RIDGE

5025779 - ST MARY'S UNIVERSITY

PLANNING REPORT - ENERGY AND THERMAL ASSESSMENT FOR ST MARY'S R BUILDING REPORT

October 2024

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Prepared for

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Version Control

Project	5025779
Issue Date	28/10//2024
Originator	PD
Checked	TG
Version	PO3

VERSION CONTROL

VERSION	DATE	DESCRIPTION	CREATED BY	REVIEWED BY
PO1	14/08/2024	Draft	YA	TG
PO2	19/08/2024	For Information	YA	TG
PO3	28/10/2024	Design Update	PD	TG

CONTENTS

1. EXECUTIVE SUMMARY

The report outlines the energy and overheating performance of the redevelopment of 'R' Building at St Mary's University, the proposed building is assessed under the following:

- Compliance Modelling for Building Regulations Part L and BREEAM Ene01 credits.
- Operational Energy assessment for Space type Energy Usage Intensities.
- Overheating Assessment using TM52 for BREEAM Hea04 credits
- Low and Zero Carbon Feasibility Analysis for BREEAM Ene04 Low Carbon Design.

1.1. Planning Requirements

The local planning highlights that new buildings over $100m^2$ must provide an Energy Statement outlining compliance with the Energy Hierarchy. This includes:

1. Outlining a minimum on-site reduction of at least 35%, of which 15% is to be achieved through energy efficiency measures (Be Lean and Be Clean Stage of the Energy Hierarchy).
2. Assessment of Low and Zero Carbon technologies available on-site to meet the 20% reduction which must be achieved through on-site renewable energy measures requirement.
3. Assessment of local Decentralised energy networks and CHPs.

This Stage 3 report highlight performance against all the targets highlighted above.

1.2. Planning Results Summary

- The Be Lean and Be Clean measures attained a 18% energy reduction compared to the notional building achieving the 15% reduction aligning with the GLA.
- The addition of Be Green measures using $75m^2$ of Photovoltaics on the roof to achieve a total reduction of 28% covering the 20% additional reduction using on site renewables.
- The LZC feasibility study performed outlines the renewable technologies which were applicable and taken forward for the project with PV and ASHPs being optimal for the project.

1.3. Compliance Summary

The following table shows improvement in carbon emissions against the notional building:

Table 1. Notional and the Building's Emissions Rate comparison table.

BUILDING	TARGET ($kgCO_2/m^2$)	BUILDING ($kgCO_2/m^2$)	REQUIRED IMPROVEMENT	ACTUAL IMPROVEMENT	PASS/FAIL
St Mary's (Be Lean and Be Clean)	4.20	3.41	15%	18.81%	**PASS**
St Mary's (Be Lean, Be Clean and Be Green)	4.20	2.27	35%	45.95%	**PASS**

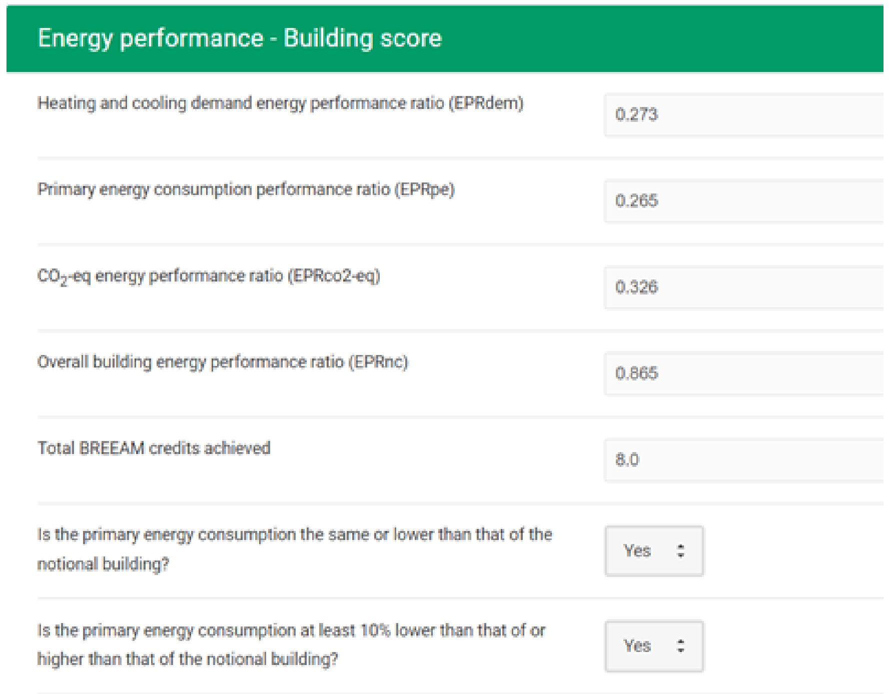
The following table shows improvement in primary energy rate against the notional building:

Table 2. Notional and the Building's Primary Energy Rate comparison table.

BUILDING	TARGET (kWh/m^2)	BUILDING (kWh/m^2)	REQUIRED IMPROVEMENT	ACTUAL IMPROVEMENT	PASS/FAIL
St Mary's (Be Lean and Be Clean)	45.83	37.06	15%	19.14%	**PASS**
St Mary's (Be Lean, Be Clean and Be Green)	45.83	23.80	35%	48.07%	**PASS**

1.4. BREEAM Compliance

St Mary's 'R' Building is projected to achieve 8 credits for Ene01 Reduction of energy use and carbon emissions using the provision of $75m^2$ PV as seen in the image below:



Energy performance - Building score	
Heating and cooling demand energy performance ratio (EPRdem)	0.273
Primary energy consumption performance ratio (EPRpe)	0.265
CO_2-eq energy performance ratio (EPRco2-eq)	0.326
Overall building energy performance ratio (EPRnc)	0.865
Total BREEAM credits achieved	8.0
Is the primary energy consumption the same or lower than that of the notional building?	Yes
Is the primary energy consumption at least 10% lower than that of or higher than that of the notional building?	Yes

Figure 1 BREEAM credits achieved for Proposed St Mary's R Building for Ene01 energy performance

1.5. Thermal Comfort Summary

Building spaces with mechanical cooling will be assessed for sufficient thermal comfort using Predicted Mean Vote (PMV) and Percentage of People Dissatisfied (PPD) measures according to TM52.

The process and results from this analysis will contribute to the building currently achieving the 3/3 credits within the BREEAM issue Hea 04 – Thermal Comfort.

The table below presents the TM52 pass rates summary for all required spaces for this report, the expanded results can be found in appendix 10.3

Table 3 BREEAM Hea04 Thermal Comfort Results.

ST MARY'S R BUILDING	ROOM CONDITIONING TYPE	NUMBER OF COMPLIANT SPACES	PASS/FAIL
Design Summer Year 1	Mechanically Cooled	12 / 12	**PASS**

1.6. Space EUI Summary

An overview of the end users for 'R' building energy usage is defined in figure 2. Small power is the highest end user followed by Interior lighting and auxiliary energy. The building is internally loaded as seen in the estimated results with a higher cooling energy than heating energy.

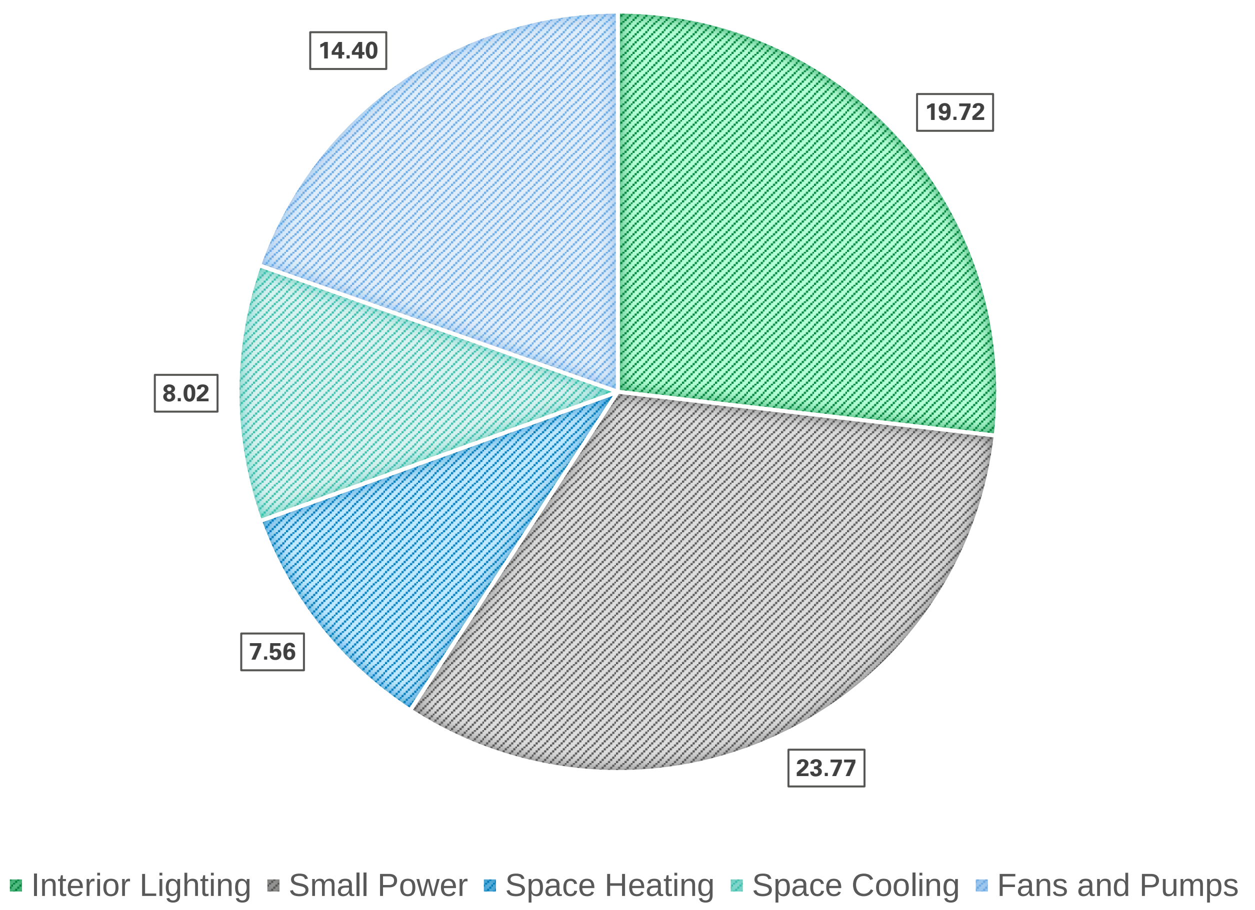


Figure 2 St Mary's R Building estimated energy breakdown per year

1.7. LZC feasibility Study

The feasibility study in Section 9.1 outlines the green measures which have been adopted. Photovoltaics and Air to Water heat pumps have been deemed the most appropriate for the project based on site location, environment conditions, local planning policy restrictions and investment costs.

2. INTRODUCTION

Ridge and Partners LLP have been instructed by St Mary's University to perform the following for the proposed Redevelopment of R Building.

- Compliance Modelling for Building Regulations Part L and BREEAM ENE 01 credits.
- Operational Energy assessment for Space type Energy Usage Intensities.
- Overheating Assessment using TM52 for BREEAM Hea04 Thermal Comfort credits
- Low and Zero Carbon Feasibility Analysis for BREEAM ENE 04 Low Carbon Design

The report will outline compliance of the proposed works with Local Planning policy requirements and Building regulations for compliance.

2.1. Energy Modelling for Compliance

The results presented have been performed using IES VE 2024 (Version 2024.0.0.0) to assess the primary energy rate and emission rate of the actual building against notional target building. Compliance against Building Regulation England Part L is achieved when the actual dwellings outperform the target notional dwelling across both calculation outputs.

The Primary Energy Rate is the annual primary energy use of the building per unit floor area according to the National Calculation Methodology (NCM). Primary energy consists of space heating, water heating, ventilation, and lighting. The expressed energy rate in kWh/m^2/year is also adjusted for any renewable energy generated on site of the dwelling.

The Emission Rate is the annual CO^2 emission per unit floor area due to the primary energy use.

2.2. TM54 Operational Energy Assessment

Building energy estimations made at the design stage for building regulations compliance is often found to be significantly different from actual energy use in a building's operation, this is primary due to the exclusion of unregulated energy uses such as small power, external lighting, lifts etc.

TM54 is a methodology that engineers can use to undertake better-informed calculations of energy use in operation and produce performance targets against which measured performance in use can be compared.

2.3. TM52 Overheating Analysis

Over time due to climate change, urbanisation, and the introduction of winter energy efficiency measures, thermal discomfort from higher temperatures have become an issue in buildings. Occupant thermal discomfort happens in buildings through either poor design, poor management, or inadequate services. CIBSE TM52 is a methodology for predicting the likelihood of a building overheating.

2.4. Qualification

The report and modelling have been updated by Philip Domingue who is a member of CIBSE and an accredited Low Carbon Consultant (LCC) with CIBSE.

The report and the modelling have been reviewed by Tom Green who has 4 years of experience within the industry as an energy modeller. He is a member of CIBSE and is currently working towards his chartership as a Chartered Engineer. He is also registered as a Low Carbon Consultant by CIBSE.

3. METHODOLOGY

The aim of this report is to evaluate the Proposed St Mary's R Building using Operational and Thermal modelling methods. This analysis is performed in the following ways:

- CIBSE Technical Memorandum 52 (TM52) – The limits of thermal comfort: avoiding overheating in European buildings for Thermal Assessment
- CIBSE Technical Memorandum 54 (TM54) – Evaluating operational energy use at the design stage (2022) for Operational Energy Assessment

The proposed development has been assessed through dynamic thermal modelling using Integrated Solutions Virtual Environment (IES VE) 2024 (version 2024.0.0.0) which complies with CIBSE AM11: Building performance modelling (2015b).
IES VE is used by sustainable design experts around the globe as it is an in-depth suite of integrated analysis tools for the design and retrofit of buildings. The platform allows designers to test different options, identify passive solutions, compare low carbon and renewable technologies, and draw conclusions on energy use, CO_2 emissions and occupant comfort.

Figure 1 below is an Illustration of the dynamic simulation model built within IES VE.

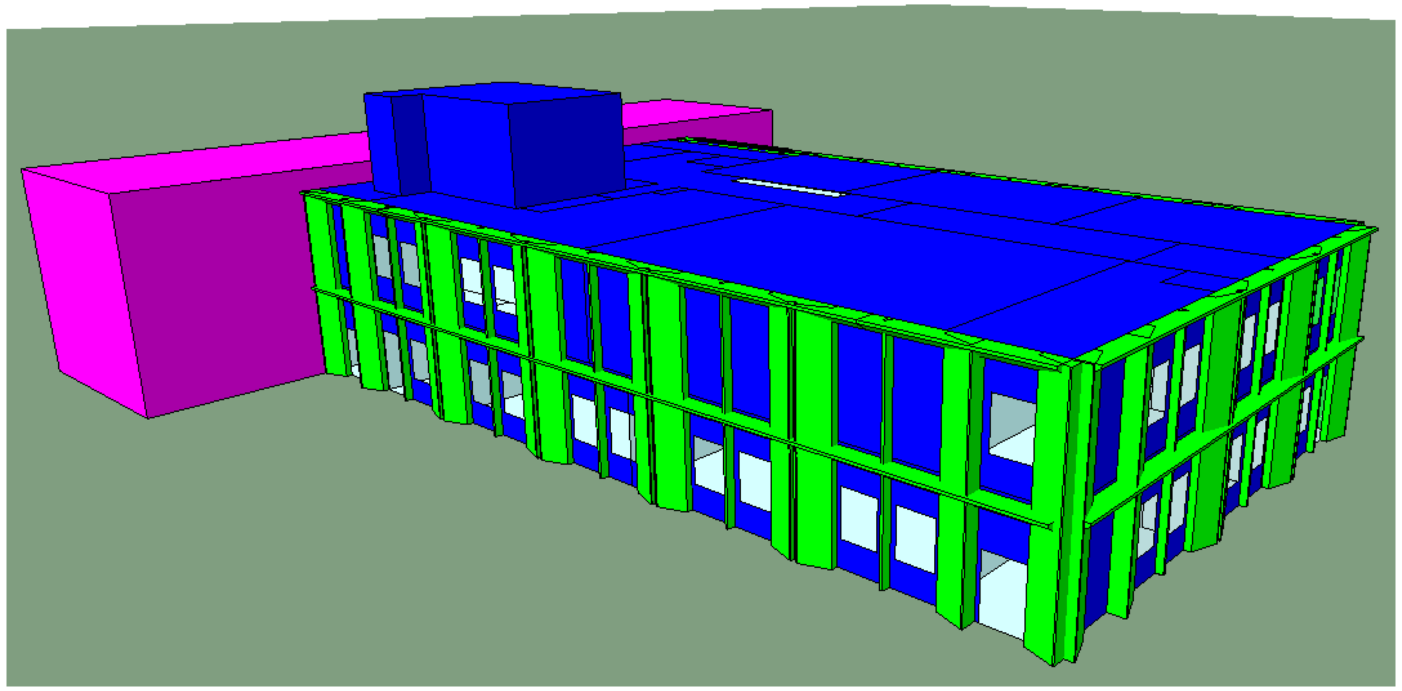


Figure 3 IES VE Model

This report focuses on the results from the specified assessments and the modelling input variables utilised.

The building has also been developed to achieve the overarching requirements of the London Plan outlined in the Greater London Authority (GLA) Energy Assessment Guidance for planning applications.

4. LOCAL PLANNING CONTEXT AND REQUIREMENTS

The proposed development is situated in the London Borough of Richmond upon Thames.

4.1. Local Planning Requirements

The proposed development is situated in the London Borough of Richmond upon Thames which, in 2019, developed a revised local plan. The local plan outlines policies and constraints of the local borough which has been further improved, in June 2020, by a sustainability construction checklist.

Below highlights the relevant local planning policies from Policy LP22:

- All non-residential buildings over 100m² will be required to meet BREEAM 'Excellent' Standard and achieve a minimum 35% energy reduction along with achieving zero carbon standards in line with the London Plan policy.
- Development proposals of a non-residential development of 1,000m², or more, will need to provide an assessment of the provision of on-site decentralised energy (DE) networks and combined heat and power (CHP).
- Where feasible, new development of 50 units or more, or new non-residential development of 1,000m² or more, as well as schemes for the Proposal Sites identified in this Plan, will need to provide on-site DE and CHP; this is particularly necessary within the clusters identified for DE opportunities in the borough-wide Heat Mapping Study. Where on-site provision is not feasible, provision should be made for future connection to a local DE network should one become available.

This is progressed further by the Sustainability Construction Checklist which outlines the following:

Major new non-residential buildings, including extensions, over 1,000sqm floorspace	• Zero carbon standards from 2019 • BREEAM 'Excellent' • Submit energy statement • Submit Sustainable Construction Checklist

Figure 4 - Image of the Construction Requirements of Major non-residential buildings, including extensions, over 1,000m² floorspace

The reference, in Figure 4, to the zero carbon standards from 2019 is a reference to the Greater London Authority local plan.

4.2. Greater London Authority Requirements

The Greater London Authority (GLA) Local Plan adopted in March 2021, outlines the planning policies for the entirety of Greater London, and it also sets the precedent for sustainable design for the UK.

Policy SI2: Minimising greenhouse gas emissions states that major developments should be net zero carbon and should follow the strategy highlighted in Figure 5. The primary part of following the GLA is to align with the energy hierarchy, which has been outlined below.

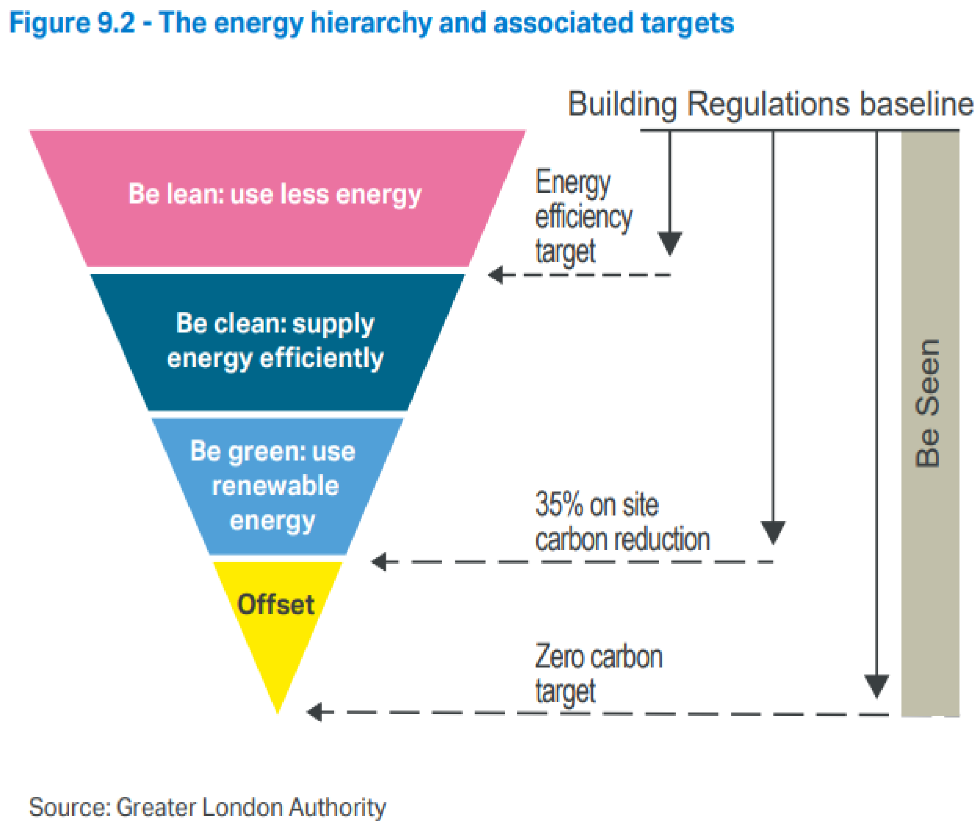


Figure 5 - The Energy Hierarchy from the Greater London Authority

The energy hierarchy above requires the following steps in more detail:

- Be Lean: use less energy and manage demand during operation
- Be Clean: exploit local energy resources (such as secondary heat) and supply energy efficiency and cleanly
- Be Green: maximise opportunities for renewable energy by producing, storing and using renewable energy on site
- Be Seen: monitor, verify and report on energy performance

Through the above energy hierarchy, the following targets must be achieved against Part L requirements:

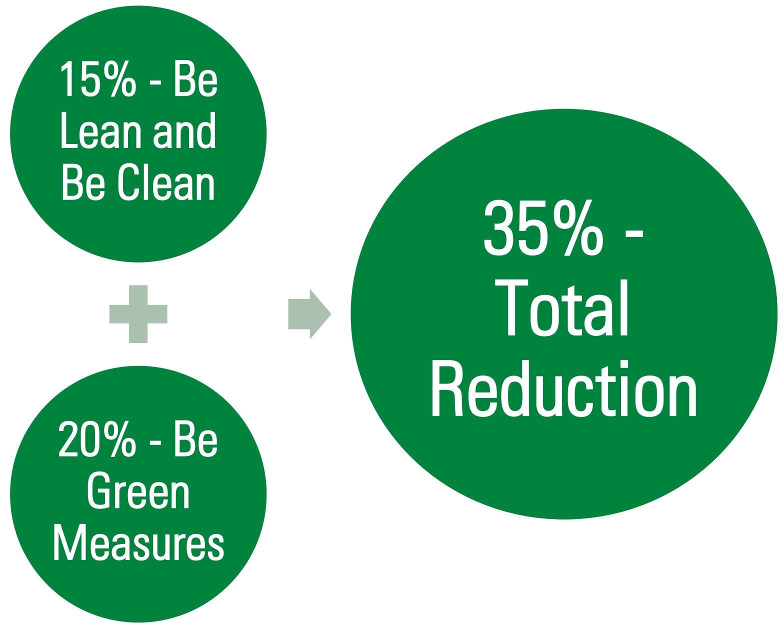


Figure 6. Energy reduction to be achieved for major developments according to the Greater London Authority Local Plan.

5. BREEAM ASSESSMENT CRITERIA

To achieve the Hea 04 Thermal comfort credits, the following is required and has been performed using the overheating assessment.

Table 4 Assessment Criteria for the BREEAM Thermal Comfort credit

	ASSESSMENT CRITERIA	COMPLIANCE DEMONSTRATED
Credit 1: Thermal modelling		
1.	Thermal Modelling to be carried out using software providing full dynamic thermal analysis in accordance with CIBSE AM11.	Use of a CIBSE AM11 complaint software in IES VE 2023 with modelled variables shown in F
2.	The software used to carry out the simulation at the detailed design stage provides full dynamic thermal analysis.	Full dynamic thermal results are provided for each relevant space. These are detailed in the Results Section
3.a	For air-conditioned spaces, summer and winter operative temperature ranges in occupied spaces are in accordance with criteria set out in CIBSE Guide A <u>or</u> the thermal environment in occupied spaces meet the Category B requirements for PPD, PMV and local discomfort.	Compliance with PPD,PMV requirements are presented in Section 10.3 and full DSY results presented Section 14, Section 15, and Section 16. All the rooms pass the assessment.
3.b.i	For naturally ventilated spaces, the winter operative temperature ranges are in accordance with the criteria set out in CIBSE Guide A Environmental design.	
3.b.ii	The building is designed to limit the risk of overheating in accordance with CIBSE TM52 or CIBSE TM59	
4	For air-conditioned buildings, all PMV and PPD indices are reported via the BREEAM assessment scoring and reporting tool.	Indices will be reported in the BREEAM assessment tool
Credit 2: Design for future thermal comfort		
6	Demonstrate that thermal comfort requirements are achieved for a projected climate change environment, or the building has been designed to be easily adapted in future passive design solutions to meet thermal comfort requirements.	Results for projected climate change scenarios are presented in Appendix D and E. All the rooms pass the assessment.
7	Where criteria 6 is not met, the project team demonstrates how the building has been adapted or designed to be easily adapted in future using passive design solutions to subsequently achieve compliance.	
8	For air-conditioned buildings, all PMV and PPD indices are reported via the BREEAM assessment scoring and reporting tool.	Indices will be reported in the BREEAM assessment tool
Credit 3: Thermal Zoning and Controls		
9	Criteria 1 to 4 above are achieved	All the criteria are achieved

	ASSESSMENT CRITERIA	COMPLIANCE DEMONSTRATED
10	Criteria 1 to 4 above has informed the temperature control strategy for the building and its users	Refer to Appendix F
11.a	The strategy for space conditioning systems has addressed different requirements for different zones within the building.	Different ventilation strategies for different zones are outlined in Appendix F
11.b.i	The strategy for space conditioning systems has addressed the degree of occupant control required for these zones and considers user knowledge of building services, occupancy, user interaction with space conditioning systems and user expectations.	Heating controls, ventilation strategies and occupancy considerations have been taken into consideration and outlined in Appendix F
11.c	The strategy for space conditioning systems has addressed how the proposed systems will interact with each other and how this may affect thermal comfort.	The Lecture Hall is conditioned by an AHU with heat recovery exclusively. The Buildings DHW is performed by a roof unit ASHP for efficient performance. Space conditioning where provided will be managed by room level setpoints and done by a roof top unit AHU for Lecture Hall and a combination of radiant panels and chilled beams for teaching, office spaces. Ventilation is provided using an MVHR for teaching spaces and office areas with an extract only system for WCs and plant rooms.
11.d	If there are multiple systems, the strategy for space conditioning systems has addressed the need or otherwise for an accessible building user actuated manual override for any automatic systems.	Local control of space conditioning systems allows manual override.

Under BREEAM Hea 04, occupied spaces are rooms within the assessed building that is likely to be occupied for 30 minutes or more by a building user. Ancillary and support spaces would not be considered for an overheating assessments.

6. APPROACH TO OVERHEATING MITIGATION

The aim of this overheating assessment is to show that the proposed development makes reasonable provisions to reduce unwanted solar gains in the summer and provides an adequate means to remove excess heat from the internal environment.

To predict whether a building will overheat, important physical parameters are considered within the simulations –

- air temperature,
- radiant temperature,
- humidity,
- air movement,
- clothing insulation levels and
- activity information levels.

In this report, the spaces with mechanical cooling through VRF or FCU systems will be assessed for sufficient thermal comfort using Predicted Mean Vote (PMV) and Percentage of People Dissatisfied (PPD) measures according to TM52.

Similarly following the same guidance, free running spaces in the building with no mechanical cooling will be assessed against three overheating criteria described in Section 7.

The separate analysis will maintain most of the same inputs and assumptions.

7. THERMAL COMFORT CRITERIA

According to TM52, a building is providing an adequate internal thermal condition if the occupants are not conscious of the internal temperature. Measures of overheating criteria differ depending on the space's air conditioning strategy.

Free Running Spaces

CIBSE TM52 presents the following criteria for free running spaces to measure the predictive risk of overheating. A room is classed as overheating if any two of the following three criteria are failed.

(a) Criterion 1: Hours of Exceedance
The number of hours that the operative temperature of the space can exceed the maximum acceptable comfort temperature by 1K or more during occupied hours of the non-heating season shall not be more than 3 percent.

The non-heating season is considered from 1st May to 30th September.

(b) Criterion 2: Daily Weighted Exceedance
To consider the severity of overheating, the weighted exceedance shall be less than or equal to 6 in any one day. Weighted exceedance is a sum of the product of the number of degrees the operative temperature exceeds the maximum acceptable comfort temperature and the duration the temperature rise occurs.

(c) Criterion 3: Upper Limit Temperature
To set an absolute maximum value for the indoor temperature, the difference between the operative temperature and maximum acceptable comfort temperature shall not exceed 4K.

Mechanically Cooled Spaces

For mechanically conditions spaces, TM52 considers a space as overheating if the value of the PMV index is above 0.5

PMV is an index that predicts the average value of votes from a group of representative occupants on a seven-point thermal sensation scale as shown below.

Table 5 PMV Index range

COLD	COOL	SLIGHTLY COOL	NEUTRAL	SLIGHTLY WARM	WARM	HOT
-3	-2	-1	0	+1	+2	+3

Under a dynamic simulation PMV is calculated using information on metabolic rates, clothing insulation, air temperature and air velocity.

PMV is used to calculate a PPD which is the quantitative prediction of the percentage of thermal dissatisfied people that are either too warm or too cold.

Maximum Acceptable Temperature

Section 4.1.4 of CIBSE TM52 describes the maximum acceptable temperatures (T_{max}) can be calculated using the following formula. T_{rm} refers to the running outdoor mean temperature. T_{op} is the actual operative temperature of the space.

$$T_{max} = 0.33T_{rm} + 18.8$$

$$\Delta T = T_{op} - T_{max}$$

8. ASSESSMENT OF LOCAL HEAT NETWORKS

Figure 7 (below), which is the London heat network maps, shows that an existing (13,875.64m) or a proposed heat networks (2,224.2m) is not feasible. The distance of the site is extremely high from the proposed and existing heat networks, which makes connection to the local networks not feasible.

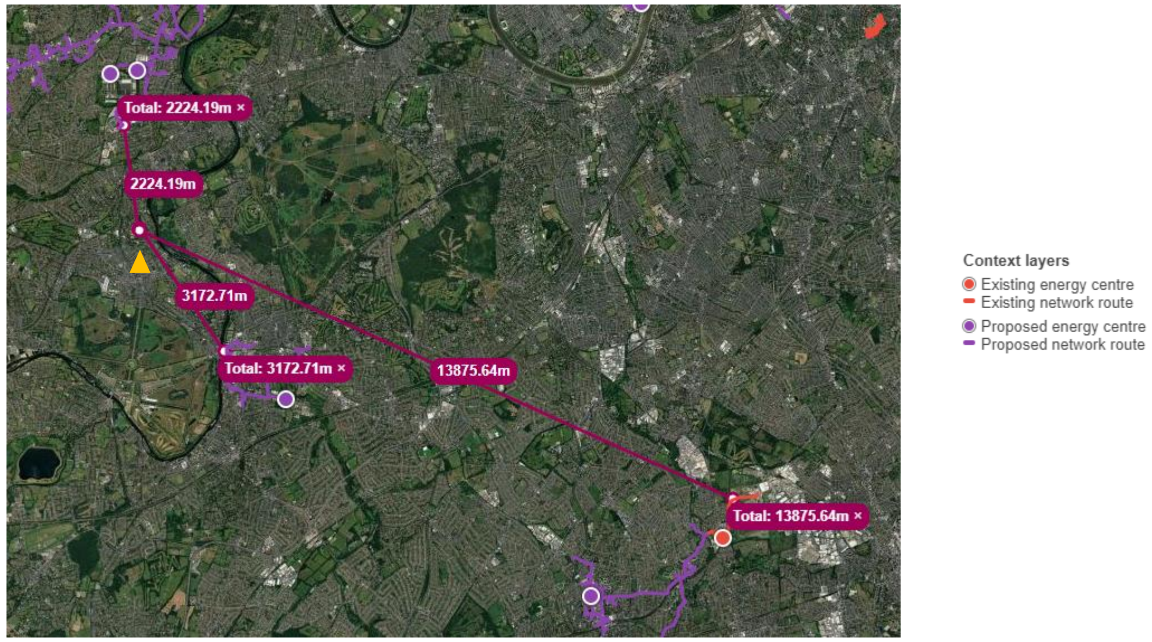


Figure 7 The distance from the existing and proposed heat networks from St Mary's using the London heat map

9. GREEN MEASURES

It is important to understand the building's energy annual consumption to assess the suitability of any Low & Zero Carbon (LZC) technologies. The following section present a preliminary low and zero carbon technology (LZC) feasibility study for the proposed St Mary's R Building.

9.1. Low and Zero Carbon Technologies Feasibility.

Table 6 - Renewable technologies feasibility overview

TECHNOLOGY	CHARACTERISTICS	COMMENTS	FEASIBILITY
Solar Technologies			
Photovoltaics (PV)	Photovoltaic (Solar PV) systems use solar cells to convert sunlight into electricity.	Requires careful orientation and tilt to obtain optimum generation performance. Note that specialist maintenance is required. Access considerations should be considered. Low carbon savings compared to capital cost of installation.	Feasible and Suitable
Solar Thermal	Solar thermal is a system for generating hot water from the sun.	Consideration of adequate DHW demand is required. Low. Note that specialist maintenance is required. Medium carbon savings.	Feasible Not Suitable
Wind Technologies			

TECHNOLOGY	CHARACTERISTICS	COMMENTS	FEASIBILITY
Wind Turbines	Wind turbines convert the wind's kinetic energy into electrical power.	Ideally located in open non-urban areas. Medium. Regular maintenance is required, special consideration for safe access is required. Low to medium carbon savings depending on scale of system.	Not Suitable Not Feasible
Bio-fuel technologies			
Biomass Boilers	Biomass boilers generate heat through burning organic matter.	Direct replacement to existing gas fired system. However careful considerations should be given to fuel storage and availability. Medium. Some technologies are self-cleaning. Quality of fuel might increase the maintenance requirements for these systems. High carbon savings.	Not Suitable Not Feasible
Low Carbon Technologies			
Combined Heat and Power CHP	Combined Heat & Power (CHP) converts a single fuel into both electricity and heat in a single process at the point of use.	Requires predictable and relatively high constant DHW loads for efficient performance. Medium. CHP plant requires regular planned maintenance. Medium carbon savings. Please consider type of fuel for better CO_2 savings.	Not Suitable
Fuel Cells	A fuel cell is a device that generates electricity by a chemical reaction.	Requires predictable and relatively high constant loads for an efficient operation. Medium. Specialist maintenance is required. Medium. Please note that technology is not common. Carbon savings depend on fuel source.	Not Suitable
Air to air heat pumps (Electric or Gas)	Low-temperature heat, which occurs naturally in the air, is converted to high-grade heat by using an electrically driven or gas-powered pump.	Can provide both heating and cooling to an internal environment. Low Specialist maintenance is required. Please note that refrigerants are often use and their impact on the environment requires consider Medium. System can provide both low carbon heating and cooling.	Feasible and Suitable
Ground to air/water heat pumps (Electric)	The principle of operation revolves around the refrigerant (with a very low boiling point) being heated by the ground through an evaporator heat exchanger and pumped by a compressor to the indoor heat exchanger whereby it cools and condenses back to a liquid whilst expelling heat into the space.	System to provide low carbon heating and cooling. Ground conditions will dictate the systems technical feasibility Low maintenance requirements Medium-High carbon savings. Efficiency of the system is highly dependent on heating and cooling flow and return temperatures. Please note it is often associated with high capital costs of installation.	Suitable Not Feasible

TECHNOLOGY	CHARACTERISTICS	COMMENTS	FEASIBILITY
Water Energy			
Hydroelectric / tidal / wave power	Hydro power systems convert the potential energy of elevated water into kinetic energy in a turbine, which drives a generator to produce electricity.	There is flowing water in vicinity of the site, but it would not be cost effective for the Medium. Planned maintenance is required. Medium to high.	Not Suitable Not Feasible

10. RESULTS

10.1. Energy Modelling

GLA Be Lean and Be Clean

To demonstrate the proposed St Mary's R Building complies with the London Plan energy policies, below in Table 7 are the results of its building regulations assessment without the consideration of low and zero carbon technologies.

For this stage of energy analysis, the notional building's system type and performance values are used within the building energy model. This allows a comparison against the minimum Part L 2021 Target Emissions Rate (TER). The building achieves the local planning target of 15% improvement using be lean and be clean measures.

Table 7 Summary of Be Lean and Be Clean Assessment Results

COMPLIANCE MEASURE	TARGET	BUILDING	COMPLIANCE	IMPROVEMENT
Emissions Rate ($kgCO_2/m^2$.annum)	4.20	3.41	**YES**	18.81 %
Primary Energy Rate (kWh_{PE}/m^2.annum)	45.83	37.06	**YES**	19.14 %

The BRUKL for the Be Lean and Be Clean model is shown in Appendix A

Be Green

To maximise the use of renewable energy sources in the development and to comply with GLA requirements, Table 8 below are outcomes of the energy assessments performed with the actual proposed building systems with the provision of $75m^2$ of PV. The building achieves the local planning target of 35% improvement using be lean, be clean and be green measures. As well as the local planning target, the improvement of 46% also passes the GLA requirement of at least 35% improvement.

Table 8 Summary of Results for Be Lean, Be Clean and Be Green measures

COMPLIANCE MEASURE	TARGET	BUILDING	COMPLIANCE	IMPROVEMENT
Emissions Rate ($kgCO_2/m^2$.annum)	4.20	2.27	**YES**	45.95 %
Primary Energy Rate (kWh_{PE}/m^2.annum)	46.83	23.80	**YES**	48.07 %

A copy of the BRUKL Document for the analysis is shown in Appendix B.

10.2. Space type EUIs

The Predicted Operational energy for St Mary's R building is 73.47 kWh/m^2 based on the inputs from the delegated MEP and Architectural team. The buildings energy based on end use is depicted below: The 75m^2 of PV on the roof generates 15,674.1 kWh, 10.24 kWh/m², of energy.

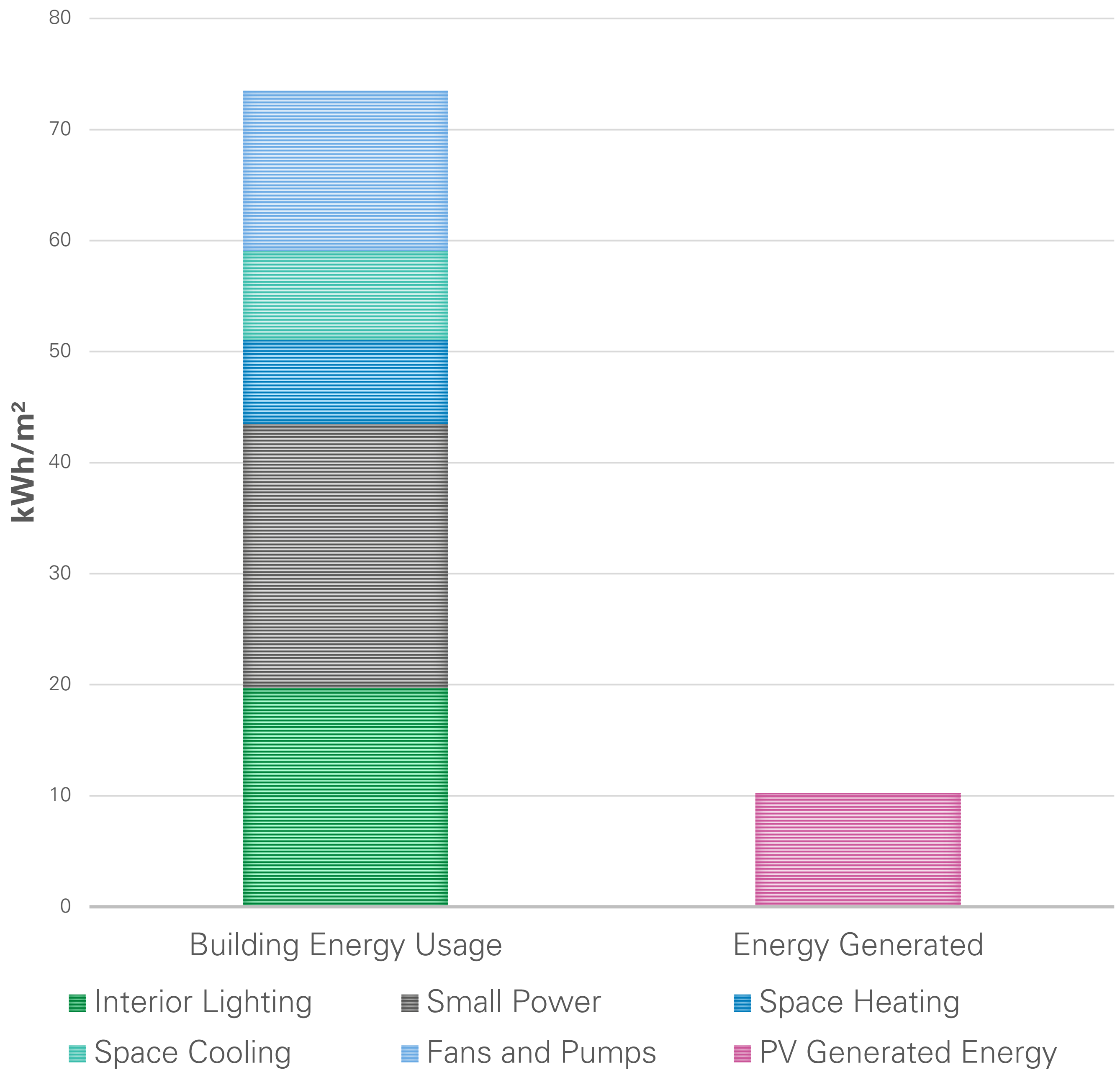


Figure 8 - Energy consumption and PV generated energy for St Mary's R Building

The current overview of the building shows Small Power to be highest end use followed by lighting and auxiliary energy. The equipment and lighting layout is based on CIBSE Guide A values. Due to the high occupancy numbers the ventilation required for the spaces is high leading to high auxiliary energy. The buildings an internally loaded building which requires more cooling than heating.

10.3. Thermal Comfort

The Thermal Comfort assessment for St Mary's Building is assessed with current and future weather files for BREEAM Hea04 Thermal Comfort. The weather file utilised for the assessments based on the proximity of site is:

- Thermal Modelling – London_LHR_DSY1_2020High50

The weather file utilised for design for future comfort credit on the pathway to BREEAM Excellent are:

- London_LHR_DSY2_2020High50
- London_LHR_DSY3_2020High50

The analysis shows that all the rooms pass the assessment based on the current mechanical design as shown in table 9.

The results of these assessments have impacted the design in the following ways:

- Control strategy for heating and cooling mechanical servicing equipment.
- Heating and cooling zones in the building to limit the energy usage of heating and cooling.
- Optimal temperatures for each occupied zone have been refined following this exercise.
- These temperatures have been found to be optimised when controlled by temperatures sensors which safeguards errors produced by building users.

Table 9 BREEAM Hea04 Thermal Comfort Results

R BUILDING	ROOM CONDITIONING TYPE	NUMBER OF COMPLIANT SPACES
Design Summer Year 1	Mechanically Cooled	12 / 12
Design Summer Year 2	Mechanically Cooled	12 / 12
Design Summer Year 3	Mechanically Cooled	12 / 12

Assessed rooms in the proposed buildings results are shown in Appendix C for the current weather file. Appendix D and E show results for the future weather files.

11. CONCLUSION

The report has highlighted how the building performs against the relevant criteria, achieving passes in each necessary planning condition.

- The Be Lean and Be Clean measures attained a 18.81% energy reduction compared to the notional building achieving the 15% reduction aligning with the GLA.

- The addition of Be Green measures using 75m^2 of Photovoltaics on the roof to achieve a total reduction of 27.14% covering the 20% planning condition additional reduction using on site renewables.

- The LZC feasibility study performed outlines the renewable technologies which were applicable and taken forward for the project with PV and ASHPs being optimal for the project.

- An analysis of local heat networks and CHPs found that no connection to an existing or proposed, district heat network can be obtained.

The report has also highlighted the building meets and exceeds the criteria to achieve BREEAM excellent with:

- 8 credits achieved in Ene01 – Energy Performance
- 3 credits achieved in Hea04 – Thermal Overheating

12. APPENDIX A – BE LEAN AND BE CLEAN BRUKL

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2021

Project name

St Mary's University Twickenham with no PV — As designed

Date: Thu Oct 24 14:44:05 2024

Administrative information

Building Details

Address: Waldergrave Road, Strawberry Hill, London, TW1 4SX

Certifier details

Name: Ridge & Partners LLP

Telephone number:

Address: The Cowyards, Bladon, Woodstock, Oxford, OX20 1 QR

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.27

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.27

BRUKL compliance module version: v6.1.e.1

Foundation area [m²]: 704.93

The CO_2 emission and primary energy rates of the building must not exceed the targets

Target CO_2 emission rate (TER), $kgCO_2/m^2annum$	4.2	
Building CO_2 emission rate (BER), $kgCO_2/m^2annum$	3.41	
Target primary energy rate (TPER), kWh_{PE}/m^2annum	45.83	
Building primary energy rate (BPER), kWh_{PE}/m^2annum	37.06	
Do the building's emission and primary energy rates exceed the targets?	BER =< TER	BPER =< TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	First surface with maximum value
Walls*	0.26	0.2	0.2	00000002:Surf[1]
Floors	0.18	0.15	0.15	00000002:Surf[2]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	0.15	0.15	01000000:Surf[3]
Windows** and roof windows	1.6	1.3	1.3	00000002:Surf[0]
Rooflights***	2.2	1.8	1.8	01000012:Surf[0]
Personnel doors^	1.6	-	-	No personnel doors in building
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	No high usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]

* Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.
** Display windows and similar glazing are excluded from the U-value check.
*** Values for rooflights refer to the horizontal position.
^ For fire doors, limiting U-value is 1.8 W/m²K
NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
m³/(h.m²) at 50 Pa	8	3

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	<0.9

1- Rad Panels + MVHR

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.5	-	0.67	-	0.75
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

2- Radiant Panels + Chilled Beams + MVHR

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.5	5.6	0	1.6	0.75
Standard value	2.5*	N/A	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

3- Rads + MVHR

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.5	-	-	-	0.75
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

4- Rads

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.5	-	0.67	-	-
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

5- AHU (H/C/V)

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.5	5.6	0	-	0.75
Standard value	2.5*	5	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

"No HWS in project, or hot water is provided by HVAC system"

Zone-level mechanical ventilation, exhaust, and terminal units

ID	System type in the Approved Documents
A	Local supply or extract ventilation units
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter

NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
00 - Stairs	-	-	-	1.6	-	-	-	-	-	-	N/A
00 - WC Block	-	-	-	1.6	-	-	-	-	-	-	N/A
00 - Stairs	-	-	-	1.6	-	-	-	-	-	-	N/A
00 - Lobby 1	-	-	-	1.6	-	-	-	-	-	-	N/A
00 - Lobby 3	-	-	-	1.6	-	-	-	-	-	-	N/A
00 - Lobby 2	-	-	-	1.6	-	-	-	-	-	-	N/A
01 - Stairs	-	-	-	1.6	-	-	-	-	-	-	N/A
01 - Lecture Hall	-	-	-	2.2	-	-	-	-	-	-	N/A
01 - WC Block	-	-	-	1.6	-	-	-	-	-	-	N/A
01 - Stairs	-	-	-	1.6	-	-	-	-	-	-	N/A
01 - Lobby 5	-	-	-	1.6	-	-	-	-	-	-	N/A
01 - Lobby 4	-	-	-	1.6	-	-	-	-	-	-	N/A

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
00 - Stairs	120	-	-
00 - Anatomage	120	-	-
00 - Clinical Teaching	120	-	-
00 - MEP	120	-	-
00 - WC Block	120	-	-
00 - Mock Emergency Ward	120	-	-
00 - Electrical Room	120	-	-
00 - Store	120	-	-
00 - Clinical Teaching Ward	120	-	-
00 - Stairs	120	-	-
00 - Fire Lobby	120	-	-
00 - Lobby 1	120	-	-
00 - Lobby 3	120	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
00 - Lobby 2	120	-	-
01 - Classroom 3	120	-	-
01 - Stairs	120	-	-
01 - Fire Lobby 1	120	-	-
01 - Lecture Hall	120	-	-
01 - Admin Office	120	-	-
01 - Cupboard	120	-	-
01 - MEP	120	-	-
01 - WC Block	120	-	-
01 - Stairs	120	-	-
01 - Fire Lobby 2	120	-	-
01 - Board Room	120	-	-
01 - Dean's Office	120	-	-
01 - Exec Office	120	-	-
01 - Classroom 1	120	-	-
01 - Classroom 2	120	-	-
01 - Lobby 5	120	-	-
01 - Lobby 4	120	-	-
02 - Plant Room	120	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
00 - Anatomage	NO (-51.3%)	NO
00 - Clinical Teaching	NO (-49.4%)	NO
00 - Mock Emergency Ward	N/A	N/A
00 - Clinical Teaching Ward	NO (-68.9%)	NO
01 - Classroom 3	NO (-68%)	NO
01 - Lecture Hall	N/A	N/A
01 - Admin Office	NO (-57%)	NO
01 - Board Room	NO (-17.4%)	NO
01 - Dean's Office	N/A	N/A
01 - Exec Office	N/A	N/A
01 - Classroom 1	NO (-67.5%)	NO
01 - Classroom 2	NO (-71.3%)	NO

Regulation 25A: Consideration of high efficiency alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	YES
Is evidence of such assessment available as a separate submission?	YES
Are any such measures included in the proposed design?	YES

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m²]	1516.5	1516.5
External area [m²]	2363.9	2363.9
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	623.87	696.94
Average U-value [W/m²K]	0.26	0.29
Alpha value* [%]	25.11	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
	Offices and Workshop Businesses
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
100	**Residential Institutions: Universities and Colleges**
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
	Non-residential Institutions: Libraries, Museums, and Galleries
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
	Others: Miscellaneous 24hr Activities
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	2.78	2.2
Cooling	2.34	2.84
Auxiliary	8.21	9.72
Lighting	6.59	9.05
Hot water	4.53	7.26
Equipment*	38.36	38.36
TOTAL**	**24.45**	**31.06**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	0	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*0*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	73.81	69.26
Primary energy [kWh_{PE}/m^2]	37.06	45.83
Total emissions [kg/m²]	3.41	4.2

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Chilled ceilings/passive chilled beams & mix. vent., [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	33.3	79.1	3	4.3	7.4	3.08	5.1	3.5	5.6
	Notional	20.4	86.4	2	5.2	13	2.78	4.63	----	----
[ST] Split or multi-split system, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	10.2	46.3	0.8	3.1	5.5	3.43	4.19	3.5	5.6
	Notional	14.5	65.4	1.5	3.9	2.3	2.78	4.63	----	----
[ST] Central heating using water: radiators, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	0	0	0	0	9.1	3.29	0	3.5	0
	Notional	0	0	0	0	5.6	2.78	0	----	----
[ST] Central heating using water: radiators, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	37.4	0	3.2	0	12.9	3.29	0	3.5	0
	Notional	25.8	0	2.6	0	8.1	2.78	0	----	----
[ST] Central heating using water: radiators, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	154.6	0	13.1	0	1.9	3.29	0	3.5	0
	Notional	125.8	0	12.6	0	1.9	2.78	0	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2]	= Heating energy demand
Cool dem [MJ/m2]	= Cooling energy demand
Heat con [kWh/m2]	= Heating energy consumption
Cool con [kWh/m2]	= Cooling energy consumption
Aux con [kWh/m2]	= Auxiliary energy consumption
Heat SSEFF	= Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER	= Cooling system seasonal energy efficiency ratio
Heat gen SSEFF	= Heating generator seasonal efficiency
Cool gen SSEER	= Cooling generator seasonal energy efficiency ratio
ST	= System type
HS	= Heat source
HFT	= Heating fuel type
CFT	= Cooling fuel type

13. APPENDIX B – BE LEAN, BE CLEAN AND BE GREEN BRUKL

BRUKL Output Document

HM Government

Compliance with England Building Regulations Part L 2021

Project name

St Mary's University Twickenham with 75 PV

As designed

Date: Thu Oct 24 14:40:43 2024

Administrative information

Building Details

Address: Waldergrave Road, Strawberry Hill, London, TW1 4SX

Certifier details

Name: Ridge & Partners LLP

Telephone number:

Address: The Cowyards, Bladon, Woodstock, Oxford, OX20 1 QR

Certification tool

Calculation engine: Apache

Calculation engine version: 7.0.27

Interface to calculation engine: IES Virtual Environment

Interface to calculation engine version: 7.0.27

BRUKL compliance module version: v6.1.e.1

Foundation area [m²]: 704.93

The CO_2 emission and primary energy rates of the building must not exceed the targets

Target CO_2 emission rate (TER), $kgCO_2/m^2annum$	4.2	
Building CO_2 emission rate (BER), $kgCO_2/m^2annum$	2.27	
Target primary energy rate (TPER), kWh_{PE}/m^2annum	45.83	
Building primary energy rate (BPER), kWh_{PE}/m^2annum	23.8	
Do the building's emission and primary energy rates exceed the targets?	BER =< TER	BPER =< TPER

The performance of the building fabric and fixed building services should achieve reasonable overall standards of energy efficiency

Fabric element	$U_{a-Limit}$	U_{a-Calc}	U_{i-Calc}	First surface with maximum value
Walls*	0.26	0.2	0.2	00000002:Surf[1]
Floors	0.18	0.15	0.15	00000002:Surf[2]
Pitched roofs	0.16	-	-	No pitched roofs in building
Flat roofs	0.18	0.15	0.15	01000000:Surf[3]
Windows** and roof windows	1.6	1.3	1.3	00000002:Surf[0]
Rooflights***	2.2	1.8	1.8	01000012:Surf[0]
Personnel doors^	1.6	-	-	No personnel doors in building
Vehicle access & similar large doors	1.3	-	-	No vehicle access doors in building
High usage entrance doors	3	-	-	No high usage entrance doors in building

$U_{a-Limit}$ = Limiting area-weighted average U-values [W/(m²K)]
U_{a-Calc} = Calculated area-weighted average U-values [W/(m²K)]
U_{i-Calc} = Calculated maximum individual element U-values [W/(m²K)]

* Automatic U-value check by the tool does not apply to curtain walls whose limiting standard is similar to that for windows.

** Display windows and similar glazing are excluded from the U-value check.

*** Values for rooflights refer to the horizontal position.

^ For fire doors, limiting U-value is 1.8 W/m²K

NB: Neither roof ventilators (inc. smoke vents) nor swimming pool basins are modelled or checked against the limiting standards by the tool.

Air permeability	Limiting standard	This building
m³/(h.m²) at 50 Pa	8	3

Building services

For details on the standard values listed below, system-specific guidance, and additional regulatory requirements, refer to the Approved Documents.

Whole building lighting automatic monitoring & targeting with alarms for out-of-range values	YES
Whole building electric power factor achieved by power factor correction	<0.9

1- Rad Panels + MVHR

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.5	-	0.67	-	0.75
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

2- Radiant Panels + Chilled Beams + MVHR

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.5	5.6	0	1.6	0.75
Standard value	2.5*	N/A	N/A	2^	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

^ Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.

3- Rads + MVHR

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.5	-	-	-	0.75
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

4- Rads

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.5	-	0.67	-	-
Standard value	2.5*	N/A	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

5- AHU (H/C/V)

	Heating efficiency	Cooling efficiency	Radiant efficiency	SFP [W/(l/s)]	HR efficiency
This system	3.5	5.6	0	-	0.75
Standard value	2.5*	5	N/A	N/A	N/A
Automatic monitoring & targeting with alarms for out-of-range values for this HVAC system					YES

* Standard shown is for all types >12 kW output, except absorption and gas engine heat pumps.

"No HWS in project, or hot water is provided by HVAC system"

Zone-level mechanical ventilation, exhaust, and terminal units

ID	System type in the Approved Documents
A	Local supply or extract ventilation units
B	Zonal supply system where the fan is remote from the zone
C	Zonal extract system where the fan is remote from the zone
D	Zonal balanced supply and extract ventilation system
E	Local balanced supply and extract ventilation units
F	Other local ventilation units
G	Fan assisted terminal variable air volume units
H	Fan coil units
I	Kitchen extract with the fan remote from the zone and a grease filter
NB: Limiting SFP may be increased by the amounts specified in the Approved Documents if the installation includes particular components.	

Zone name	SFP [W/(l/s)]									HR efficiency	
ID of system type	A	B	C	D	E	F	G	H	I		
Standard value	0.3	1.1	0.5	2.3	2	0.5	0.5	0.4	1	Zone	Standard
00 - Stairs	-	-	-	1.6	-	-	-	-	-	-	N/A
00 - WC Block	-	-	-	1.6	-	-	-	-	-	-	N/A
00 - Stairs	-	-	-	1.6	-	-	-	-	-	-	N/A
00 - Lobby 1	-	-	-	1.6	-	-	-	-	-	-	N/A
00 - Lobby 3	-	-	-	1.6	-	-	-	-	-	-	N/A
00 - Lobby 2	-	-	-	1.6	-	-	-	-	-	-	N/A
01 - Stairs	-	-	-	1.6	-	-	-	-	-	-	N/A
01 - Lecture Hall	-	-	-	2.2	-	-	-	-	-	-	N/A
01 - WC Block	-	-	-	1.6	-	-	-	-	-	-	N/A
01 - Stairs	-	-	-	1.6	-	-	-	-	-	-	N/A
01 - Lobby 5	-	-	-	1.6	-	-	-	-	-	-	N/A
01 - Lobby 4	-	-	-	1.6	-	-	-	-	-	-	N/A

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
00 - Stairs	120	-	-
00 - Anatomage	120	-	-
00 - Clinical Teaching	120	-	-
00 - MEP	120	-	-
00 - WC Block	120	-	-
00 - Mock Emergency Ward	120	-	-
00 - Electrical Room	120	-	-
00 - Store	120	-	-
00 - Clinical Teaching Ward	120	-	-
00 - Stairs	120	-	-
00 - Fire Lobby	120	-	-
00 - Lobby 1	120	-	-
00 - Lobby 3	120	-	-

General lighting and display lighting	General luminaire	Display light source	
Zone name	Efficacy [lm/W]	Efficacy [lm/W]	Power density [W/m²]
Standard value	95	80	0.3
00 - Lobby 2	120	-	-
01 - Classroom 3	120	-	-
01 - Stairs	120	-	-
01 - Fire Lobby 1	120	-	-
01 - Lecture Hall	120	-	-
01 - Admin Office	120	-	-
01 - Cupboard	120	-	-
01 - MEP	120	-	-
01 - WC Block	120	-	-
01 - Stairs	120	-	-
01 - Fire Lobby 2	120	-	-
01 - Board Room	120	-	-
01 - Dean's Office	120	-	-
01 - Exec Office	120	-	-
01 - Classroom 1	120	-	-
01 - Classroom 2	120	-	-
01 - Lobby 5	120	-	-
01 - Lobby 4	120	-	-
02 - Plant Room	120	-	-

The spaces in the building should have appropriate passive control measures to limit solar gains in summer

Zone	Solar gain limit exceeded? (%)	Internal blinds used?
00 - Anatomage	NO (-51.3%)	NO
00 - Clinical Teaching	NO (-49.4%)	NO
00 - Mock Emergency Ward	N/A	N/A
00 - Clinical Teaching Ward	NO (-68.9%)	NO
01 - Classroom 3	NO (-68%)	NO
01 - Lecture Hall	N/A	N/A
01 - Admin Office	NO (-57%)	NO
01 - Board Room	NO (-17.4%)	NO
01 - Dean's Office	N/A	N/A
01 - Exec Office	N/A	N/A
01 - Classroom 1	NO (-67.5%)	NO
01 - Classroom 2	NO (-71.3%)	NO

Regulation 25A: Consideration of high efficiency alternative energy systems

Were alternative energy systems considered and analysed as part of the design process?	YES
Is evidence of such assessment available as a separate submission?	YES
Are any such measures included in the proposed design?	YES

Technical Data Sheet (Actual vs. Notional Building)

Building Global Parameters

	Actual	Notional
Floor area [m²]	1516.5	1516.5
External area [m²]	2363.9	2363.9
Weather	LON	LON
Infiltration [m³/hm²@ 50Pa]	3	3
Average conductance [W/K]	623.87	696.94
Average U-value [W/m²K]	0.26	0.29
Alpha value* [%]	25.11	10

* Percentage of the building's average heat transfer coefficient which is due to thermal bridging

Building Use

% Area	Building Type
	Retail/Financial and Professional Services
	Restaurants and Cafes/Drinking Establishments/Takeaways
	Offices and Workshop Businesses
	General Industrial and Special Industrial Groups
	Storage or Distribution
	Hotels
	Residential Institutions: Hospitals and Care Homes
	Residential Institutions: Residential Schools
100	**Residential Institutions: Universities and Colleges**
	Secure Residential Institutions
	Residential Spaces
	Non-residential Institutions: Community/Day Centre
	Non-residential Institutions: Libraries, Museums, and Galleries
	Non-residential Institutions: Education
	Non-residential Institutions: Primary Health Care Building
	Non-residential Institutions: Crown and County Courts
	General Assembly and Leisure, Night Clubs, and Theatres
	Others: Passenger Terminals
	Others: Emergency Services
	Others: Miscellaneous 24hr Activities
	Others: Car Parks 24 hrs
	Others: Stand Alone Utility Block

Energy Consumption by End Use [kWh/m²]

	Actual	Notional
Heating	2.78	2.2
Cooling	2.34	2.84
Auxiliary	8.21	9.72
Lighting	6.59	9.05
Hot water	4.53	7.26
Equipment*	38.36	38.36
TOTAL**	**24.45**	**31.06**

* Energy used by equipment does not count towards the total for consumption or calculating emissions.
** Total is net of any electrical energy displaced by CHP generators, if applicable.

Energy Production by Technology [kWh/m²]

	Actual	Notional
Photovoltaic systems	9.09	0
Wind turbines	0	0
CHP generators	0	0
Solar thermal systems	0	0
Displaced electricity	*9.09*	*0*

Energy & CO_2 Emissions Summary

	Actual	Notional
Heating + cooling demand [MJ/m²]	73.81	69.26
Primary energy [kWh$_{PE}$/m²]	23.8	45.83
Total emissions [kg/m²]	2.27	4.2

HVAC Systems Performance

System Type		Heat dem MJ/m2	Cool dem MJ/m2	Heat con kWh/m2	Cool con kWh/m2	Aux con kWh/m2	Heat SSEEF	Cool SSEER	Heat gen SEFF	Cool gen SEER
[ST] Chilled ceilings/passive chilled beams & mix. vent., [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	33.3	79.1	3	4.3	7.4	3.08	5.1	3.5	5.6
	Notional	20.4	86.4	2	5.2	13	2.78	4.63	----	----
[ST] Split or multi-split system, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	10.2	46.3	0.8	3.1	5.5	3.43	4.19	3.5	5.6
	Notional	14.5	65.4	1.5	3.9	2.3	2.78	4.63	----	----
[ST] Central heating using water: radiators, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	0	0	0	0	9.1	3.29	0	3.5	0
	Notional	0	0	0	0	5.6	2.78	0	----	----
[ST] Central heating using water: radiators, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	37.4	0	3.2	0	12.9	3.29	0	3.5	0
	Notional	25.8	0	2.6	0	8.1	2.78	0	----	----
[ST] Central heating using water: radiators, [HS] ASHP, [HFT] Electricity, [CFT] Electricity										
	Actual	154.6	0	13.1	0	1.9	3.29	0	3.5	0
	Notional	125.8	0	12.6	0	1.9	2.78	0	----	----
[ST] No Heating or Cooling										
	Actual	0	0	0	0	0	0	0	0	0
	Notional	0	0	0	0	0	0	0	----	----

Key to terms

Heat dem [MJ/m2]	= Heating energy demand
Cool dem [MJ/m2]	= Cooling energy demand
Heat con [kWh/m2]	= Heating energy consumption
Cool con [kWh/m2]	= Cooling energy consumption
Aux con [kWh/m2]	= Auxiliary energy consumption
Heat SSEFF	= Heating system seasonal efficiency (for notional building, value depends on activity glazing class)
Cool SSEER	= Cooling system seasonal energy efficiency ratio
Heat gen SSEFF	= Heating generator seasonal efficiency
Cool gen SSEER	= Cooling generator seasonal energy efficiency ratio
ST	= System type
HS	= Heat source
HFT	= Heating fuel type
CFT	= Cooling fuel type

14. APPENDIX C TM52 DSY 1 RESULTS

Table 10 Results for overheating assessment with DSY 1

SPACE	PMV MIN / MAX (-0.5 < PMV < +0.5)	PPD MIN / MAX (<10%)	COMPLIANCE
00 - Anatomage	-0.23 / 0.42	5.00 / 8.62	✓
00 - Clinical Teaching	-0.23 / 0.39	5.00 / 8.12	✓
00 - Clinical Teaching Ward	-0.23 / 0.38	5.00 / 7.97	✓
00 - Mock Emergency Ward	-0.23 / 0.41	5.00 / 8.50	✓
01 - Admin Office	-0.42 / 0.29	5.00 / 8.70	✓
01 - Board Room	-0.31 / 0.41	5.00 / 8.47	✓
01 - Classroom 1	-0.23 / 0.30	5.00 / 6.91	✓
01 - Classroom 2	-0.23 / 0.37	5.00 / 7.87	✓
01 - Classroom 3	-0.23 / 0.35	5.00 / 7.49	✓
01 - Dean's Office	-0.45 / 0.24	5.00 / 9.14	✓
01 - Exec Office	-0.44 / 0.23	5.00 / 9.06	✓
01 - Lecture Hall	-0.39 / 0.37	5.00 / 8.21	✓

15. APPENDIX D TM52 DSY 2 RESULTS

Table 11 Results for overheating assessment with DSY 2

SPACE	PMV MIN / MAX (-0.5 < PMV < +0.5)	PPD MIN / MAX (<10%)	COMPLIANCE
00 - Anatomage	-0.23 / 0.42	5.00 / 8.70	✓
00 - Clinical Teaching	-0.23 / 0.39	5.00 / 8.23	✓
00 - Clinical Teaching Ward	-0.23 / 0.38	5.00 / 8.01	✓
00 - Mock Emergency Ward	-0.23 / 0.41	5.00 / 8.54	✓
01 - Admin Office	-0.42 / 0.31	5.00 / 8.70	✓
01 - Board Room	-0.31 / 0.44	5.00 / 9.02	✓
01 - Classroom 1	-0.24 / 0.31	5.00 / 6.98	✓
01 - Classroom 2	-0.23 / 0.38	5.00 / 7.93	✓
01 - Classroom 3	-0.24 / 0.35	5.00 / 7.57	✓
01 - Dean's Office	-0.46 / 0.24	5.00 / 9.43	✓
01 - Exec Office	-0.45 / 0.23	5.00 / 9.28	✓
01 - Lecture Hall	-0.41 / 0.37	5.00 / 8.46	✓

16. APPENDIX E TM52 DSY 3 RESULTS

Table 12 Results for overheating assessment with DSY 3

SPACE	PMV MIN / MAX (-0.5 < PMV < +0.5)	PPD MIN / MAX (<10%)	COMPLIANCE
00 - Anatomage	-0.23 / 0.41	5.00 / 8.52	☑
00 - Clinical Teaching	-0.23 / 0.37	5.00 / 7.87	☑
00 - Clinical Teaching Ward	-0.24 / 0.39	5.00 / 8.10	☑
00 - Mock Emergency Ward	-0.23 / 0.41	5.00 / 8.58	☑
01 - Admin Office	-0.46 / 0.28	5.00 / 9.44	☑
01 - Board Room	-0.31 / 0.42	5.00 / 8.75	☑
01 - Classroom 1	-0.23 / 0.31	5.00 / 7.02	☑
01 - Classroom 2	-0.23 / 0.38	5.00 / 7.98	☑
01 - Classroom 3	-0.23 / 0.36	5.00 / 7.64	☑
01 - Dean's Office	-0.47 / 0.24	5.00 / 9.57	☑
01 - Exec Office	-0.46 / 0.23	5.00 / 9.44	☑
01 - Lecture Hall	-0.42 / 0.37	5.00 / 8.66	☑

17. APPENDIX F: MODELLING VARIABLES

17.1. Model

To complete the Part L2 compliance assessment, a 3D model was built in IES Ve 2023 software, the figure shows the model.

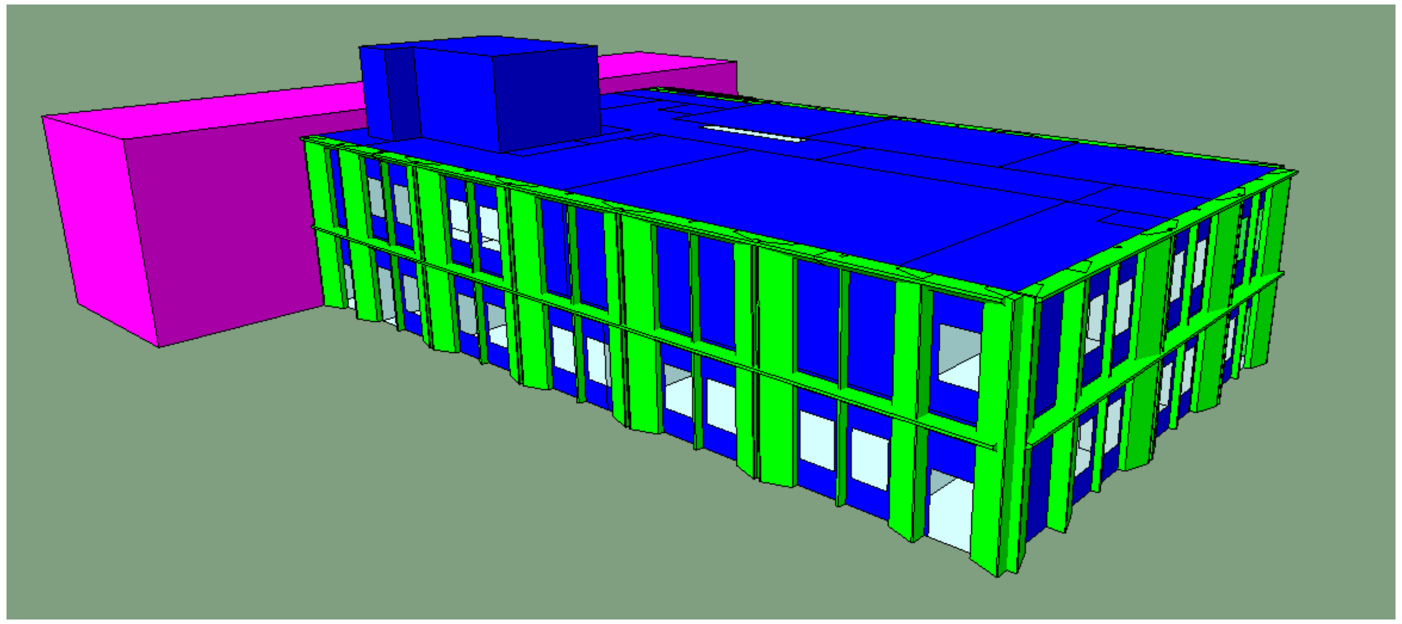


Figure 9 - IES Model from the South-east

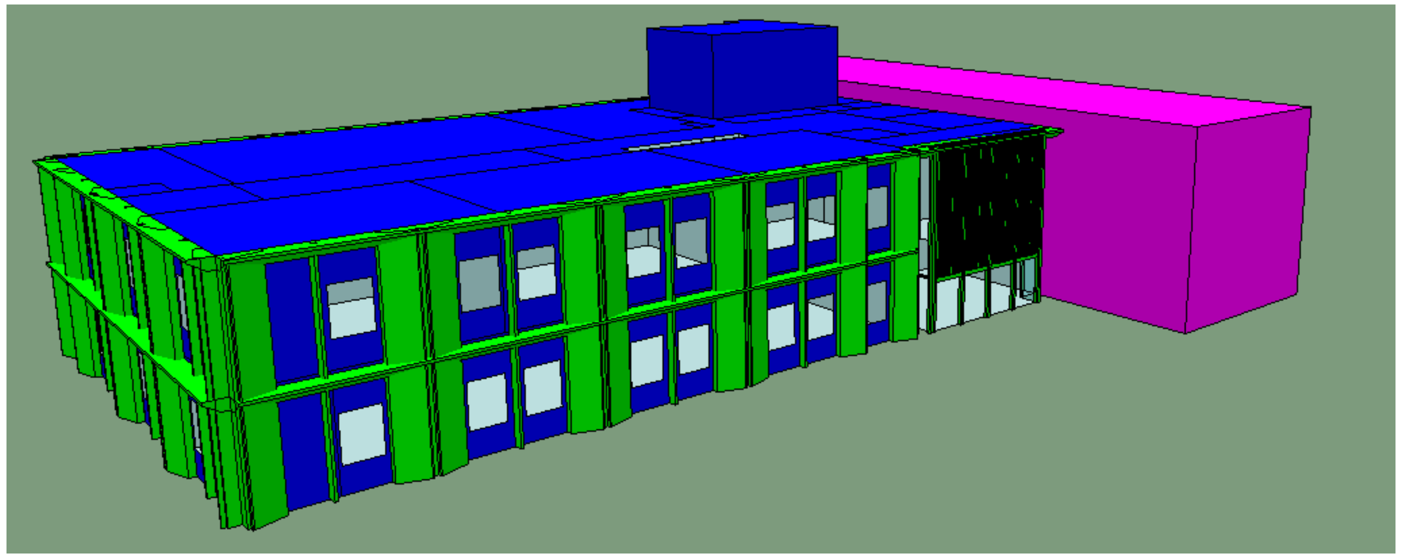


Figure 10 - IES Model from the North-east

17.2. Building Information

The IES 3D model geometry, location and orientation were based on drawings that have been extracted from the following Revit Model:

- STMA-RDG-ZZ-ZZ-M-A-000001 – Revit Model
- STMA-RDG-ZZ-ZZ-M-A-000002 – Revit Model

17.3. Location and Weather data

The site is located in Twickenham. Part L states that CIBSE Test Reference Year (TRY) weather files that are as proximate as possible should be used to assess the proposed design. Therefore, the weather file for London (LondonTRY.fwt) has been used to model the conditions of the site most accurately for the Operational Energy assessment and compliance Modelling.

17.4. Architectural Specification

External Fabric Thermal Performance

The following thermal fabric performances have been applied to the model which have been compared building regulations level, the notional building performance level and LETI levels, Net Zero standards.

Table 13. Fabric performance options for the proposed R building compared to LETI, Notional and Part L values.

BUILLDING ELEMENT	U-VALUES PART L (W/M^2K)	U-VALUES NOTIONAL (W/M^2K)	U-VALUES ST MARY'S PROPOSED (W/M^2K)	U-VALUES LETI (W/M^2K)
Roof	0.18	0.15	0.15	0.10
External Wall	0.26	0.18	0.20	0.13
Ground floor	0.18	0.15	0.15	0.09
Windows	1.60	1.40	1.30	1.00
Rooflights	2.20	2.10	1.80	1.00
Pedestrian Doors	1.60	1.90	1.40	1.20
Window G value	-	-	0.40	-
Roof G value	-	-	0.30	-

Table 14. Air permeability

Infiltration Rates	PART L	NOTIONAL	ACTUAL	LETI
Air Permeability Rate ($m^3/m^2.h$)	8.00	3.00	3.00	1.00

Outlined below are the NCM room groups used in the modelling of the St Mary's University R Building.

Table 15. NCM Modelling Types Applied

ROOM GROUP	NCM BUILDING TYPE	NCM
01. WCs	C2: University or College	Toilet
02. Lecture Theatre	C2: University or College	Hall/lecture theatre/assembly area
03. Classrooms	C2: University or College	Classroom
04. Anatomage	C2: University or College	Classroom
05. Clinical teaching	C2: University or College	Classroom
06. Lobby	C2: University or College	Circulation
07. Voids	C2: University or College	

ROOM GROUP	NCM BUILDING TYPE	NCM
08. Offices	C2: University or College	Office
09. Board Room and Meeting Room	C2: University or College	Office (Meeting)
10. Admin Office	C2: University or College	Office (Open)
11. Stores	C2: University or College	Cupboard
12. Circulation	C2: University or College	Circulation
13. Plant Room	C2: University or College	Light Plant Room

17.5. Mechanical Specification

The set points are based on the range of set points from CIBSE Guide A Table 1.5 for Naturally ventilated rooms and The cooled rooms which are complaint with BREEAM HEA04 Thermal Modelling set point criteria.

Table 16. Setpoints for the Baseline

ROOM	HEATING SET POINT (°C)	COOLING SET POINT (°C)
00 - Anatomage	22	25
00 - Clinical Teaching	21	25
00 - Clinical Teaching Ward	21	25
00 - Electrical Room		
00 - Fire Lobby	19	25
00 - Lift		
00 - Lift		
00 - Lobby 1	19	25
00 - Lobby 2	19	25
00 - Lobby 3	19	25
00 - MEP		
00 - Mock Emergency Ward	21	25
00 - Stairs	19	25
00 - Stairs	19	25
00 - Store		
00 - WC Block	19	25
01 - Admin Office	21	25
01 - Board Room	21	25
01 - Classroom 1	21	25
01 - Classroom 2	21	25
01 - Classroom 3	21	25
01 - Cupboard		
01 - Dean's Office	21	25
01 - Exec Office	21	25
01 - Fire Lobby 1	19	25
01 - Fire Lobby 2	19	25
01 - Lecture Hall	19	25
01 - Lift		
01 - Lift		
01 - Lobby 4	19	25
01 - Lobby 5	19	25
01 - MEP		
01 - Stairs	19	25
01 - Stairs	19	25
01 - WC Block	19	25
02 - Plant Room		

Details of the modelled mechanical building services are summarised below:

Modelled Mechanical System Efficiency

Table 17. Modelled Mechanical Systems Outline

SYSTEM	SOURCE	LOCATION SERVED	HEATING SCOP	COOLING SEER	HEAT RECOVERY	SFP (W/L.S)
AHU(H/C/V)	Air Source Heat Pump	Lecture Theatre	3.50	5.60	75%	2.20
Radiant Panels + Chilled Beams + MVHR	Air Source Heat Pump	Teaching Spaces and Offices	3.50	5.60	75%	1.60
Radiant Panels + MVHR	Air Source Heat Pump	Circulation Spaces	3.50		75%	1.60

SYSTEM	SOURCE	LOCATION SERVED	HEATING SCOP	COOLING SEER	HEAT RECOVERY	SFP (W/L.S)
Radiators + MVHR	Air Source Heat Pump	EWCs	3.50		75%	1.60
Radiators	Air Source Heat Pump	Store	3.50			
DHW (Part L only)	Air Source Heat Pump	Whole Building	3.50			

17.6. Part L Lighting Specification

For the nature of the ApacheSim calculation, an assumed efficacy of 120 lm/W was assumed for the Part L calculations. This is compliant with the minimum requirement being 95 lm/W.

17.7. Small Power

The tables below are a summary of the input gains for the assessed spaces utilised in the Operational energy and Overheating assessments. The building is operational from 09:00 to 17:00 Monday to Friday during which all the internal gains are running.

Table 18 Health centre Internal Gain Inputs

SPACES	OCCUPANCY (PEOPLE)	EQUIPMENT LOAD (W/M²)	LIGHTING LOAD (W/M²)
00 - Anatomage	48	15	10
00 - Clinical Teaching	38	15	10
00 - Clinical Teaching Ward	36	15	10
00 - Electrical Room		5	
00 - Fire Lobby		5	10
00 - Lift			
00 - Lift			
00 - Lobby 1		5	10
00 - Lobby 2		5	10
00 - Lobby 3		5	10
00 - MEP		5	0
00 - Mock Emergency Ward	36	15	10
00 - Stairs		5	10
00 - Stairs		5	10
00 - Store			
00 - WC Block		5	10
01 - Admin Office	36	15	10
01 - Board Room	12	15	10
01 - Classroom 1	36	15	10
01 - Classroom 2	24	15	10
01 - Classroom 3	48	15	10
01 - Cupboard			
01 - Dean's Office	1	15	10
01 - Exec Office	1	15	10
01 - Fire Lobby 1	2	5	10
01 - Fire Lobby 2	2	5	10
01 - Lecture Hall	165	15	10
01 - Lift	14		
01 - Lift	14		
01 - Lobby 4	2	5	10
01 - Lobby 5	2	5	10
01 - MEP		10	0
01 - Stairs		5	10
01 - Stairs		5	10
01 - WC Block		5	10
02 - Plant Room			10

17.8. Ventilation Strategy

The building is largely served by mechanical supply and extract ventilation systems with heat recovery. Below is a summary of the specified ventilation rates applied to the spaces.

Table 19 Health centre room mechanical ventilation rates

SPACE	MAX VENTILATION RATE
00 - Anatomage	480.00l/s
00 - Clinical Teaching	380.00l/s
00 - Clinical Teaching Ward	380.00l/s

SPACE	MAX VENTILATION RATE
00 - Electrical Room	n/a
00 - Fire Lobby	0.70 ACH
00 - Lift	n/a
00 - Lift	n/a
00 - Lobby 1	0.70 ACH
00 - Lobby 2	0.70 ACH
00 - Lobby 3	0.70 ACH
00 - MEP	1.00 ACH
00 - Mock Emergency Ward	380.00l/s
00 - Stairs	0.00 l/s
00 - Stairs	0.00 l/s
00 - Store	n/a
00 - WC Block	8 ACH
01 - Admin Office	540 l/s
01 - Board Room	120 l/s
01 - Classroom 3	360 l/s
01 - Classroom 1	240 l/s
01 - Classroom 2	480 l/s
01 - Cupboard	n/a
01 - Dean's Office	15 l/s
01 - Exec Office	15 l/s
01 - Fire Lobby 1	0.70 ACH
01 - Fire Lobby 2	0.70 ACH
01 - Lecture Hall	1815 l/s
01 - Lift	n/a
01 - Lift	n/a
01 - Lobby 4	0.70 ACH
01 - Lobby 5	0.70 ACH
01 - MEP	1.00 ACH
01 - Stairs	0.00 l/s
01 - Stairs	0.00 l/s
01 - WC Block	245.60 l/s
02 - Plant Room	1 ACH

17.9. PMV/PPD Inputs

According to CIBSE Guide A Table 1.5 the clothing values for various rooms have been presented in the table below.

Table 20 Clothing Insulation (CLO) levels

SPACE	MINIMUM CLO	MAXIMUM CLO
00 - Anatomage	0.60	1.00
00 - Clinical Teaching	0.60	1.00
00 - Clinical Teaching Ward	0.60	1.00
00 - Mock Emergency Ward	0.60	1.00
01 - Admin Office	0.70	0.90
01 - Board Room	0.70	0.90
01 - Classroom 3	0.60	1.00
01 - Classroom 1	0.60	1.00
01 - Classroom 2	0.60	1.00
01 - Dean's Office	0.70	0.90
01 - Exec Office	0.70	0.90
01 - Lecture Hall	0.60	1.00

This table below presents the associated metabolic rate (MET) of activity expected from the room occupants in different spaces.

Table 21 Occupant Activity Metabolic Rates

ACTIVITY	MET	SPACES APPLIED
Sedentary work, Standing	1.40	00 – Anatomage, 00 – Clinical Teaching, 00 – Clinical Teaching Ward, 00 – Fire Lobby, 00 – Lobby 1, 00 – Lobby 2, 00 – Lobby 3, 00 – Mock Emergency Ward, 00 – Stairs, 00 – Stairs, 01 – Classroom 1, 01 – Classroom 02, 01 – Classroom 03, 01 – Fire Lobby 1, 01 – Fire Lobby 2, 01 – Lecture Hall, 01 – Lobby 4, 01 – Lobby 5, 01 – stairs, 01 - Stairs
Seated Office work	1.20	01 – Admin Office, 01 – Board Room, 01 – Dean's Office, 01 – Exec office

Operative temperature calculation requires the modelled air speed in a space to be set at 0.1m/s and relative humidity of 50% based on CIBSE TM52.

18. APPENDIX G: DETAILED LZC FEASIBILITY ASSESSMENT

18.1. Solar Photovoltaics

System Description

Photovoltaic (Solar PV) systems use solar cells to convert sunlight into electricity. These cells consist in either one or two layers of a semi-conducting material, usually silicon. When light shines on the cells it creates an electric field across the layers, causing electricity to flow. The greater the light intensity the greater the flow of electricity. There are three basic kinds of solar cells:

- Mono-crystalline: Typical efficiency = 21%
- Polycrystalline: Typical efficiency = 15%
- Thin film: Typical efficiency = 19%

In the northern hemisphere, this technology is ideally located on inclined south-facing facades or roofs of a building. The units work at their highest efficiency when inclined between 20-40° from horizontal and facing within 20° of due south.

Key Consideration

ADVANTAGES	DISADVANTAGES
Electrical generating technology – good for a building with a large electrical load.	Significantly reduced output during winter months particularly during snowy conditions
A true renewable technology.	
Tried and tested technology with good payback periods.	
Large area of roof available to install PV – ideal.	

Land Use / Roof Use

Suitable roof area for this technology must refer to the sensitivity of the system's performance to orientation, tilt angle and local shading obstructions. The building's roof would allow for solar panels to be orientated and tilted in a favourable location.

Local Planning Criteria

Local authorities can sometimes impose restrictions where glare from reflected sunlight off the panels could cause nuisance or problems with the local area. Advice should be sought from the relevant body within the Reading planning requirement.

Noise

The panels themselves are silent as they have no moving parts, however the only source of minor noise may be the inverter. This piece of equipment is not usually located anywhere near a frequently occupied space for safety reasons; therefore, noise is not considered to be an issue for this technology.

Possibility of electricity export

Should the generation of electricity from the PV system exceed the requirement of the building at any point, it can be exported and sold to the grid. Utilities providers typically offer two different rates for the electricity based upon the predictability of electricity exported. Suitable measures and infrastructure to enable the system to export electricity are typically inexpensive and relatively simple for small systems, but co-ordination with the local district network operator is usually necessary.

Available Grants

Currently none available

Summary

Due to the orientation and height of the neighbouring building being the same as the proposed building there will be no shading. The only limitation is PV on the roof cannot protrude more than 0.2 m based on the council policy which limits the height of the panel. The roof area is 750 m^2 requiring only 75m^2 to achieve planning policy reduction of 35%. This makes PV panels a feasible option as an energy generation source for the site.

18.2. Solar Thermal

System Description

Solar thermal is a system for generating hot water from the sun. Typical systems consist of a circulation loop filled with glycol that runs from a solar Collection box into a hot water storage tank. In the solar collection box, the sun heats the glycol coil with brings the heat into the hot water tank effectively acting as an electric emersion heater, heating the water in the tank. This type of system can act alone as a water heater or as a pre-heat, bringing the mains water up in temperature before it is heated to LTHW temperatures (for heating) or domestic hot water temperatures.

Key Consideration

ADVANTAGES	DISADVANTAGES
Low running costs.	Usually a long payback period.
Not carbon intensive.	Requires a hot water storage tank, sometimes an additional one.
Minimal upkeep.	Takes space away from more efficient PV panel on a roof array.
Small operating costs.	
Can add efficiency to an existing system.	
Eligible for renewable heat incentive.	

Land Use / Roof Use

Most commonly installed as a roof mounted system.

Local Planning Criteria

Local authorities can sometimes impose restrictions where glare from reflected sunlight off the panels could cause nuisance or problems with the local area. Advice should be sought from the relevant body within the Reading planning requirement.

Noise

The panels themselves are mostly silent save for the occasional sound of running water. There is a pump in the plant room but depending on the system, this will shut off once the water begins moving. This piece of equipment is not usually located anywhere near a frequently occupied space for safety reasons, therefore noise is not considered to be an issue for this technology.

Possibility of electricity export

None.

Available Grants

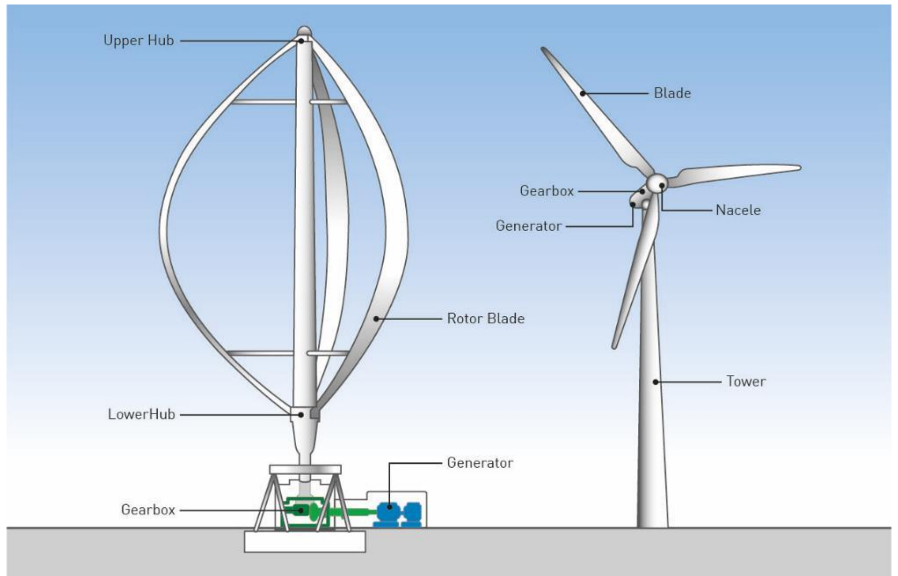
Currently none available

Summary

Solar thermal hot water is not a great technology for the R Building project as similar gains are likely to be achieved with solar panels and heat pumps along with the fact that the DHW demand for the building is not high due to the building being a higher educational institution with low DHW demand. The cost effectiveness for this technology is not high as the peak performance is during summer and the lack of storage tank proves the point of the technology not being feasible for the project.

18.3. Wind Turbines

System Description



Wind turbines harness the power of the wind and use it to generate electricity. Wind turbines use large blades to catch the wind. When the wind blows, the blades are forced round, driving a turbine which generates electricity. The stronger the wind, the more electricity produced.

There are two types of domestic-sized wind turbines:

- Pole mounted: these are free standing and are erected in a suitably exposed position, often about 5kW to 6kW.
- Building mounted: these are smaller than mast mounted systems and can be installed on the roof of a home where there is a suitable wind resource. Often these are around 1kW to 2kW in size.

Key Consideration

ADVANTAGES	DISADVANTAGES
Reduced electricity bills: Once the initial installation fee is paid, electricity costs will be reduced.	Maintenance costs can be £100-£200 per year but can get as expensive at £2000 if the inverter need to be replaced.
Reduced carbon footprint: Wind electricity is green, renewable energy and doesn't release any harmful carbon dioxide or other pollutants.	Lifespan can be longer than 20 years, but battery lifespan is only 6 to 10 years.
	Noisy.
	Not suitable for urban environments with tall buildings and increased turbulence.

Land Use / Roof Use

Either ground or building mounted.

Local Planning Criteria

Small scale turbines are allowed in Reading.

Noise

Noise complaints are common for urban installations.

Possibility of electricity export

Should the generation of electricity from the turbines exceed the requirement of the building at any point, it can be exported and sold to the grid. Utilities providers typically offer two different rates for the electricity based upon the predictability of electricity exported. Suitable measures and infrastructure to enable the system to export electricity are typically inexpensive and relatively simple for small systems, but co-ordination with the local district network operator is usually necessary.

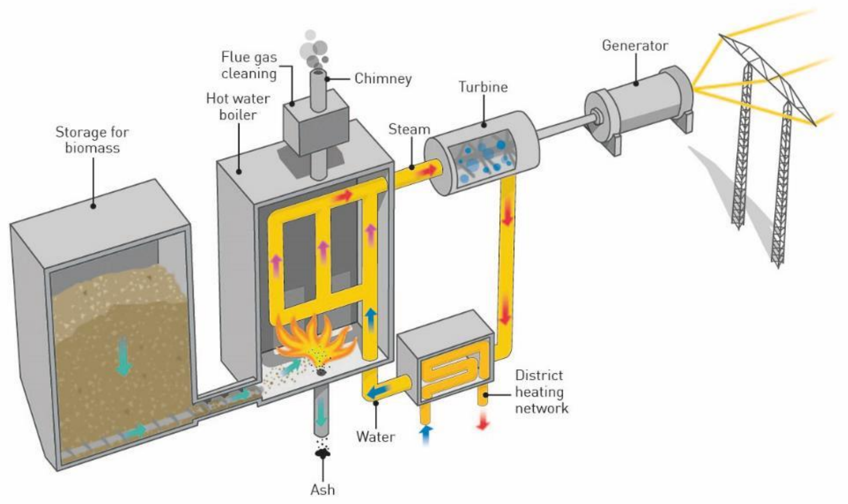
Available Grants

Wind turbines are eligible for Feed-in Tariffs clients will be paid for the electricity generated by the system. They will also receive another payment for the electricity you export.

Summary

The investment for wind turbines and their maintenance costs are extremely high. The implication of the wind turbine effecting the local biodiversity and eco system of the environment plays a role in this technology not being feasible for the project. The Local plan also states that this technology is not suitable.

18.4. Biomass Boilers



System Description

Wood-fuelled heating systems, also called biomass systems, burn wood pellets, chips or logs to provide warmth in a single room or to power central heating and hot water boilers.

Key Consideration

ADVANTAGES	DISADVANTAGES
Often cheaper than other heating options	Ash removal necessary
A low carbon heating option – lower if biomass is sourced locally	Cost
Funding available	Some councils require planning permission for flues
	Space
	Large delivery trucks required to deliver fuel
	Fire hazard in the basement of the Grade I listed church

Land Use

The boilers are large but storage for the biomass must be considered as well

Local Planning Criteria

Commonly accepted by local planning authorities if:

- Flues on the rear or side elevation of the building are no more than a meter above the highest part of the roof
- In a conservation area or a World Heritage site, the flue is not to be fitted on the principal or side elevation if it would be visible from a highway
- The building is not listed or in a designated area (in which case you may need permission for internal alterations too)
- In Scotland, the flue is not in an Air Quality Management Area
- If the project also requires an outside building to store fuel or related equipment the same rules apply to that building as for other extensions and garden outbuildings

Noise

Will generate noise both from circulator pumps, fuel feeders and the burning of the biomass. This piece of equipment is not usually located anywhere near a frequently occupied space for safety reasons; therefore, noise levels will be decreased.

Possibility of electricity export

No.

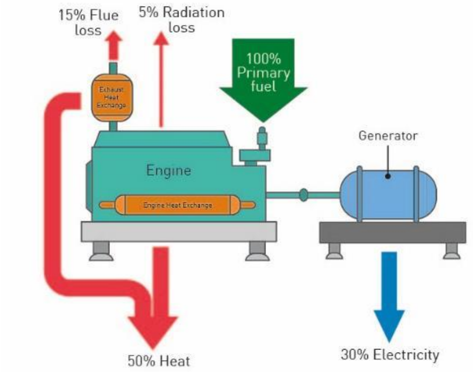
Available Grants

Can benefit from Renewable Heat Incentive

Summary

Unfortunately, due to site space restrictions and the necessary large deliveries of fuel this method is deemed unfeasible for the site. The implication of obtaining the fuel from certifiable sources plays an underlying requirement along with the cost for transportation makes it a problem. As well as the move away from fossil fuels, makes the technology unsuitable.

18.5. Combined Heat and Power (CHP)



System Description

Combined Heat & Power (CHP) converts a single fuel into both electricity and heat in a single process at the point of use. CHP is highly energy efficient and as well as supplying heat and power, it can deliver a number of positive financial, operational and environmental benefits.

CHP is a well-proven technology, recognized worldwide as a viable alternative to traditional centralized generation. With CHP, an engine which is normally fuelled by natural gas, is linked to an alternator to produce electricity. CHP maximizes the fuel and converts it into electricity at around 35% efficiency and heat at around 50%. Heat is recovered from the engine by removal from the exhaust, water jacket and oil cooling circuits. Typically, a good CHP scheme can deliver an efficiency increase of anything up to 25% compared to the separate energy systems it replaces.

Key Consideration

ADVANTAGES	DISADVANTAGES
Stabilized electricity costs over a fixed period	Cost
Reduce primary energy use	Creation of excess heat that will need to be dumped (unless it can be tied into a local system serving heat to local houses
Reduced CO_2 emissions	Fuel delivery and storage for biomass
Reduce transmission losses	Maintenance costs can be high

Can use biomass, gas or oil

Land Use
Needs a large area for the plant and storage of fuel

Local Planning Criteria
Same permissions needed as those for biomass boilers

Noise
Not significant. This piece of equipment is not usually located anywhere near a frequently occupied space for safety reasons, therefore noise is not considered to be an issue for this technology.

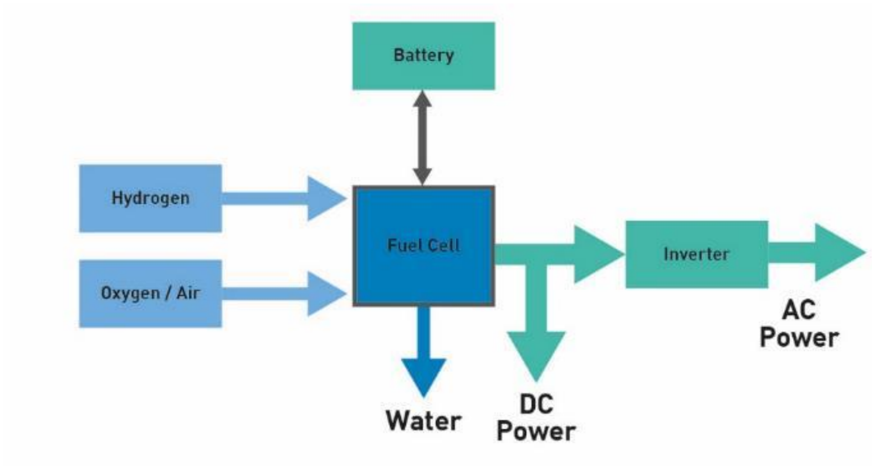
Possibility of electricity export
Not likely. Commonly heat is overproduced, requiring more intensive delivery to external sources than electricity.

Available Grants
No, but there are assistance schemes to recoup capital and running costs (https://www.local.gov.uk/costs-and-funding-combined-heat-and-power). If biomass is used, the plant is eligible for Renewable Heat Incentive money.

Summary

The electricity and heating production are directly paired, overproduction and therefore dumping of heat is common. The building is internally loaded making dumping of heat a problem which will lead to overheating and creating an non-optimal environment. Without a use for this excess heat, the CHP is less efficient. It is therefore not recommended for the project.

18.6. Fuel Cells



System Description
A fuel cell is a device that generates electricity by a chemical reaction. Every fuel cell has two electrodes, one positive and one negative, called, respectively, the anode and cathode. The reactions that produce electricity take place at the electrodes.

One great appeal of fuel cells is that they generate electricity with very little pollution—much of the hydrogen and oxygen used in generating electricity ultimately combine to form a harmless by-product, namely water.
Hydrogen does not occur free in nature; it can be made by "re-forming" natural gas or another fossil fuel, or by using electricity to split ("electrolyze") water into its components of oxygen and hydrogen.

Key Consideration

ADVANTAGES	DISADVANTAGES
Most abundant element.	Hydrogen is currently very expensive because it's difficult to generate, handle, and store, requiring bulky and heavy or complex insulating bottles if stored as a cryogenic (super-cold) liquid.
Hydrogen has the highest energy content.	It can be stored at moderate temperatures this is currently very expensive.
Hydrogen is non-polluting: The only by-product of hydrogen when it burns is heat and water.	Hydrogen is most commonly separated by coal or natural gas – which are not-renewable.
Hydrogen is a renewable fuel source: The trick is to break the water molecules down to release it which can be energy and carbon intensive.	It is highly flammable.
	Hydrogen is difficult to transport in large quantities.

Land Use
Plant can be relatively small but storage of Hydrogen is dangerous and should be carefully analysed for health and safety risks.

Local Planning Criteria
Currently no formalized route for the approval of hydrogen and fuel cell installations. Full guidelines can be found at: http://www.hse.gov.uk/research/rrpdf/rr715.pdf.

Noise
None.

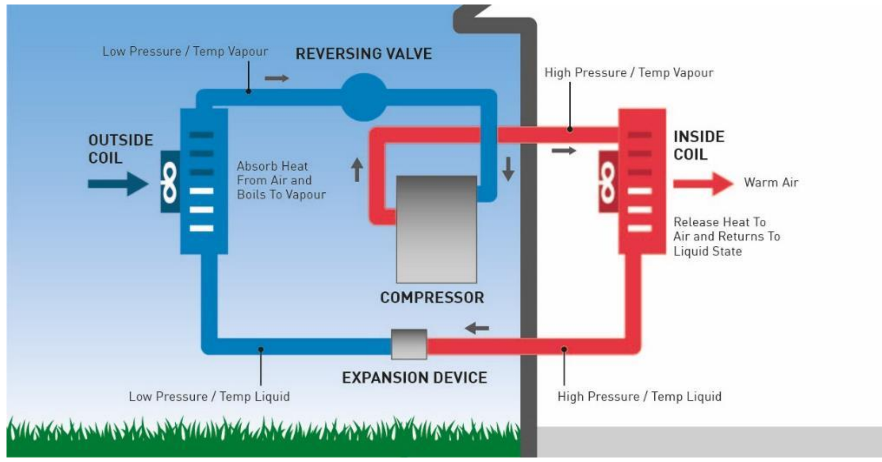
Possibility of electricity export
Potential, but excess is not produced at peak times as with PV panels. It is therefore dependent on the current price of electricity if selling it would make sense.

Available Grants
Not currently.

Summary

Fuel cells are not common and whilst there are no moving parts or high maintenance costs, the risks associated with the technology and its infrequent use makes it unviable for the project.

18.7. Air to Air/Water heat pumps



System Description

Air source heat pumps (ASHP) absorb heat from the outside air. This heat can then be used to heat radiators, underfloor heating systems, or warm air convectors and hot water in your home.

An ASHP extracts heat from the outside air in the same way that a fridge extracts heat from its inside. It can get heat from the air even when the temperature is as low as -15° C. Heat pumps have some impact on the environment as they need electricity to run, but the heat they extract from the ground, air, or water is constantly being renewed naturally.

Key Consideration

ADVANTAGES	DISADVANTAGES
Minimal maintenance.	Some occupants find terminals unsightly.
Provide heating and cooling.	Condensers can be noisy.
No fuel deliveries.	Cost.
Coefficient of Performance (COP) is between 2 and 3.	Not as low carbon an option if using mains electricity.
Pairs well with PV panels as there is no transmission loss making the ASHP more efficient.	
Works well with underfloor heating.	

Land Use

Externally mounted condensers can take up a fairly large amount of space.

Local Planning Criteria

Since the end of 2011, if you live in England, all heat pumps (air, ground and water) are considered a permitted development, so no planning permission is required. Different outcomes apply however if you live in a listed property, conservation area or a world heritage site. Additionally, this provision is only applicable to ASHPs that are used for heating only. Further guidance can be found here: https://www.thegreenage.co.uk/tech/heat-pumps-and-planning-permission/.

Noise

Condensers are noisy and become more so when they are under a heavy load. Care should be taken where they are placed, and appropriate action taken to limit noise pollution

Possibility of electricity export

No.

Available Grants

Yes, through the Renewable Heat Incentive.

Summary

ASHPs would be a good choice to deliver both heating and cooling to the building. The unit can be set up on the roof performing all the required space conditioning using indoor room-based supply units. The high efficiency for modern units makes it a feasible option for utilising in the project.

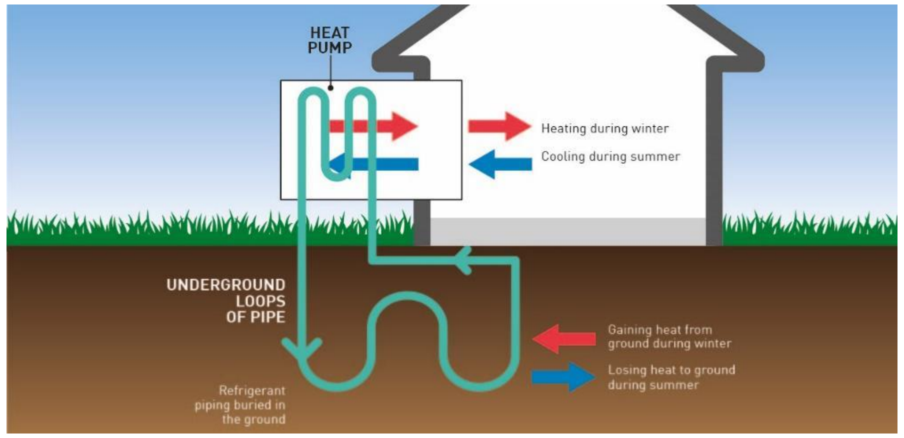
18.8. Ground to Air/Water heat pumps

System Description

For a ground source heat pump (GSHP), heat from the ground is absorbed at low temperatures into a fluid inside a loop of pipe (a ground loop) buried underground. The fluid then passes through a compressor that raises it to a higher temperature, which can then heat water for the heating and hot water circuits of the house.

Normally the loop is laid flat or coiled in trenches about two metres deep, but if there is not enough space, a vertical loop down into the ground to a depth of up to 100 metres can be run. Heat pumps have some impact on the environment as they need electricity to run, but the heat they extract from is constantly being renewed naturally. The loop can also be installed in the piles of the building which reduces the environmental impact and decreases the cost of earthworks.

Key Consideration



ADVANTAGES	DISADVANTAGES
Minimal maintenance.	Some occupants find terminals unsightly.
Provide heating and cooling.	Costs more, primarily due to installation than an ASHP – can be less costly if pile loops are used.
No fuel deliveries.	Not as low carbon an option if using mains electricity.
Higher COP than ASHPs of around 4 rather than between 2 and 3.	
Pairs well with PV panels as there is no transmission loss making the GSHP more efficient.	

Works well with underfloor heating.

Land Use

If pile loops are not used, extensive ground works need to be carried out to bury the thermal loops.

Local Planning Criteria

Since the end of 2011, if you live in England, all heat pumps (air, ground and water) are considered a permitted development, so no planning permission is required. Different outcomes apply however if you live in a listed property, conservation area or a world heritage site. Additional guidance can be found here: https://www.thegreenage.co.uk/tech/heat-pumps-and-planning-permission/.

Noise

With no condensers, GSHPs are relatively quiet although circulator pumps will generate some noise.

Possibility of electricity export

No.

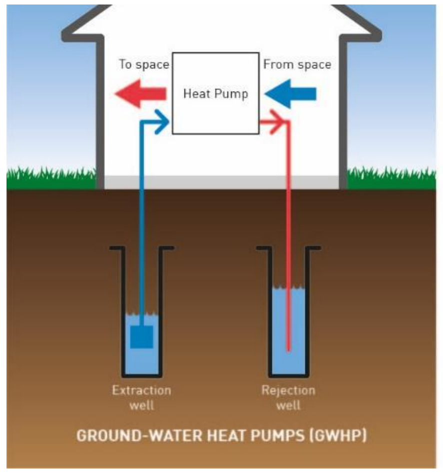
Available Grants

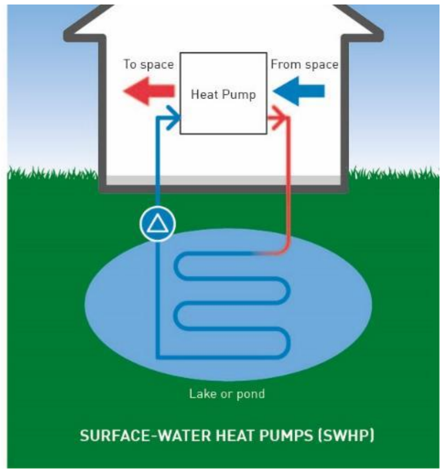
Yes, through the Renewable Heat Incentive.

Summary

The investment is extremely high for the payback period and the suitability for the ground conditions would require an additional assessment making it a low-level option for feasibility.

18.9. Water to Air/Water heat pumps





System Description

An Open Water Heat Pump system works by recovering the solar energy stored naturally in river water or open water. The water then passes through heat pumps to yield its low-grade heat before being returned to the river with a temperature change of 3°C. The Energy Secretary has described water source heat pumps as "game changing" in relation to Britain's need for renewable energy.

Water source heat pumps (WSHP) work the same way as ASHPs and GSHPs where the thermal loops collect heat or cold and deliver it to the unit to be converted.

Key Consideration

ADVANTAGES	DISADVANTAGES
Minimal maintenance.	Some occupants find terminals unsightly.
Provide heating and cooling.	Stricter environmental regulations are faced if open loops are used.
No fuel deliveries.	Cannot store summer heat in the water to extract in the winter.
The high thermal capacity of water promotes an efficient transfer of energy.	Loops are more easily damaged by recreational activities or the environment as they are installed in waterbodies.
Has a much larger area of heat to draw from as it is a liquid based heat store.	Not as low carbon an option if using mains electricity.
Pairs well with PV panels as there is no transmission loss.	
Works well with underfloor heating.	

Land Use

Require access to bodies of water.

Local Planning Criteria

Since the end of 2011, if you live in England, all heat pumps (air, ground and water) are considered a permitted development, so no planning permission is required. Different outcomes apply however if you live in a listed property, conservation area or a world heritage site. Additional guidance can be found here: https://www.thegreenage.co.uk/tech/heat-pumps-and-planning-permission/.

Noise

With no condensers, WSHPs are relatively quiet although circulator pumps will generate some noise.

Possibility of electricity export

No.

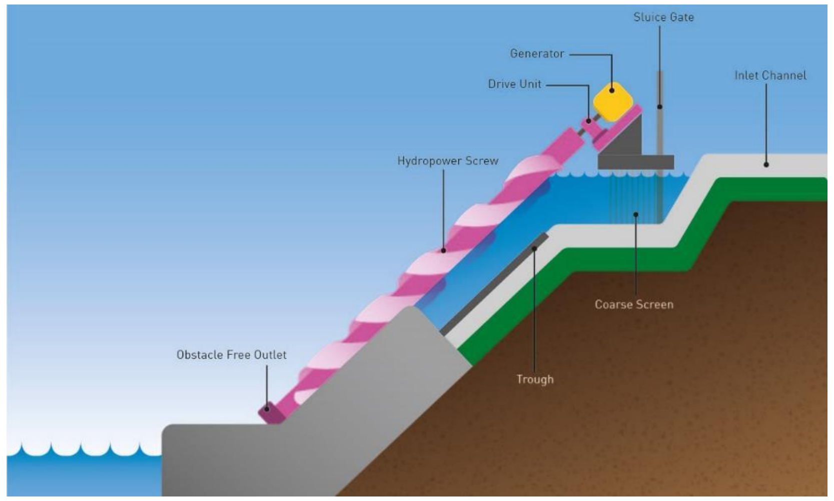
Available Grants

Yes, through the Renewable Heat Incentive.

Summary

River Thames is in vicinity of the site but the high-level investment, utilisation of the mains electricity in the building and lack of performance during winter makes this a low-level option for feasibility.

SMALL SCALE HYDROELECTRIC



System Description

Hydro power systems convert the potential energy of elevated water into kinetic energy in a turbine, which drives a generator to produce electricity. The greater the height and the more water there is flowing through the turbine, the more electricity can be generated.

The amount of electricity a system generates depends on how efficiently it converts the power of the moving water into electrical power.

Key Consideration

ADVANTAGES	DISADVANTAGES
Efficient energy store: it takes only two gallons per minute to generate electricity with micro-hydro.	Requires flowing water nearby.
Reliable: follows electricity demand in the UK with higher rainfall in the winter.	Reduced production in the summer months.
No fuel deliveries.	

Land Use

Disruption is likely to the flow of the waterway but not a great deal of space is required for small scale instalments.

Local Planning Criteria

The elements of a small-scale hydroelectricity scheme create potential impacts on landscape and visual amenity, nature conservation, the water regime.

Some form of environmental assessment is essential when it comes to applying for planning permission and environmental licenses.

Under the Town and Country Planning (Assessment of Environmental Effects) Regulations 1988, the planning application for any development that the planning authority considers likely to have a significant impact on the environment must be accompanied by an Environmental Statement.

It would typically cover such issues as flora, fauna, noise levels, traffic, land use, archaeology, recreation, landscape, and air and water quality.

Noise

Noise may be an issue from the turbine at the point of generation do consideration should be made to baffle noise from surrounding residences.

Possibility of electricity export

At peak times, there is potential for electricity export and some electricity providers offer buy back schemes.

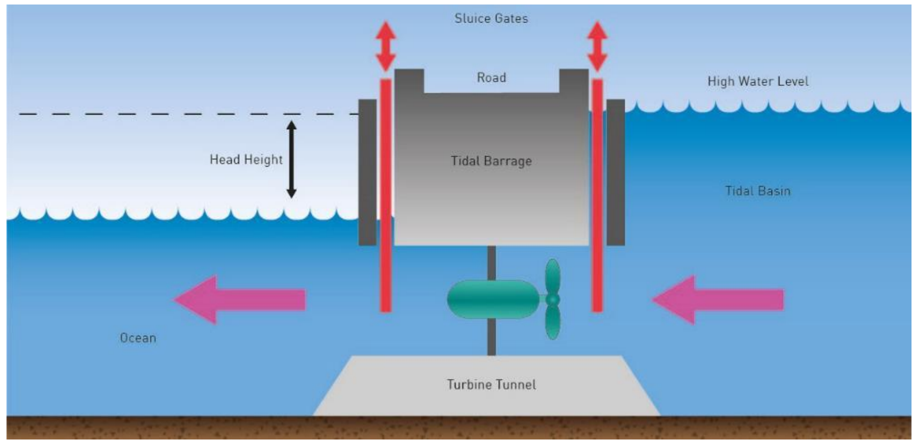
Available Grants

There are no national grant schemes but Feed-in-Tariffs are common.

Summary

There is flowing water near the site which makes the technology an option to consider as the river Thames is in proximity. The flow of the river would be limited and the investment being high with a long payback period makes this a low-level option for feasibility.

18.10. Tidal Hydroelectric



System Description

Tidal energy is a form of hydro power that utilizes the use of the tides in the oceans and seas that surround every continent on the planet. Turbines, barrages, and other types of energy harnessing tools are used to capture and generate a great deal of renewable energy from these tides. The idea for tidal energy has been around for thousands of years, and technological progress is being made to make it a realistic energy source.

Key Consideration

ADVANTAGES	DISADVANTAGES
Predictable energy source.	Effects on marine life.
Low operating costs.	High construction costs.
Effective even at low speeds.	Reduced effectiveness if tidal movement changes.
No operating carbon emissions.	Limit access and transportation in the installation area.
	Limited worldwide applicability.
	Immature technology.
	Potentially high maintenance costs.

Land Use

Often installed in tidal estuaries which don't take up on shore land but have impacts on the local ecosystem.

Local Planning Criteria

The environmental impacts of these installations make planning permission more difficult to get.

Noise
No.

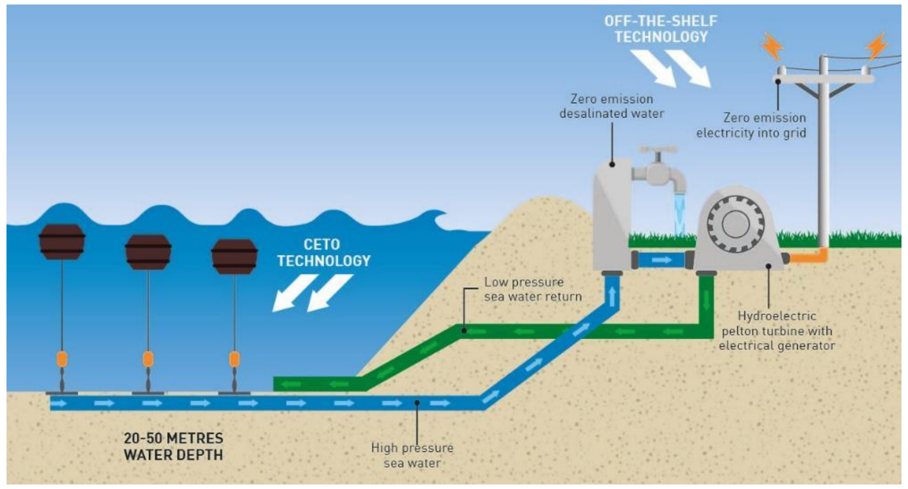
Possibility of electricity export
No Feed-in-Tariffs are currently available.

Available Grants
Grants have been historically granted to organizations designing and installing tidal hydroelectric. Ongoing funding is not currently available.

Summary

The site is not close enough to the approved estuary near London which is the Thames Estuary to make this technology feasible.

18.11. Wave Power Hydroelectric



System Description
Gravitational attraction of the sun and the moon as well as the force of wind are mainly responsible for the wave being created. Wave energy may vary from a few watts to kilowatts per meter which is fluxed in the open sea or against coasts. The greatest power is achieved in winter and smallest in the summer, mainly in the zones of the prevailing westerlies and trade winds.

Both vertical as well as horizontal movement of the water contributes to wave energy. Every particle of water experiences almost a circular motion moving up and down reaching the crests and troughs.

Key Consideration

ADVANTAGES	DISADVANTAGES
Predictable energy source.	Effects on marine life.
Worldwide potential.	High construction costs.
Low operating costs.	Reduced effectiveness if tidal movement changes.
Can be built offshore.	Limit access and transportation in the installation area.
No operating carbon emissions.	Difficult to transmit power.
	Immature technology.
	High maintenance costs.

Land Use
Installed just offshore which limits accessibility to the ocean for recreation and transport.

Local Planning Criteria
The environmental impacts of these installations make planning permission more difficult to get.

Noise
No.

Possibility of electricity export
Feed-in-Tariffs are available.

Available Grants
No.

Summary

The site is not close enough to the approved estuary near London which is the Thames Estuary to make this technology feasible.