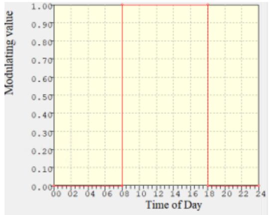
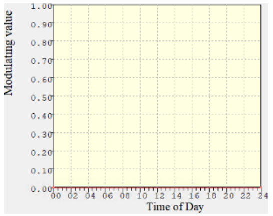
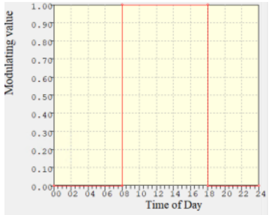
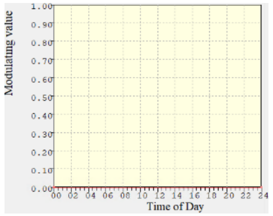
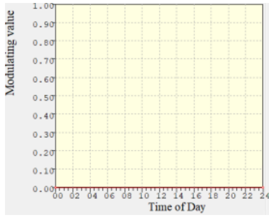
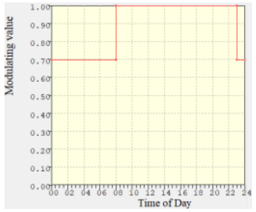
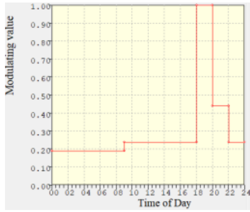
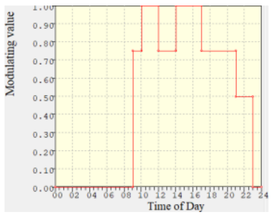
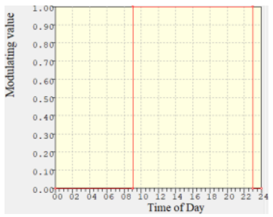
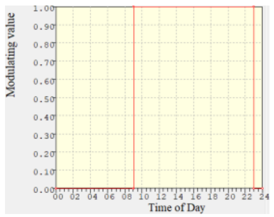
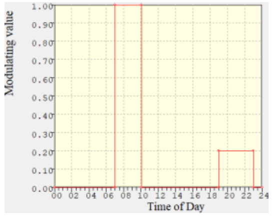
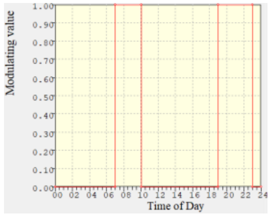
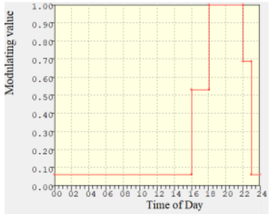
Office	Weekdays:  Weekends and Holiday: 	Weekdays:  Weekends and Holiday: 	All Days: 	Occupancy: Maximum Sensible Gain: 73.00 W/person Maximum Latent Gain: 50.00 W/person Lighting: Maximum Sensible Gain: 11.25 W/m^2 Maximum Power Consumption: 11.25 W/m^2 Equipment: Maximum Sensible Gain: 11.90 W/m^2 Maximum Latent Gain: 0.09 W/m^2
Plant	All Days: 	All Days: 	All Days: 	Occupancy: Maximum Sensible Gain: 90.00 W/person Maximum Latent Gain: 90.00 W/person Lighting: Maximum Sensible Gain: 7.50 W/m^2 Maximum Power Consumption: 7.50 W/m^2 Equipment: Maximum Sensible Gain: 50.50 W/m^2 Maximum Latent Gain: 0.00 W/m^2
Reception	Weekdays:	Weekdays:	Weekdays:	Occupancy:

	 Weekend and Holidays: 	 Weekend and Holidays: 	 Weekend and Holidays: 	Maximum Sensible Gain: 85.40 W/person Maximum Latent Gain: 54.60 W/person Lighting: Maximum Sensible Gain: 15.60 W/m² Maximum Power Consumption: 15.60 W/m² Equipment: Maximum Sensible Gain: 5.59 W/m² Maximum Latent Gain: 0.00 W/m²
Risers	None	None	None	
Staff Shower Room	All Days: 	All Days: 	All Days: 	Occupancy: Maximum Sensible Gain: 60.00 W/person Maximum Latent Gain: 60.00 W/person Lighting: Maximum Sensible Gain: 10.40 W/m² Maximum Power Consumption: 10.40 W/m² Equipment: Maximum Sensible Gain: 1.56 W/m² Maximum Latent Gain: 0.00 W/m²
Stairs	None	All Days: 	None	Lighting: Maximum Sensible Gain: 3.75 W/m² Maximum Power Consumption: 4.69 W/m²
Storage	Weekdays:	Weekdays:	All Days:	Occupancy: Maximum Sensible Gain: 70.00 W/person

	 Weekend and Holidays: 	 Weekend and Holidays: 		Maximum Latent Gain: 70.00 W/person Lighting: Maximum Sensible Gain: 3.75 W/m² Maximum Power Consumption: 3.75 W/m² Equipment: Maximum Sensible Gain: 0.00 W/m² Maximum Latent Gain: 0.00 W/m²
Studio	All Days: 	All Days: 	All Days: 	Occupancy: Maximum Sensible Gain: 75.00 W/person Maximum Latent Gain: 55.00 W/person Lighting: Maximum Sensible Gain: 2.00 W/m² Maximum Power Consumption: 2.00 W/m² Equipment: Maximum Sensible Gain: 450 W Maximum Latent Gain: 0.00 W
Study Space	All Days: 	All Days: 	All Days: 	Occupancy: Maximum Sensible Gain: 73.20 W/person Maximum Latent Gain: 46.80 W/person Lighting: Maximum Sensible Gain: 11.25 W/m² Maximum Power Consumption: 11.25 W/m² Equipment: Maximum Sensible Gain: 27.81 W/m² Maximum Latent Gain: 0.00 W/m²
WC	All Days:	All Days:	All Days:	Occupancy:

				Maximum Sensible Gain: 60.00 W/person Maximum Latent Gain: 60.00 W/person Lighting: Maximum Sensible Gain: 10.40 W/m² Maximum Power Consumption: 10.40 W/m² Equipment: Maximum Sensible Gain: 1.56 W/m² Maximum Latent Gain: 0.00 W/m²

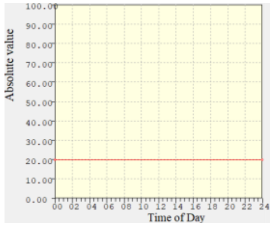
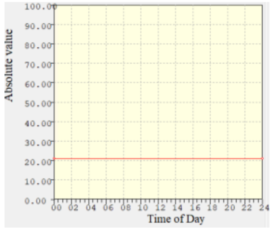
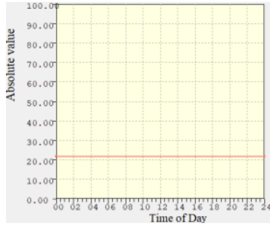
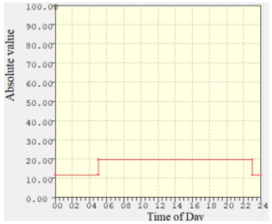
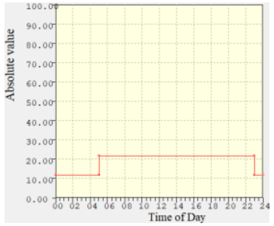
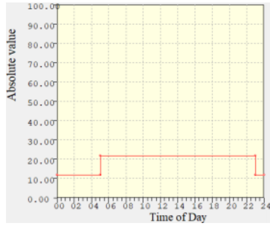
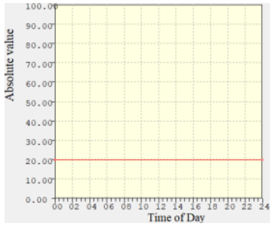
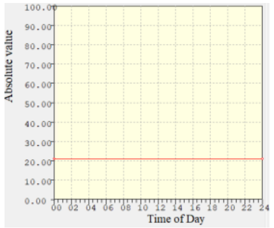
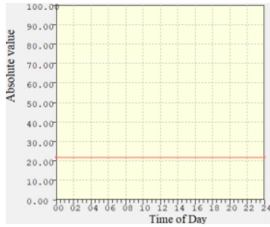
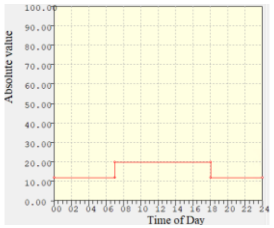
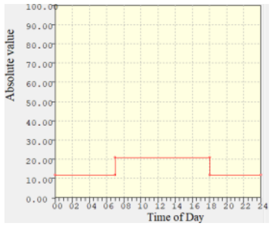
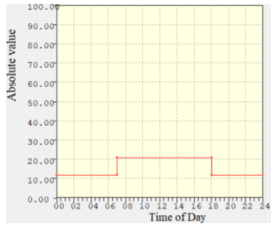
Ventilation Rates

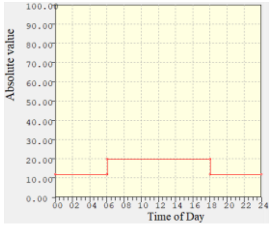
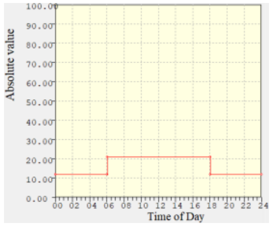
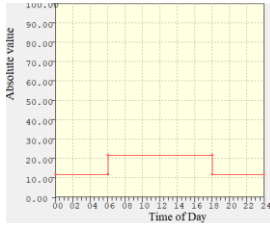
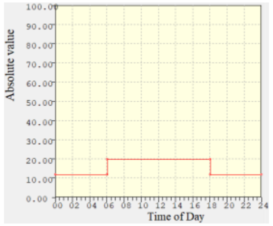
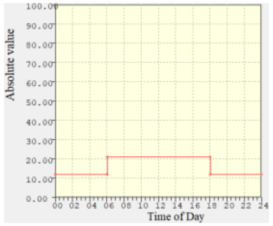
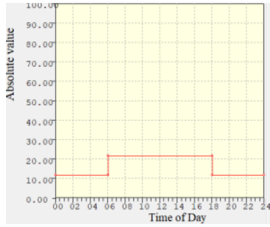
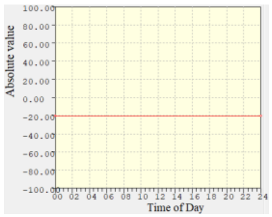
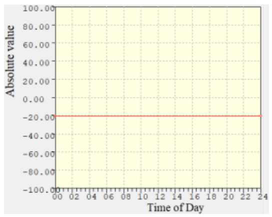
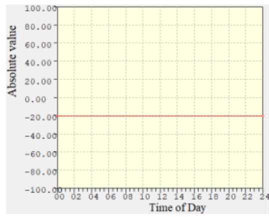
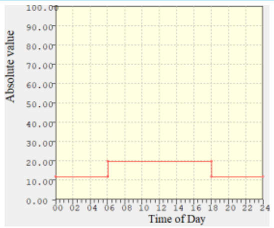
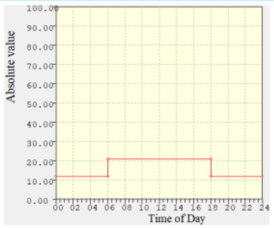
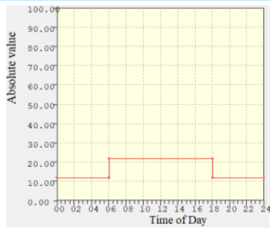
Table Appendix B. 2 – Mechanical Ventilation Rates

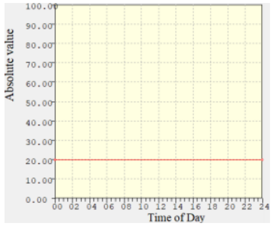
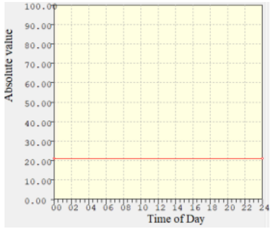
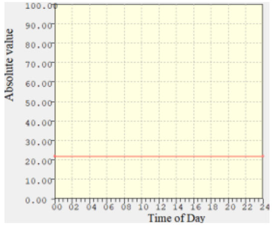
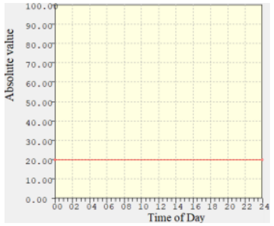
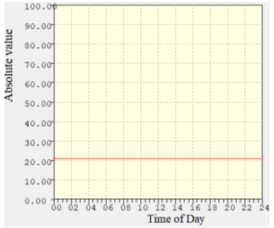
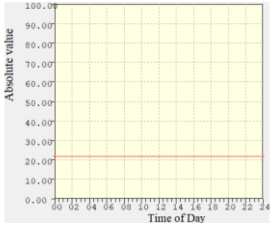
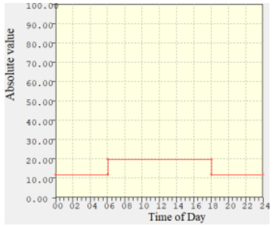
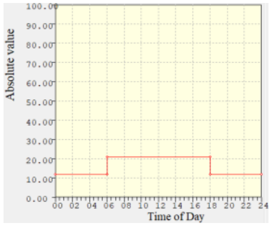
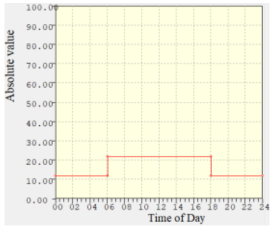
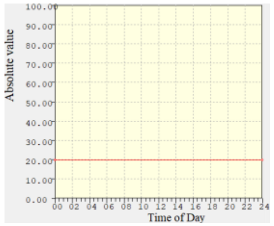
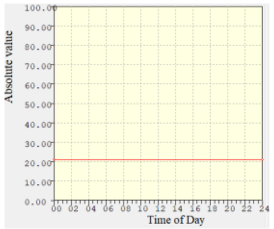
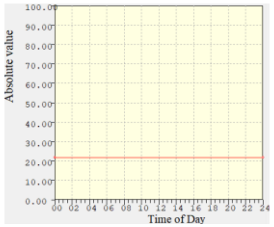
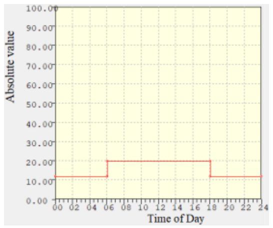
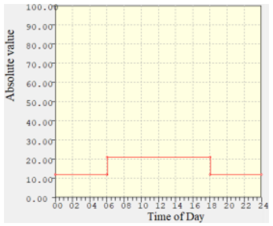
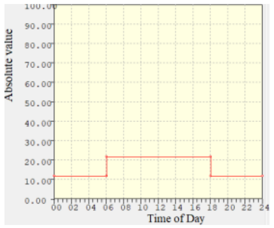
Space Type	Mechanical Ventilation Rate	Source
Circulation	None	N/A
Communal Area	0.5 l/s/m²	Ventilation: Approved Document F Volume 2, Table 1.1
Ensuite	8 l/s	Ventilation: Approved Document F Volume 1, Table 1.2
Kitchenette	15 l/s	Ventilation: Approved Document F Volume 2, 1.28
Laundry	8 l/s	Ventilation: Approved Document F Volume 1, Table 1.2
Lift	None	N/A
Office	0.5 l/s/m²	Ventilation: Approved Document F Volume 2, 1.33
Plant	None	N/A
Reception	0.5 l/s/m²	Ventilation: Approved Document F Volume 2, Table 1.1
Risers	None	N/A
Staff Shower Room	15 l/s	Ventilation: Approved Document F Volume 2, 1.26
Stairs	None	N/A
Storage	None	N/A
Studio	13 l/s	Ventilation: Approved Document F Volume 1, Table 1.2
Study Space	0.5 l/s/m²	Ventilation: Approved Document F Volume 2, Table 1.1
WC	6 l/s	Ventilation: Approved Document F Volume 2, 1.26

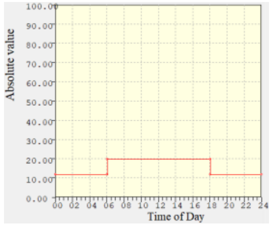
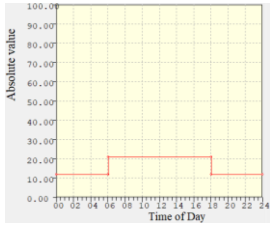
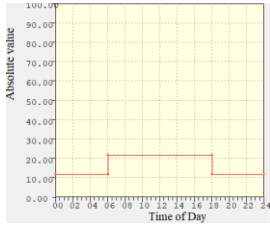
Sensitivity Test 2: Heating Setpoint

Table Appendix B.3 – Heating Setpoint Profiles

	Setpoint 20	Setpoint 21	Setpoint 22
Circulation			
Communal Area			
Ensuite			
Kitchenette			

Laundry			
Lift	None	None	None
Office			
Plant			
Reception			
Risers	None	None	None

Staff Shower Room			
Stairs			
Storage			
Studio			
Study Space			

WC			

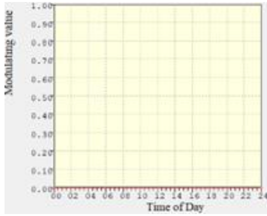
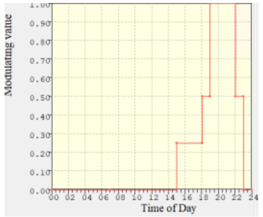
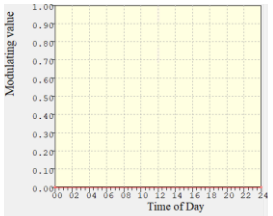
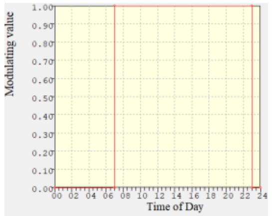
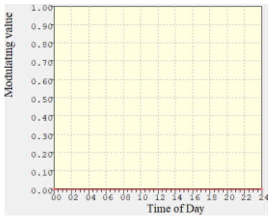
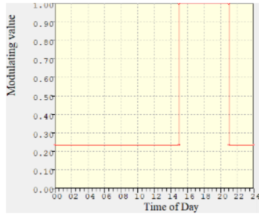
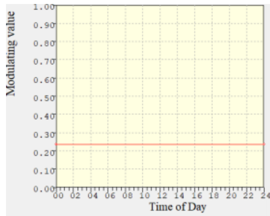
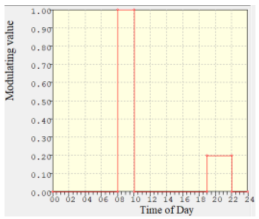
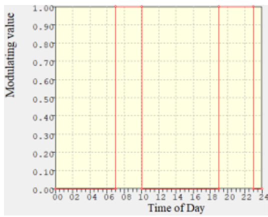
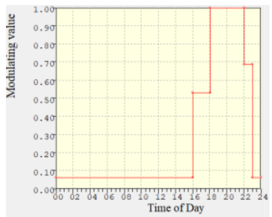
Sensitivity Test 3: Occupancy Density

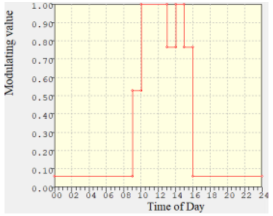
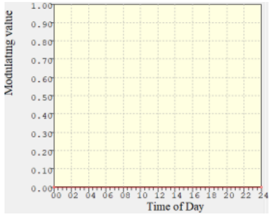
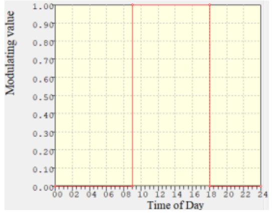
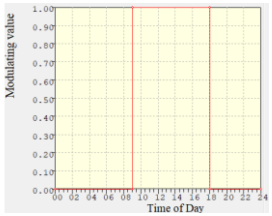
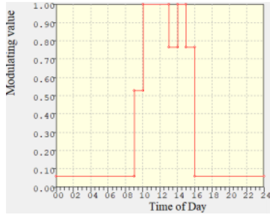
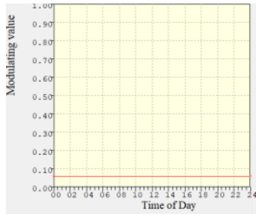
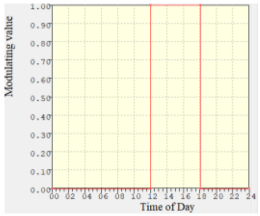
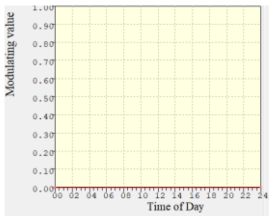
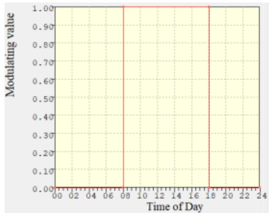
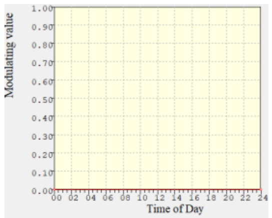
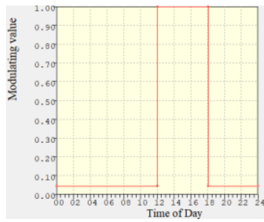
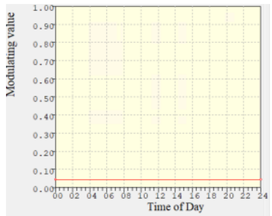
Table Appendix B.4 - Occupancy Density

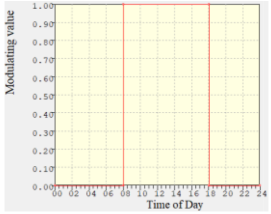
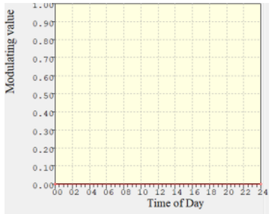
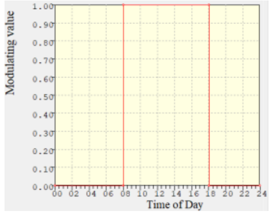
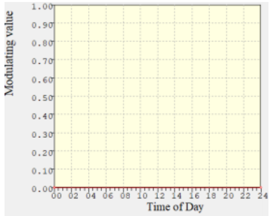
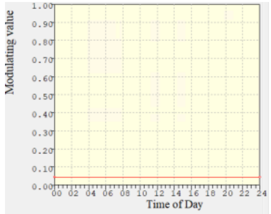
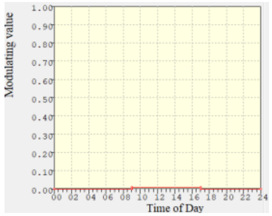
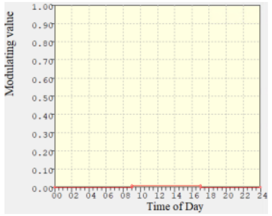
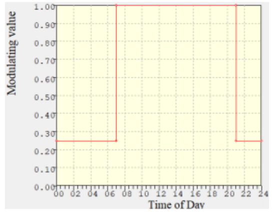
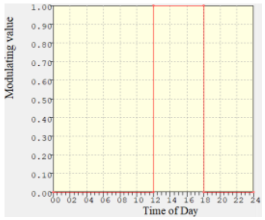
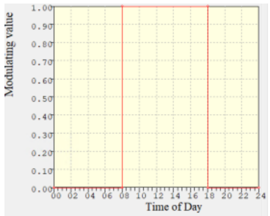
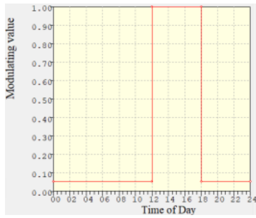
	Reduced Density (m²/person)	Baseline Density (m²/person)	Increased Density (m²/person)
Circulation	0	0	0
Communal Area	13.139	8.759	4.380
Ensuite	6.525	4.350	2.175
Kitchenette	15.630	10.420	5.210
Laundry	12.390	8.260	4.130
Lift	0	0	0
Office	14.565	9.710	4.855
Plant	13.637	9.091	4.546
Reception	12.987	8.658	4.329
Risers	0	0	0
Staff Shower Room	6.525	4.350	2.175
Stairs	0	0	0
Storage	12.390	8.260	4.130
Studio	N/A	N/A	N/A
Study Space	6.480	4.320	2.160
WC	6.525	4.350	2.175

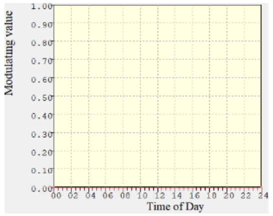
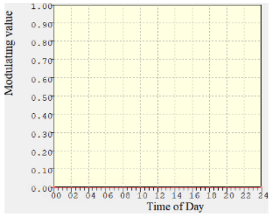
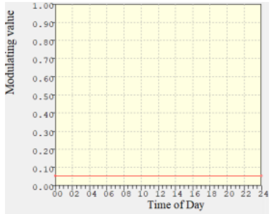
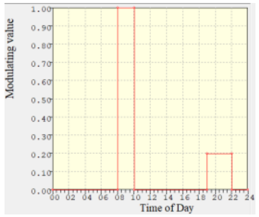
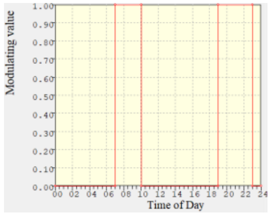
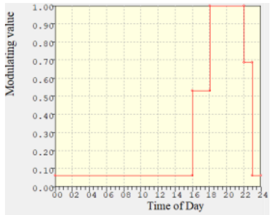
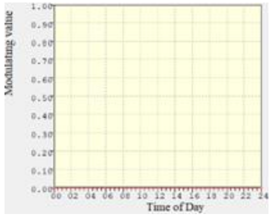
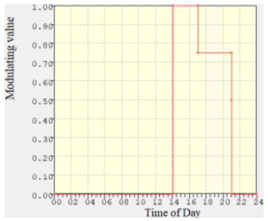
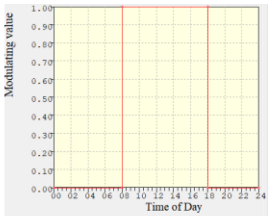
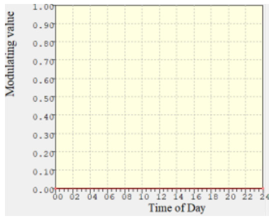
Sensitivity Test 4: Occupancy Schedules

Table Appendix B.5 – Reduced Occupancy Schedule Profiles

Space Type	Occupancy	Lighting	Equipment
Circulation	None	All Days: 	None
Communal Area	Typical Day:  Holiday: 	Typical Day:  Holiday: 	Typical Day:  Holiday: 
Ensuite	All Days: 	All Days: 	All Days: 
Kitchenette	Typical Day:	Weekdays:	Weekdays:

	 Holiday: 	 Weekend and Holiday: 	 Weekend and Holiday: 
Laundry	Typical Day:  Holiday: 	Typical Day:  Holiday: 	Typical Day:  Holiday: 
Lift	None	None	None
Office	Weekdays:	Weekdays:	All Days:

	 Weekends and Holiday: 	 Weekends and Holiday: 	
Plant	All Days: 	All Days: 	All Days: 
Reception	Weekdays:  Weekend and Holidays:	Weekdays:  Weekend and Holidays:	Weekdays:  Weekend and Holidays:

			
Risers	None	None	None
Staff Shower Room	All Days: 	All Days: 	All Days: 
Stairs	None	All Days: 	None
Storage	All Days: 	Weekdays:  Weekend and Holidays:	All Days: 

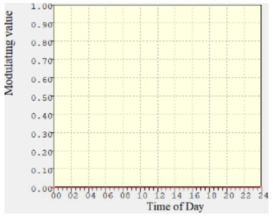
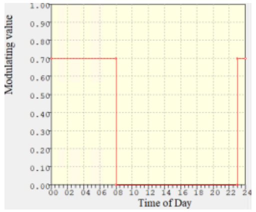
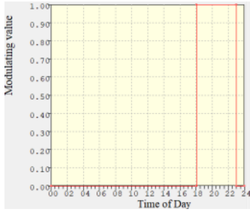
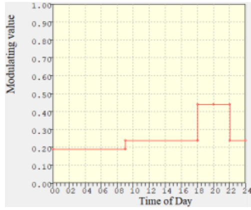
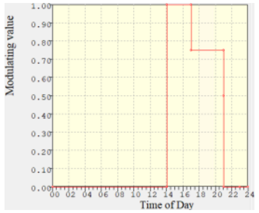
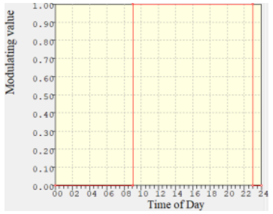
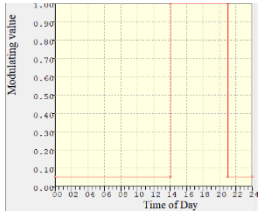
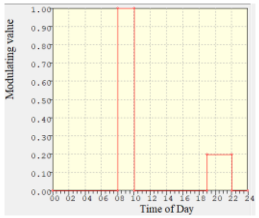
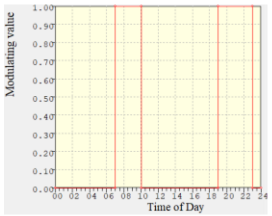
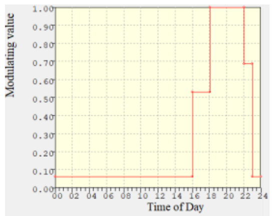
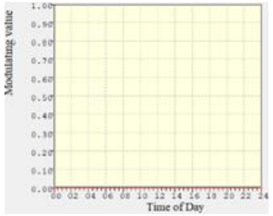
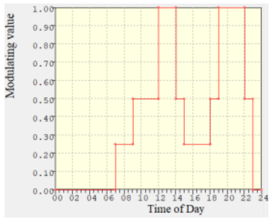
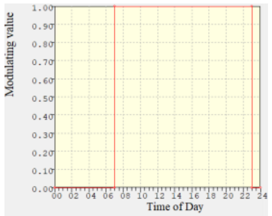
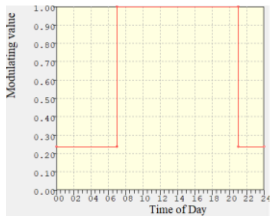
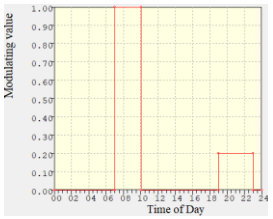
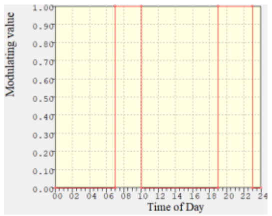
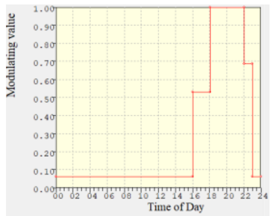
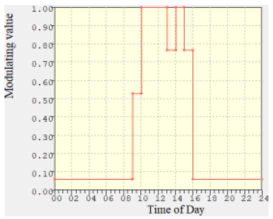
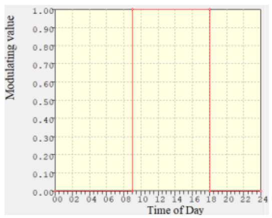
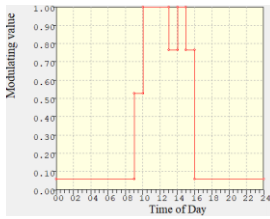
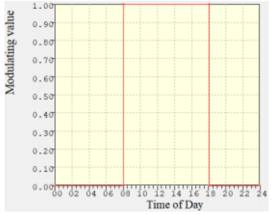
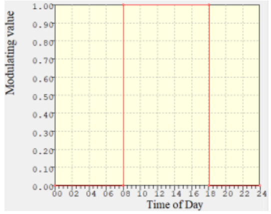
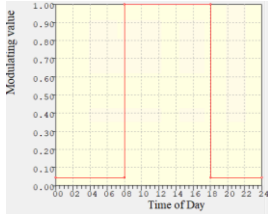
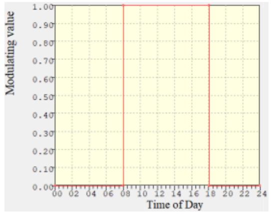
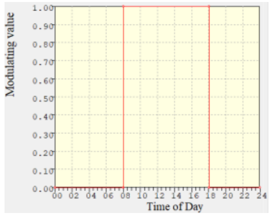
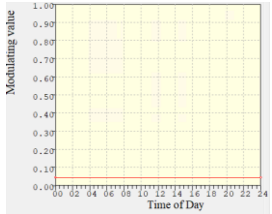
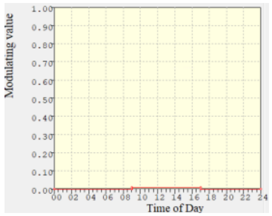
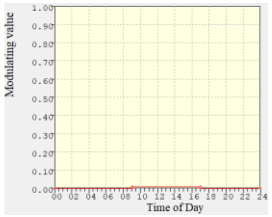
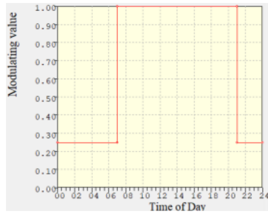
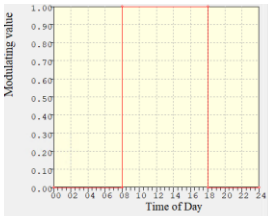
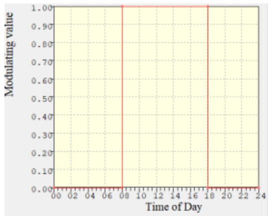
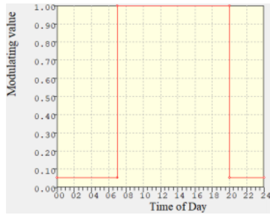
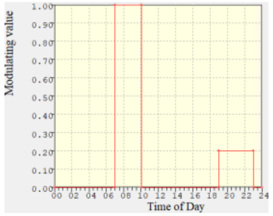
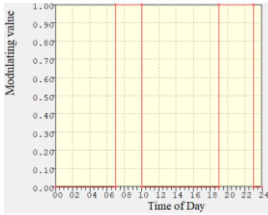
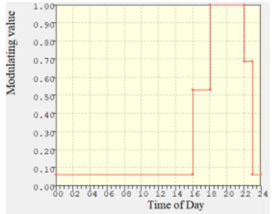
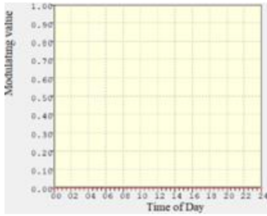
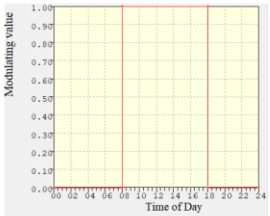
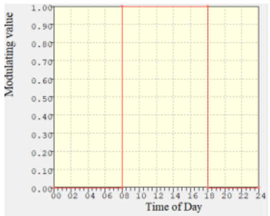
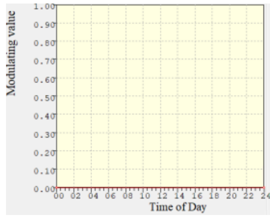
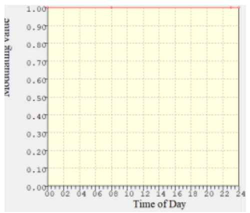
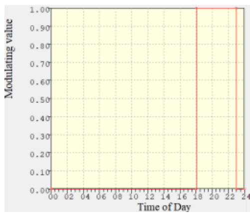
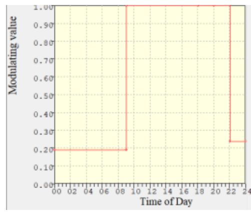
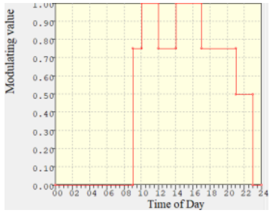
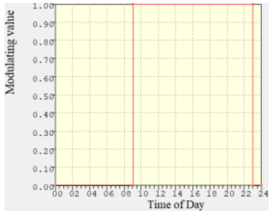
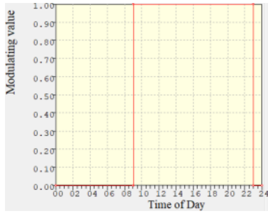
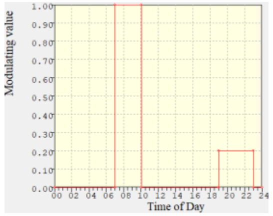
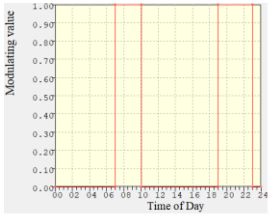
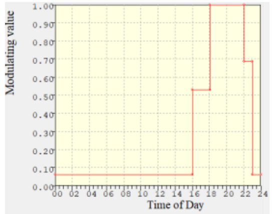
			
Studio	All Days: 	All Days: 	All Days: 
Study Space	All Days: 	All Days: 	All Days: 
WC	All Days: 	All Days: 	All Days: 

Table Appendix B.6 – Increased Occupancy Schedule Profiles

Space Type	Occupancy	Lighting	Equipment
Circulation	None	All Days: 	None
Communal Area	All Days: 	All Days: 	All Days: 
Ensuite	All Days: 	All Days: 	All Days: 
Kitchenette	All Days: 	All Days: 	All Days: 
Laundry	All Days:	All Days:	All Days:

			
Lift	None	None	None
Office	All Days: 	All Days: 	All Days: 
Plant	All Days: 	All Days: 	All Days: 
Reception	All Days: 	All Days: 	All Days: 
Risers	None	None	None
Staff Shower Room	All Days:	All Days:	All Days:

			
Stairs	None	All Days: 	None
Storage	All Days 	All Days 	All Days: 
Studio	All Days: 	All Days: 	All Days: 
Study Space	All Days:	All Days:	All Days:

			
WC	All Days: 	All Days: 	All Days: 

C. Data Outputs

Baseline Simulation

Table Appendix C.1 – IES Outputs Baseline Simulation

	Total Electricity (MWh)	Interior Lighting (MWh)	Exterior Lighting MWh)	Elevators & Escalators (MWh)	Refrigeration (MWh)	Other Process (MWh)	Space Heating (MWh)	Water Heating (MWh)	Space Cooling (MWh)	Interior Central Fans (MWh)	Interior Local Fans (MWh)	Pumps (MWh)	Total Grid Displaced Elec. PV (MWh)	Total Energy (MWh)
Jan 01-31	54.4414	6.9037	2.6509	11.772	0.2588	23.08	1.8834	6.5401	1.2263	0	0.0517	0.0744	-0.4959	53.9455
Feb 01-28	49.1609	6.3239	2.3834	10.584	0.2341	20.8915	1.4649	5.9072	1.2579	0	0.0468	0.0672	-0.8214	48.3395
Mar 01-31	52.7562	6.6813	2.5658	11.394	0.2619	22.9368	0.8558	6.5401	1.3938	0	0.0524	0.0744	-1.1439	51.6123
Apr 01-30	53.2592	6.9059	2.6752	11.88	0.2465	22.4988	0.4863	6.3291	2.1161	0	0.0493	0.072	-1.5814	51.6778
May 01-31	59.3721	7.2622	2.5658	11.394	0.2619	23.3384	0.4337	6.5401	7.4492	0	0.0524	0.0744	-2.6959	56.6762
Jun 01-30	57.5989	6.5877	2.505	11.124	0.2526	22.3868	0.368	6.3291	7.9231	0	0.0505	0.072	-2.4152	55.1837
Jul 01-31	62.0333	6.5266	2.736	12.15	0.2557	22.9069	0.3887	6.54	10.4039	0	0.0511	0.0744	-2.4105	59.6228
Aug 01-31	57.1695	5.5377	2.5658	11.394	0.2619	22.1595	0.2911	6.54	8.2927	0	0.0524	0.0744	-2.2712	54.8982
Sep 01-30	57.5768	6.5337	2.5901	11.502	0.2495	22.3555	0.2959	6.329	7.5991	0	0.0499	0.072	-1.405	56.1718
Oct 01-31	54.5088	7.0283	2.6509	11.772	0.2588	23.1478	0.3574	6.5401	2.6274	0	0.0517	0.0744	-0.9186	53.5902
Nov 01-30	52.9751	7.105	2.505	11.124	0.2526	22.6584	1.0393	6.3291	1.8391	0	0.0505	0.072	-0.7488	52.2263
Dec 01-31	54.289	6.6121	2.736	12.15	0.2557	22.9604	1.8374	6.54	1.0717	0	0.0511	0.0744	-0.2688	54.0202
Summed Total	665.1411	80.0082	31.1296	138.24	3.05	271.321	9.702	77.0038	53.2004	0	0.6098	0.876	-17.1765	647.9645

Sensitivity Test: DSY2

Table Appendix C.2 - IES Outputs DSY2 Simulation

	Total Electricity (MWh)	Interior Lighting (MWh)	Exterior Lighting MWh)	Elevators & Escalators (MWh)	Refrigeration (MWh)	Other Process (MWh)	Space Heating (MWh)	Water Heating (MWh)	Space Cooling (MWh)	Interior Central Fans (MWh)	Interior Local Fans (MWh)	Pumps (MWh)	Total Grid Displaced Elec. PV (MWh)	Total Energy (MWh)
Jan 01-31	55.5004	6.9037	2.6509	11.772	0.2588	23.08	3.0649	6.5401	1.1039	0	0.0517	0.0744	-0.582	54.9184
Feb 01-28	50.0478	6.3239	2.3834	10.584	0.2341	20.8915	2.5437	5.9072	1.066	0	0.0468	0.0672	-0.8547	49.1931

Mar 01-31	52.775	6.6813	2.5658	11.394	0.2619	22.9368	0.6856	6.5401	1.5828	0	0.0524	0.0744	-1.7507	51.0243
Apr 01-30	55.0214	6.9059	2.6752	11.88	0.2465	22.4988	0.4193	6.3291	3.9453	0	0.0493	0.072	-1.9211	53.1003
May 01-31	57.8285	7.2622	2.5658	11.394	0.2619	23.3384	0.4163	6.5401	5.9232	0	0.0524	0.0744	-2.1574	55.6711
Jun 01-30	59.0659	6.5877	2.505	11.124	0.2526	22.3868	0.3847	6.3291	9.3734	0	0.0505	0.072	-2.3238	56.7421
Jul 01-31	61.3128	6.5266	2.736	12.15	0.2557	22.9069	0.3666	6.54	9.7054	0	0.0511	0.0744	-2.1392	59.1736
Aug 01-31	58.6467	5.5377	2.5658	11.394	0.2619	22.1595	0.335	6.54	9.726	0	0.0524	0.0744	-2.2505	56.3962
Sep 01-30	57.773	6.5337	2.5901	11.502	0.2495	22.3555	0.3098	6.329	7.7814	0	0.0499	0.072	-1.9075	55.8655
Oct 01-31	54.3218	7.0283	2.6509	11.772	0.2588	23.1478	0.5056	6.5401	2.2923	0	0.0517	0.0744	-1.3254	52.9964
Nov 01-30	52.5925	7.105	2.505	11.124	0.2526	22.6584	0.609	6.3291	1.8869	0	0.0505	0.072	-0.5709	52.0216
Dec 01-31	54.2523	6.6121	2.736	12.15	0.2557	22.9604	1.7571	6.54	1.1154	0	0.0511	0.0744	-0.4499	53.8024
Summed Total	669.1382	80.0082	31.1296	138.24	3.05	271.321	11.3976	77.0038	55.5019	0	0.6098	0.876	-18.2331	650.905

Sensitivity Test: DSY3

Table Appendix C.3 - IES Outputs DSY3 Simulation

	Total Electricity (MWh)	Interior Lighting (MWh)	Exterior Lighting MWh)	Elevators & Escalators (MWh)	Refrigeration (MWh)	Other Process (MWh)	Space Heating (MWh)	Water Heating (MWh)	Space Cooling (MWh)	Interior Central Fans (MWh)	Interior Local Fans (MWh)	Pumps (MWh)	Total Grid Displaced Elec. PV (MWh)	Total Energy (MWh)
Jan 01-31	54.5239	6.9037	2.5658	11.394	0.2619	23.08	2.4592	6.5401	1.1925	0	0.0524	0.0744	-0.57	53.9539
Feb 01-28	50.5135	6.3239	2.3834	10.584	0.2341	20.8915	3.0918	5.9072	0.9835	0	0.0468	0.0672	-0.4725	50.0409
Mar 01-31	54.7691	6.6813	2.736	12.15	0.2557	22.9368	2.1973	6.5401	1.1465	0	0.0511	0.0744	-1.47	53.2991
Apr 01-30	52.8902	6.9059	2.505	11.124	0.2526	22.4988	0.4799	6.3291	2.6723	0	0.0505	0.072	-1.904	50.9862
May 01-31	58.2165	7.2397	2.6509	11.772	0.2588	23.3292	0.4185	6.5401	5.8811	0	0.0517	0.0744	-2.2536	55.9628
Jun 01-30	59.9646	6.5937	2.5901	11.502	0.2495	22.3189	0.4098	6.3291	9.8496	0	0.0499	0.072	-2.4225	57.5421
Jul 01-31	61.9808	6.543	2.5658	11.394	0.2619	22.9841	0.4133	6.54	11.152	0	0.0524	0.0744	-2.586	59.3948
Aug 01-31	58.2571	5.5377	2.736	12.15	0.2557	22.1595	0.3003	6.54	8.4522	0	0.0511	0.0744	-2.341	55.9161
Sep 01-30	55.5587	6.5031	2.505	11.124	0.2526	22.3077	0.2654	6.329	6.1493	0	0.0505	0.072	-1.4215	54.1371
Oct 01-31	53.9371	7.0589	2.5658	11.394	0.2619	23.1956	0.3729	6.5401	2.4212	0	0.0524	0.0744	-0.6989	53.2382

Nov 01-30	53.5736	7.0438	2.6752	11.88	0.2465	22.5629	1.2419	6.3291	1.473	0	0.0493	0.072	-0.5475	53.026
Dec 01-31	55.2209	6.657	2.5658	11.394	0.2619	22.9788	3.7876	6.54	0.909	0	0.0524	0.0744	-0.4693	54.7516
Summed Total	669.4058	79.9917	31.0445	137.862	3.0531	271.2438	15.4378	77.0038	52.2823	0	0.6105	0.876	-17.1568	652.249

Sensitivity Test: Setpoint 20

Table Appendix C.4 - IES Outputs Setpoint 20 Simulation

	Total Electricity (MWh)	Interior Lighting (MWh)	Exterior Lighting MWh)	Elevators & Escalators (MWh)	Refrigeration (MWh)	Other Process (MWh)	Space Heating (MWh)	Water Heating (MWh)	Space Cooling (MWh)	Interior Central Fans (MWh)	Interior Local Fans (MWh)	Pumps (MWh)	Total Grid Displaced Elec. PV (MWh)	Total Energy (MWh)
Jan 01-31	53.6334	6.8955	2.6509	11.772	0.2588	23.0414	1.239	6.5401	1.1096	0	0.0517	0.0744	-0.4959	53.1375
Feb 01-28	48.573	6.3239	2.3834	10.584	0.2341	20.8915	0.9626	5.9072	1.1722	0	0.0468	0.0672	-0.8214	47.7516
Mar 01-31	52.9445	6.7119	2.6509	11.772	0.2588	22.9846	0.5331	6.5401	1.367	0	0.0517	0.0744	-1.1439	51.8005
Apr 01-30	52.2589	6.9059	2.505	11.124	0.2526	22.4988	0.4278	6.3291	2.0931	0	0.0505	0.072	-1.5814	50.6775
May 01-31	60.1965	7.2173	2.736	12.15	0.2557	23.32	0.4252	6.5401	7.4267	0	0.0511	0.0744	-2.6959	57.5007
Jun 01-30	57.5823	6.6162	2.505	11.124	0.2526	22.3281	0.3901	6.3291	7.9148	0	0.0505	0.072	-2.4152	55.1671
Jul 01-31	61.3458	6.543	2.5658	11.394	0.2619	22.9841	0.4133	6.54	10.517	0	0.0524	0.0744	-2.4105	58.9353
Aug 01-31	58.139	5.5377	2.736	12.15	0.2557	22.1595	0.3136	6.54	8.3209	0	0.0511	0.0744	-2.2712	55.8678
Sep 01-30	57.0408	6.5031	2.505	11.124	0.2526	22.3077	0.315	6.329	7.5818	0	0.0505	0.072	-1.405	55.6357
Oct 01-31	54.463	7.0283	2.6509	11.772	0.2588	23.1478	0.3414	6.5401	2.5975	0	0.0517	0.0744	-0.9186	53.5444
Nov 01-30	52.9802	7.0744	2.5901	11.502	0.2495	22.6106	0.6712	6.3291	1.8313	0	0.0499	0.072	-0.7488	52.2314
Dec 01-31	52.7286	6.657	2.5658	11.394	0.2619	22.9788	1.2259	6.54	0.9784	0	0.0524	0.0744	-0.2688	52.4598
Summed Total	661.8858	80.0142	31.0445	137.862	3.0531	271.253	7.2581	77.0038	52.9104	0	0.6105	0.876	-17.1765	644.7092

Sensitivity Test: Setpoint 22

Table Appendix C.5 - IES Outputs Setpoint 22 Simulation

	Total Electricity (MWh)	Interior Lighting (MWh)	Exterior Lighting MWh)	Elevators & Escalators (MWh)	Refrigeration (MWh)	Other Process (MWh)	Space Heating (MWh)	Water Heating (MWh)	Space Cooling (MWh)	Interior Central Fans (MWh)	Interior Local Fans (MWh)	Pumps (MWh)	Total Grid Displaced Elec. PV (MWh)	Total Energy (MWh)
Jan 01-31	54.5379	6.0731	2.6509	11.772	0.2588	23.0414	2.7395	6.5401	1.336	0	0.0517	0.0744	-0.4959	54.042
Feb 01-28	49.2536	5.5964	2.3834	10.584	0.2341	20.8915	2.1546	5.9072	1.3884	0	0.0468	0.0672	-0.8214	48.4322
Mar 01-31	53.2458	5.8895	2.6509	11.772	0.2588	22.9846	1.4341	6.5401	1.5897	0	0.0517	0.0744	-1.1439	52.1019
Apr 01-30	51.9172	6.1573	2.505	11.124	0.2526	22.4988	0.7016	6.3291	2.2263	0	0.0505	0.072	-1.5814	50.3358
May 01-31	59.5064	6.4582	2.736	12.15	0.2557	23.32	0.4717	6.5401	7.4492	0	0.0511	0.0744	-2.6959	56.8106
Jun 01-30	56.7522	5.8465	2.505	11.124	0.2526	22.3281	0.4004	6.3291	7.8441	0	0.0505	0.072	-2.4152	54.3371
Jul 01-31	60.3811	5.7522	2.5658	11.394	0.2619	22.9841	0.3736	6.54	10.3828	0	0.0524	0.0744	-2.4105	57.9706
Aug 01-31	56.8014	4.5572	2.736	12.15	0.2557	22.1595	0.266	6.54	8.0114	0	0.0511	0.0744	-2.2712	54.5302
Sep 01-30	56.1915	5.7439	2.505	11.124	0.2526	22.3077	0.2949	6.329	7.5118	0	0.0505	0.072	-1.405	54.7865
Oct 01-31	53.8153	6.2269	2.6509	11.772	0.2588	23.1478	0.4466	6.5401	2.6459	0	0.0517	0.0744	-0.9186	52.8966
Nov 01-30	53.3759	6.3469	2.5901	11.502	0.2495	22.6106	1.6491	6.3291	1.9766	0	0.0499	0.072	-0.7488	52.6271
Dec 01-31	53.5561	5.8451	2.5658	11.394	0.2619	22.9788	2.6117	6.54	1.232	0	0.0524	0.0744	-0.2688	53.2873
Summed Total	668.8491	80.0082	31.0445	137.862	3.0531	271.253	13.5438	77.0038	53.5942	0	0.6105	0.876	-17.1765	642.158

Sensitivity Test: Low Occupancy Density

Table Appendix C.6 - IES Outputs Low Occupancy Density Simulation

	Total Electricity (MWh)	Interior Lighting (MWh)	Exterior Lighting MWh)	Elevators & Escalators (MWh)	Refrigeration (MWh)	Other Process (MWh)	Space Heating (MWh)	Water Heating (MWh)	Space Cooling (MWh)	Interior Central Fans (MWh)	Interior Local Fans (MWh)	Pumps (MWh)	Total Grid Displaced Elec. PV (MWh)	Total Energy (MWh)
Jan 01-31	54.2466	6.8446	2.6509	11.772	0.2588	23.0414	1.9956	6.4099	1.1472	0	0.0517	0.0744	-0.4959	53.7508
Feb 01-28	49.0036	6.2788	2.3834	10.584	0.2341	20.8915	1.5448	5.7896	1.1832	0	0.0468	0.0672	-0.8214	48.1822
Mar 01-31	53.1368	6.661	2.6509	11.772	0.2588	22.9846	0.9115	6.4099	1.3619	0	0.0517	0.0744	-1.1439	51.9928
Apr 01-30	52.0816	6.8596	2.505	11.124	0.2526	22.4988	0.5137	6.2032	2.0022	0	0.0505	0.072	-1.5814	50.5002

May 01-31	59.791	7.1703	2.736	12.15	0.2557	23.32	0.4192	6.4099	7.2042	0	0.0511	0.0744	-2.6959	57.0951
Jun 01-30	57.2009	6.5685	2.505	11.124	0.2526	22.3281	0.3796	6.2031	7.7174	0	0.0505	0.072	-2.4152	54.7857
Jul 01-31	60.934	6.494	2.5658	11.394	0.2619	22.9841	0.3847	6.4099	10.3128	0	0.0524	0.0744	-2.4105	58.5235
Aug 01-31	57.782	5.477	2.736	12.15	0.2557	22.1595	0.2885	6.4099	8.1798	0	0.0511	0.0744	-2.2712	55.5108
Sep 01-30	56.632	6.4561	2.505	11.124	0.2526	22.3077	0.2878	6.2031	7.3733	0	0.0505	0.072	-1.405	55.227
Oct 01-31	54.1551	6.9786	2.6509	11.772	0.2588	23.1478	0.3511	6.4099	2.4597	0	0.0517	0.0744	-0.9186	53.2364
Nov 01-30	53.1527	7.0293	2.5901	11.502	0.2495	22.6106	1.0987	6.2032	1.7473	0	0.0499	0.072	-0.7488	52.404
Dec 01-31	53.3082	6.6067	2.5658	11.394	0.2619	22.9788	1.9394	6.4099	1.0249	0	0.0524	0.0744	-0.2688	53.0394
Summed Total	661.4246	79.4246	31.0445	137.862	3.0531	271.253	10.1147	75.4716	51.7139	0	0.6105	0.876	-17.1765	644.2479

Sensitivity Test: High Occupancy Density

Table Appendix C.7 - IES Outputs High Occupancy Density Simulation

	Total Electricity (MWh)	Interior Lighting (MWh)	Exterior Lighting MWh)	Elevators & Escalators (MWh)	Refrigeration (MWh)	Other Process (MWh)	Space Heating (MWh)	Water Heating (MWh)	Space Cooling (MWh)	Interior Central Fans (MWh)	Interior Local Fans (MWh)	Pumps (MWh)	Total Grid Displaced Elec. PV (MWh)	Total Energy (MWh)
Jan 01-31	59.589	6.8446	2.6509	11.772	0.2588	23.0414	1.0074	12.3861	1.5017	0	0.0517	0.0744	-0.4959	59.0932
Feb 01-28	54.0255	6.2788	2.3834	10.584	0.2341	20.8915	0.7687	11.1875	1.5834	0	0.0468	0.0672	-0.8214	53.204
Mar 01-31	59.1602	6.661	2.6509	11.772	0.2588	22.9846	0.4996	12.3861	1.8211	0	0.0517	0.0744	-1.1439	58.0163
Apr 01-30	59.4511	6.8596	2.505	11.124	0.2526	22.4988	0.4876	11.9866	3.6144	0	0.0505	0.072	-1.5814	57.8697
May 01-31	67.9925	7.1703	2.736	12.15	0.2557	23.32	0.451	12.3861	9.3978	0	0.0511	0.0744	-2.6959	65.2966
Jun 01-30	64.9361	6.5685	2.505	11.124	0.2526	22.3281	0.4022	11.9865	9.6466	0	0.0505	0.072	-2.4152	62.5209
Jul 01-31	68.8628	6.494	2.5658	11.394	0.2619	22.9841	0.3949	12.3859	12.2554	0	0.0524	0.0744	-2.4105	66.4523
Aug 01-31	65.4261	5.477	2.736	12.15	0.2557	22.1595	0.2904	12.3859	9.8459	0	0.0511	0.0744	-2.2712	63.1549
Sep 01-30	64.3568	6.4561	2.505	11.124	0.2526	22.3077	0.3043	11.9864	9.2981	0	0.0505	0.072	-1.405	62.9517
Oct 01-31	60.8144	6.9786	2.6509	11.772	0.2588	23.1478	0.3891	12.3862	3.1048	0	0.0517	0.0744	-0.9186	59.8958
Nov 01-30	59.1123	7.0293	2.5901	11.502	0.2495	22.6106	0.6365	11.9866	2.3857	0	0.0499	0.072	-0.7488	58.3635
Dec 01-31	58.5404	6.6067	2.5658	11.394	0.2619	22.9788	0.8768	12.386	1.3436	0	0.0524	0.0744	-0.2688	58.2716

Summed Total	**742.2671**	**79.4246**	**31.0445**	**137.862**	**3.0531**	**271.253**	**6.5084**	**145.836**	**65.7983**	**0**	**0.6105**	**0.876**	**-17.1765**	**725.0906**

Sensitivity Test: Reduced Occupancy Schedule

Table Appendix C.8 - IES Outputs Reduced Occupancy Schedule Simulation

	Total Electricity (MWh)	Interior Lighting (MWh)	Exterior Lighting MWh)	Elevators & Escalators (MWh)	Refrigeration (MWh)	Other Process (MWh)	Space Heating (MWh)	Water Heating (MWh)	Space Cooling (MWh)	Interior Central Fans (MWh)	Interior Local Fans (MWh)	Pumps (MWh)	Total Grid Displaced Elec. PV (MWh)	Total Energy (MWh)
Jan 01-31	46.5003	6.8955	2.6509	11.772	0.2588	17.7233	3.8393	2.6059	0.6309	0	0.0517	0.0721	-0.4959	46.0044
Feb 01-28	41.7493	6.3239	2.3834	10.584	0.2341	16.0318	3.0488	2.3546	0.6767	0	0.0468	0.0653	-0.8214	40.9279
Mar 01-31	44.7389	6.7119	2.6509	11.772	0.2588	17.6685	2.1239	2.6067	0.8223	0	0.0517	0.0723	-1.1439	43.595
Apr 01-30	42.0769	6.9059	2.505	11.124	0.2526	17.1886	0.666	2.5234	0.7909	0	0.0505	0.0701	-1.5814	40.4955
May 01-31	47.9145	7.2173	2.736	12.15	0.2557	17.7804	0.3987	2.6083	4.6444	0	0.0511	0.0726	-2.6959	45.2186
Jun 01-30	45.9679	6.6162	2.505	11.124	0.2526	17.1013	0.3169	2.5222	5.4094	0	0.0505	0.0699	-2.4152	43.5527
Jul 01-31	49.287	6.543	2.5658	11.394	0.2619	17.5743	0.2821	2.6074	7.9339	0	0.0524	0.0725	-2.4105	46.8765
Aug 01-31	47.3216	5.5377	2.736	12.15	0.2557	17.4062	0.1916	2.6016	6.3204	0	0.0511	0.0713	-2.2712	45.0504
Sep 01-30	45.1113	6.5031	2.505	11.124	0.2526	17.0513	0.1811	2.5225	4.8514	0	0.0505	0.07	-1.405	43.7063
Oct 01-31	44.1183	7.0283	2.6509	11.772	0.2588	17.7536	0.3462	2.6069	1.5778	0	0.0517	0.0723	-0.9186	43.1997
Nov 01-30	44.525	7.0744	2.5901	11.502	0.2495	17.226	2.3407	2.5239	0.8984	0	0.0499	0.0702	-0.7488	43.7762
Dec 01-31	45.5334	6.657	2.5658	11.394	0.2619	17.6336	3.7286	2.6066	0.5614	0	0.0524	0.0723	-0.2688	45.2646
Summed Total	**544.8445**	**80.0142**	**31.0445**	**137.862**	**3.0531**	**208.1388**	**17.4639**	**30.6899**	**35.1179**	**0**	**0.6105**	**0.8509**	**-17.1765**	**527.6678**

Sensitivity Test: Increased Occupancy Schedule

Table Appendix C.9 IES Outputs Increased Occupancy Schedule Simulation

	Total Electricity (MWh)	Interior Lighting (MWh)	Exterior Lighting MWh)	Elevators & Escalators (MWh)	Refrigeration (MWh)	Other Process (MWh)	Space Heating (MWh)	Water Heating (MWh)	Space Cooling (MWh)	Interior Central Fans (MWh)	Interior Local Fans (MWh)	Pumps (MWh)	Total Grid Displaced Elec. PV (MWh)	Total Energy (MWh)
Jan 01-31	65.7281	6.8955	2.6509	11.772	0.2588	33.8889	0.8885	8.0984	1.1485	0	0.0517	0.0744	-0.4959	65.2322
Feb 01-28	59.5163	6.3239	2.3834	10.584	0.2341	30.6105	0.7084	7.3147	1.2429	0	0.0468	0.0672	-0.8214	58.6948

Mar 01-31	65.6009	6.7119	2.6509	11.772	0.2588	33.8889	0.5436	8.0984	1.5498	0	0.0517	0.0744	-1.1439	64.457
Apr 01-30	67.0524	6.9059	2.505	11.124	0.2526	32.8022	0.5056	7.8372	4.9969	0	0.0505	0.072	-1.5814	65.471
May 01-31	75.3209	7.2173	2.736	12.15	0.2557	33.8797	0.4658	8.0984	10.3921	0	0.0511	0.0744	-2.6959	72.6251
Jun 01-30	72.4451	6.6162	2.505	11.124	0.2526	32.8022	0.4291	7.8372	10.756	0	0.0505	0.072	-2.4152	70.03
Jul 01-31	76.8631	6.543	2.5658	11.394	0.2619	33.8981	0.457	8.0984	13.5177	0	0.0524	0.0744	-2.4105	74.4526
Aug 01-31	74.9432	5.5377	2.736	12.15	0.2557	33.8797	0.3573	8.0984	11.8024	0	0.0511	0.0744	-2.2712	72.6721
Sep 01-30	71.8595	6.5031	2.505	11.124	0.2526	32.8022	0.3568	7.8372	10.3557	0	0.0505	0.072	-1.405	70.4544
Oct 01-31	66.7991	7.0283	2.6509	11.772	0.2588	33.8889	0.3923	8.0984	2.5829	0	0.0517	0.0744	-0.9186	65.8805
Nov 01-30	64.6121	7.0744	2.5901	11.502	0.2495	32.793	0.6237	7.8372	1.8199	0	0.0499	0.072	-0.7488	63.8633
Dec 01-31	64.8496	6.657	2.5658	11.394	0.2619	33.8981	0.7573	8.0984	1.09	0	0.0524	0.0744	-0.2688	64.5808
Summed Total	825.5902	80.0142	31.0445	137.862	3.0531	399.0326	6.4854	95.3522	71.2549	0	0.6105	0.876	-17.1765	808.4139

Scenario Test: "Low"

Table Appendix C.10 - IES Outputs "Low" Scenario Simulation

	Total Electricity (MWh)	Interior Lighting (MWh)	Exterior Lighting MWh)	Elevators & Escalators (MWh)	Refrigeration (MWh)	Other Process (MWh)	Space Heating (MWh)	Water Heating (MWh)	Space Cooling (MWh)	Interior Central Fans (MWh)	Interior Local Fans (MWh)	Pumps (MWh)	Total Grid Displaced Elec. PV (MWh)	Total Energy (MWh)
Jan 01-31	46.466	6.8955	2.6509	11.772	0.2588	17.7233	3.8922	2.5459	0.6038	0	0.0517	0.0721	-0.4959	45.9702
Feb 01-28	41.7064	6.3239	2.3834	10.584	0.2341	16.0318	3.0915	2.3004	0.6453	0	0.0468	0.0653	-0.8214	40.885
Mar 01-31	44.6834	6.7119	2.6509	11.772	0.2588	17.6685	2.1599	2.5468	0.7907	0	0.0517	0.0723	-1.1439	43.5395
Apr 01-30	41.9829	6.9059	2.505	11.124	0.2526	17.1886	0.6735	2.4653	0.7474	0	0.0505	0.0701	-1.5814	40.4016
May 01-31	47.7467	7.2173	2.736	12.15	0.2557	17.7804	0.3909	2.5483	4.5444	0	0.0511	0.0726	-2.6959	45.0508
Jun 01-30	45.8251	6.6162	2.505	11.124	0.2526	17.1013	0.3109	2.4642	5.3306	0	0.0505	0.0699	-2.4152	43.4099
Jul 01-31	49.1542	6.543	2.5658	11.394	0.2619	17.5743	0.28	2.5475	7.863	0	0.0524	0.0725	-2.4105	46.7437
Aug 01-31	47.2204	5.5377	2.736	12.15	0.2557	17.4062	0.1904	2.5417	6.2804	0	0.0511	0.0713	-2.2712	44.9492
Sep 01-30	44.9769	6.5031	2.505	11.124	0.2526	17.0513	0.1783	2.4646	4.7776	0	0.0505	0.07	-1.405	43.5719
Oct 01-31	43.9843	7.0283	2.6509	11.772	0.2588	17.7536	0.3364	2.5469	1.5135	0	0.0517	0.0723	-0.9186	43.0657

Nov 01-30	44.4629	7.0744	2.5901	11.502	0.2495	17.226	2.3825	2.4658	0.8527	0	0.0499	0.0702	-0.7488	43.7142
Dec 01-31	45.5054	6.657	2.5658	11.394	0.2619	17.6336	3.782	2.5467	0.54	0	0.0524	0.0723	-0.2688	45.2366
Summed Total	**543.7146**	**80.0142**	**31.0445**	**137.862**	**3.0531**	**208.1388**	**17.6683**	**29.9843**	**34.4893**	**0**	**0.6105**	**0.8509**	**-17.1765**	**526.538**

Scenario Test: "High"

Table Appendix C.11 - IES Outputs "High" Scenario Simulation

	Total Electricity (MWh)	Interior Lighting (MWh)	Exterior Lighting MWh)	Elevators & Escalators (MWh)	Refrigeration (MWh)	Other Process (MWh)	Space Heating (MWh)	Water Heating (MWh)	Space Cooling (MWh)	Interior Central Fans (MWh)	Interior Local Fans (MWh)	Pumps (MWh)	Total Grid Displaced Elec. PV (MWh)	Total Energy (MWh)
Jan 01-31	73.6367	6.8955	2.6509	11.772	0.2588	33.8889	0.7381	15.6744	1.6315	0	0.0517	0.0744	-0.4959	73.1408
Feb 01-28	66.7735	6.3239	2.3834	10.584	0.2341	30.6105	0.6266	14.1576	1.739	0	0.0468	0.0672	-0.8214	65.9521
Mar 01-31	73.6974	6.7119	2.6509	11.772	0.2588	33.8889	0.5285	15.6744	2.0854	0	0.0517	0.0744	-1.1439	72.5534
Apr 01-30	76.651	6.9059	2.505	11.124	0.2526	32.8022	0.4839	15.1688	7.2855	0	0.0505	0.072	-1.5814	75.0696
May 01-31	85.133	7.2173	2.736	12.15	0.2557	33.8797	0.4907	15.6744	12.6032	0	0.0511	0.0744	-2.6959	82.437
Jun 01-30	81.9113	6.6162	2.505	11.124	0.2526	32.8022	0.4635	15.1688	12.856	0	0.0505	0.072	-2.4152	79.4962
Jul 01-31	86.6038	6.543	2.5658	11.394	0.2619	33.8981	0.4996	15.6744	15.6398	0	0.0524	0.0744	-2.4105	84.1934
Aug 01-31	84.5433	5.5377	2.736	12.15	0.2557	33.8797	0.3944	15.6744	13.7894	0	0.0511	0.0744	-2.2712	82.2721
Sep 01-30	81.3754	6.5031	2.505	11.124	0.2526	32.8022	0.4004	15.1688	12.4963	0	0.0505	0.072	-1.405	79.9704
Oct 01-31	74.9864	7.0283	2.6509	11.772	0.2588	33.8889	0.4241	15.6744	3.1625	0	0.0517	0.0744	-0.9186	74.0678
Nov 01-30	72.5328	7.0744	2.5901	11.502	0.2495	32.793	0.5868	15.1688	2.4458	0	0.0499	0.072	-0.7488	71.784
Dec 01-31	72.7853	6.657	2.5658	11.394	0.2619	33.8981	0.6373	15.6744	1.5696	0	0.0524	0.0744	-0.2688	72.5164
Summed Total	**930.6299**	**80.0142**	**31.0445**	**137.862**	**3.0531**	**399.0326**	**6.274**	**184.5538**	**87.304**	**0**	**0.6105**	**0.876**	**-17.1765**	**913.4532**

D. General Notes

The report is based on information available at the time of the writing and discussions with the client during any project meetings. Where any data supplied by the client or from other sources have been used it has been assumed that the information is correct. No responsibility can be accepted by Ensphere Group Ltd for inaccuracies in the data supplied by any other party.

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