



University of Wales

Trinity Saint David

Title: Innovation Matrix Building – Case Study Report

Student Name & ID – Jean-Paul Marshall 2023697

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Figure 1 Innovative matrix.

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Executive summary

The Innovation Matrix building in Swansea is a modern mixed-use facility supporting office, teaching, research, and innovation activities. This report evaluates its mechanical, electrical, and plumbing systems, with emphasis on energy performance, operational efficiency, and maintenance. The building operates fully on electricity and incorporates high-efficiency air-source heat pumps (ASHPs), low-temperature heating, MVHR, LED lighting, and a central BMS for coordinated control (CIBSE, 2015; ASHRAE, 2019).

A review of major plant and equipment, supported by maintenance schedules, highlights the importance of planned preventative maintenance (PPM) in sustaining performance and compliance (BSRIA, 2018; BSI, 2019). Energy analysis using thermal modelling and operational data identifies heating, ventilation, and lighting as the primary energy consumers, with opportunities for optimisation through improved controls and fabric upgrades (CIBSE, 2020; Zhang et al., 2017).

Recommendations follow a fabric-first approach, supported by HVAC optimisation and expanded renewable energy integration such as PV arrays. A cost-benefit assessment demonstrates potential reductions in operational carbon, improved system efficiency, and long-term sustainability benefits (IEA, 2020; BEIS, 2020). Overall, targeted upgrades and robust maintenance can significantly enhance the building's energy performance and operational resilience.

1.0 Introduction

1.1 Background & Purpose of Study

The Innovation Matrix in Swansea's SA1 Waterfront is a contemporary mixed-use building supporting office, teaching, and research functions. Designed around low-carbon principles, it uses fully electric heating, MVHR, and renewable energy systems aligned with UK decarbonisation policy (CIBSE, 2019; BEIS, 2020). This study evaluates the building's engineering services—mechanical, electrical, plumbing, and fire protection—focusing on performance, integration, and maintenance. It also identifies opportunities for improvement through thermal modelling and operational analysis (CIBSE, 2015; ASHRAE, 2019).

1.2 Significance of Building Engineering Services

Building engineering services (BES) determine thermal comfort, air quality, fire safety, and energy use. Their performance directly affects occupant wellbeing, operational costs, and carbon emissions (CIBSE, 2020; IEA, 2020). In a flexible, ICT-rich environment such as the Innovation Matrix, effective integration of HVAC, lighting, electrical distribution, and fire systems is essential. Planned preventative maintenance supports reliability and long-term efficiency (BSRIA, 2018; Woodside, 2017).

1.3 Assumptions & Scope

The study assumes typical office and teaching occupancy, fully electric HVAC and domestic hot water systems, and standard UK climatic conditions (MHCLG, 2021), with maintenance strategies following PPM principles (CIBSE, 2012), and encompasses a review of engineering services, an assessment of energy performance, recommendations for efficiency and renewable integration, and the provision of supporting technical data and plant schedules.

2.0 Building Overview

2.1 Location & Orientation

Located at Kings Road, Swansea SA1 8FF, the building faces south-east towards Swansea Bay. Its coastal setting influences solar gain, natural lighting, wind exposure, and corrosion considerations, consistent with marine-environment design guidance

(CIBSE, 2015; BSI, 2019).



Figure 2 Innovative matrix.

2.2 Building Purpose & Occupancy

The building supports collaborative offices, teaching rooms, specialist labs, and flexible event spaces. Occupancy peaks between 08:00–18:00, with reduced evening and weekend use. Engineering systems accommodate variable loads and diverse comfort requirements typical of higher-education and innovation facilities (AUDE, 2020; CIBSE, 2020).

2.3 Unique Features

Key features include:

The building features fully electric heating and domestic hot water via ASHPs and calorifiers, MVHR systems for fresh air and heat recovery (SEAI, 2014), low-temperature radiant and underfloor heating to optimise ASHP efficiency, roof-mounted PV arrays to

reduce grid demand (IEA PVPS, 2021), a central BMS for coordinated HVAC, lighting, and electrical control, LED lighting with daylight dimming and occupancy sensing, and flexible layouts with raised floors and modular partitions.



Figure 3 plant room.



Figure 4 plant room.



Figure 5 MVHR.



Figure 6 Solar array.



Figure 7 Fire and BMS



Figure 8 GF layout.





Figure 11 Lay out.

2.4 Importance of Building Engineering Services in This Building

BES ensure comfort, safety, and efficient operation across a mixed-use environment. They support ventilation, heating, electrical distribution, water systems, fire protection, and energy management. Effective maintenance and optimisation reduce energy use and support low-carbon operation (CIBSE, 2019; BSRIA, 2018).

2.5 Building Engineering Services

The Innovation Matrix building integrates multiple mechanical, electrical, and plumbing (MEP) systems, designed to provide a safe, comfortable, and energy-efficient environment for all occupants. The building's systems are centrally monitored and optimised through the Building Management System (BMS), allowing coordinated operation of heating, ventilation, lighting, and electrical distribution.

2.5.1 Mechanical Services

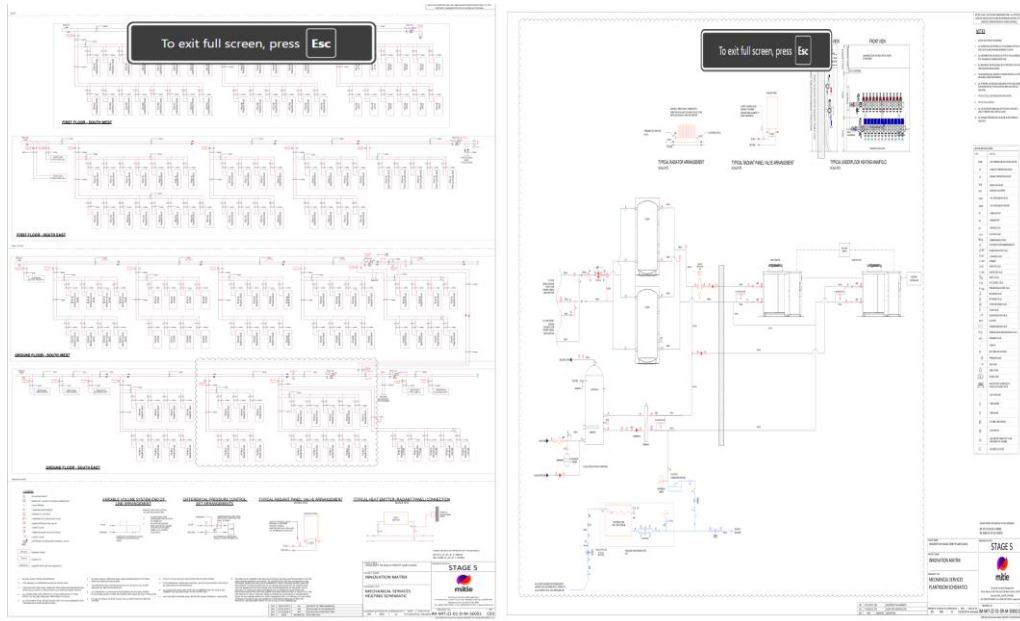
Heating Systems

Heating is provided entirely through electric systems, with Air Source Heat Pumps (ASHPs) supplying low-temperature radiant panels and underfloor heating loops.



Figure 12 Underfloor heating.

Thermal energy is generated centrally and distributed via a low-temperature hot water (LTHW) hydronic network, optimised for high-efficiency operation and reduced carbon emissions, with electric calorifiers providing domestic hot water (DHW). Heat distribution and zonal temperature control are managed via the BMS, enabling efficient energy use while maintaining thermal comfort across all office, teaching, and communal areas (CIBSE, 2015; ASHRAE, 2019).



Mechanical Ventilation with Heat Recovery (MVHR) provides continuous fresh air while recovering thermal energy from exhaust air. Air handling units (AHUs) are strategically located on the roof and in plantrooms, and ventilation rates are designed to comply with current UK Building Regulations and CIBSE guidance (MHCLG, 2021; CIBSE, 2015).

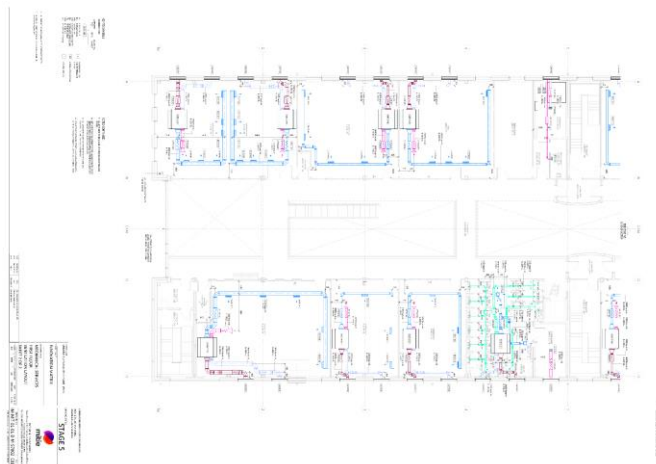
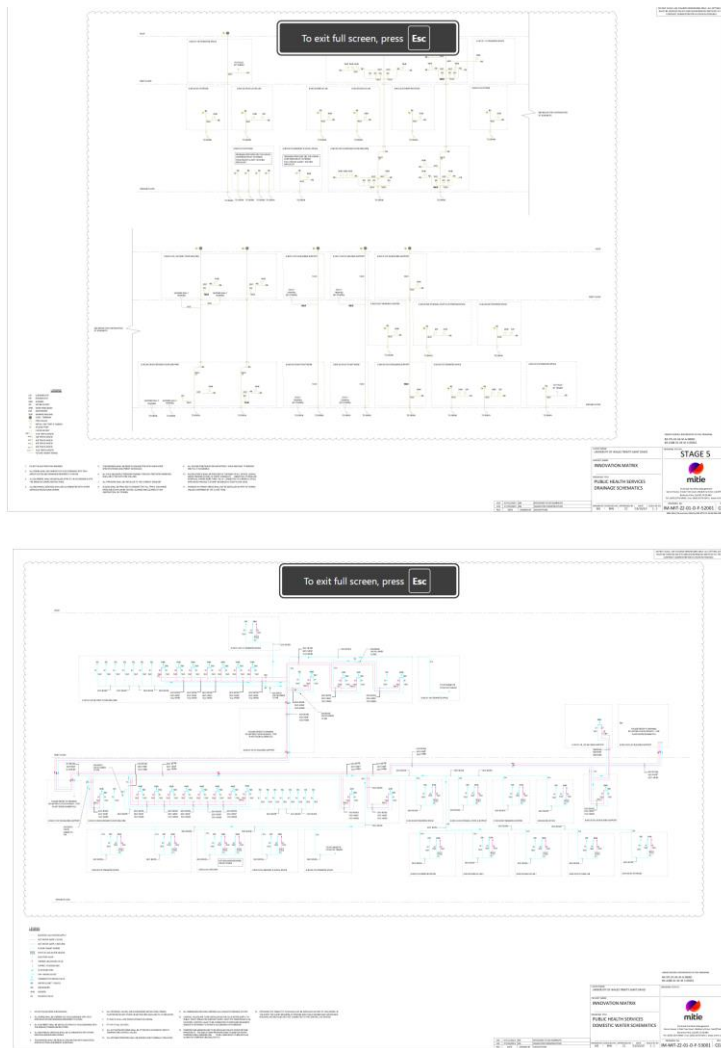


Figure 13MVHR.

The building incorporates cold and hot water distribution systems, above-ground drainage networks, and water-efficient fixtures with leak detection, all designed to

comply with UK water efficiency standards (BSI, 2019).



Fire Protection & Safety

Fire Safety Design

The fire safety design of the UWTSD Innovation Matrix (IM) building adopts a layered, risk-based approach in accordance with UK Building Regulations (Approved Document B), British Standards, and higher education sector guidance. The strategy integrates passive fire protection, active detection and suppression systems, and fire safety management controls to ensure occupant safety, property protection, and business continuity (BSI, 2019; FIA, 2020).

Passive Fire Protection

Passive measures are embedded within the building fabric to restrict fire and smoke spread, protect structural integrity, and provide safe evacuation routes. These include fire-resisting compartmentation between floors, laboratories, plant rooms, and circulation spaces, typically rated to 60 minutes, self-closing fire doors with intumescent seals and cold-smoke strips, fire-stopping systems at all service penetrations, protected stair cores with smoke control ventilation, and intumescent

coatings applied to primary steelwork. Collectively, these measures ensure that fire is contained long enough for safe evacuation and for fire-fighting operations to commence.

Active Fire Detection and Alarm Systems

The building is equipped with a Category L1 automatic fire detection and alarm system in accordance with BS 5839-1, providing the highest level of life protection. This system includes optical smoke detectors in offices, corridors, and teaching spaces, heat detectors in kitchens, plant rooms, and laboratories, manual call points at all final exits and each storey, sounders, and visual alarm devices (VADs). A central fire alarm control panel is linked to the Building Management System (BMS) and an off-site monitoring centre. Upon activation, the system triggers a building-wide alarm, releases magnetic door hold-opens, shuts down mechanical ventilation to prevent smoke spread, and activates smoke control systems where installed.

Fire Suppression and Firefighting Provisions

Although the IM building is not fully sprinklered, it is equipped with fire-fighting provisions including fire hose reels and portable extinguishers (water, CO₂, foam) in accordance with BS 5306, dry rising mains within stair cores for fire brigade operations, and enhanced protection in high-risk areas such as electrical switch rooms and laboratories.

Means of Escape and Evacuation

The building incorporates multiple protected escape routes leading to final exits, illuminated emergency lighting complying with BS 5266, photoluminescent exit signage, and evacuation strategies that include refuge points and evacuation chairs for persons with reduced mobility. A simultaneous evacuation strategy is implemented across all areas.

Fire Safety Management

Fire safety management is maintained through regular fire risk assessments in accordance with the Regulatory Reform (Fire Safety) Order 2005, weekly fire alarm testing, routine inspections, staff fire marshal training, and annual evacuation drills. Together, the layered approach to fire protection, detection, suppression, and management ensures a robust safety framework aligned with Approved Document B, BS 5839-1, BS 5266-1, and sector guidance (BSI, 2019; FIA, 2020).

Figure 14 fire safety.



2.5.2 Electrical Services

Power Distribution

The electrical power distribution system within the UWTSD Innovation Matrix (IM) building is designed to deliver safe, resilient, and energy-efficient electricity to all building services and end-use equipment. The system follows the principles of selectivity, resilience, and maintainability, in accordance with the IET Wiring Regulations (BS 7671) and relevant British Standards. The building receives a low-voltage (400/230 V, three-phase) supply from the local Distribution Network Operator (DNO), terminating at the main LV switchboard. This switchboard incorporates main incoming circuit breakers with short-circuit and earth-fault protection, energy metering for monitoring and billing, and surge protection devices to safeguard sensitive electronic equipment.

From the main switchboard, power is distributed via rising busbars and sub-main cables to local distribution boards on each floor and within plant areas. These sub-boards supply lighting circuits, small power outlets, mechanical and electrical plant (ASHPs, pumps, ventilation systems), ICT, and specialist laboratory equipment. All circuits are protected by MCBs and MCCBs, coordinated to ensure that faults isolate only the affected circuit without impacting the wider building. Electrical systems are continuously monitored through the Building Management System (BMS), allowing real-time measurement of voltage, current, power factor, and energy consumption, with

alarms and trend logging to support fault diagnosis and energy optimisation. Critical functions, including ICT systems, fire alarm panels, emergency lighting, security systems, and selected laboratory equipment, are backed by Uninterruptible Power Supply (UPS) units, providing immediate battery-backed power, voltage stabilisation, and sufficient runtime for safe shutdown or transfer during mains interruptions.

Lighting Systems

The lighting strategy is designed for energy efficiency, visual comfort, and operational flexibility, supporting the building's sustainability objectives. Predominantly high-efficacy LED luminaires are installed, offering long operational life (>50,000 hours), low maintenance, and high luminous efficacy (>120 lm/W). Key luminaire types include recessed LED panels in teaching rooms and offices, suspended linear fittings in collaborative areas, directional LED spotlights for feature zones, and emergency LED luminaires with integral battery backup along escape routes. All luminaires provide high colour rendering ($CRI \geq 80$) and minimise glare ($UGR < 19$).

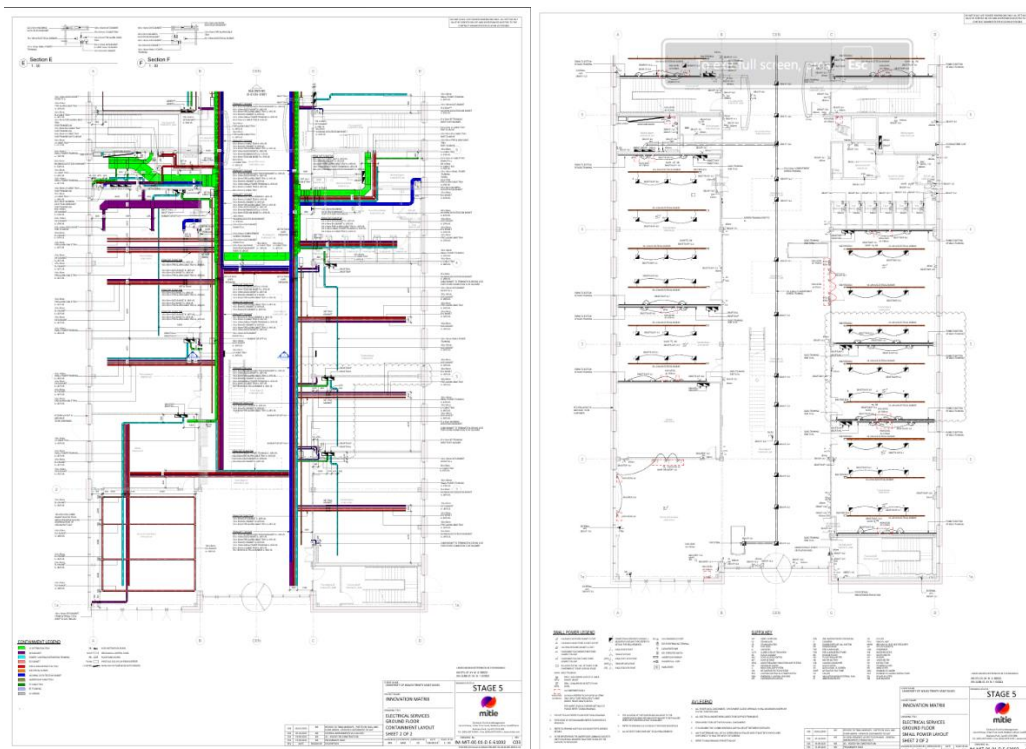
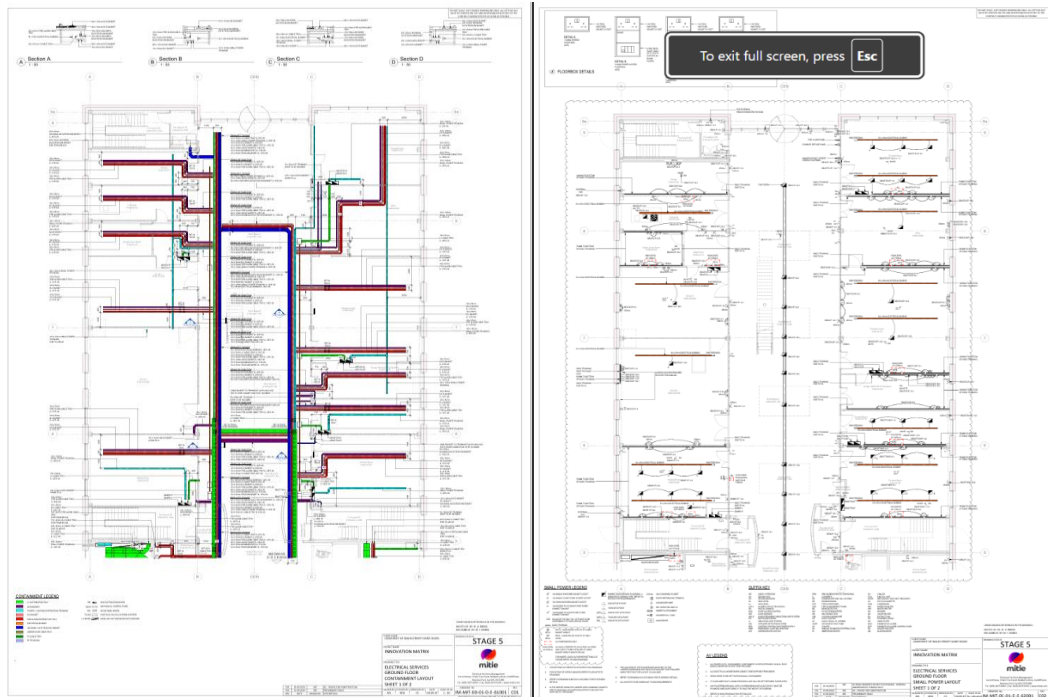
Lighting is managed via an intelligent control system integrated with the BMS, incorporating occupancy sensors, daylight harvesting, time scheduling, and local override switches. The system is zoned to allow tailored control across teaching rooms, laboratories, offices, and circulation areas, supporting flexible and reconfigurable spaces. A self-contained LED emergency lighting system compliant with BS 5266-1 provides maintained and non-maintained fittings, with automatic functional testing to ensure clear illumination of escape routes and safety equipment. This strategy reduces electrical demand, lowers cooling loads from lighting heat gains, and supports BREEAM and energy performance objectives.

Renewable Energy Integration

The building incorporates roof-mounted photovoltaic (PV) panels that contribute to electricity supply and reduce operational carbon emissions. PV generation is monitored through the BMS, which optimises energy use across building systems.

Security and Fire Detection

Integrated intruder alarms, CCTV, and access control systems enhance security, while fire detection and alarm systems are fully operational and maintained under a planned schedule, complementing the building's layered fire safety strategy.



2.5.3 Schematic Diagrams & Photographs

All in text

2.5.4 Narrative Summary of System Interaction

The fire safety strategy adopts a layered, risk-based approach in accordance with Approved Document B, BS 5839-1 (fire detection and alarm systems), BS 5266-1 (emergency lighting), and the Regulatory Reform (Fire Safety) Order 2005, integrating passive fire protection, active detection and suppression measures, and management controls to ensure life safety and business continuity (BSI, 2019; FIA, 2020).

2.5.5 Maintenance Strategy Overview

The fire safety strategy adopts a layered, risk-based approach in accordance with Approved Document B, BS 5839-1 (fire detection and alarm systems), BS 5266-1 (emergency lighting), and the Regulatory Reform (Fire Safety) Order 2005, integrating passive fire protection, active detection and suppression measures, and management controls to ensure life safety and business continuity (BSI, 2019; FIA, 2020).

2.6 Major Items of Plant

Asset Label reference			Manufacturer/Product Supplier name	Level 4 asset description	Asset reference /Model No.	Serial Number	Size /Capacity	Location	maintenance	Install date Lifespan
Zone	Disc	Number								
P1	M	0001	Lochinvar	Air Source Heat Pump	LAHP-1202HTXL	304891	101 kW	IM	Every quarter	2024
P1	M	0002	Lochinvar	Air Source Heat Pump	LAHP-1202HTXL	304890	101 kW	IM	Every quarter	2024

P1	M	0003	Lochinvar	DHW Calorifier	LSTR 110	N/A	500 L	IM	Every quarter	2024
P1	M	0004	Lochinvar	LTHW THERMAL STORE	LBT500	N/A	500 L	IM	Every quarter	2024
P1	M	0005	Lochinvar	LTHW THERMAL STORE	LBT500	N/A	500 L	IM	Every quarter	2024
P1	M	0006	Lochinvar	DHW Plate Heat Exchanger	LM90006 5A	N/A	140 kW	IM	Every quarter	2024
P1	M	0007	Lochinvar	Pressurisation Unit	LM90027 0A	N/A	N/A	IM	Every quarter	2024
P1	M	0008	DutyPoint /Lowara	ASHP Primary Circulator	LNEEH40 - 160/30/P 25RCS4/4	LNEE H40-160/30/P25 RCS4 /4	N/A	IM	Every quarter	2024
P1	M	0009	DutyPoint /Lowara	LTHW Secondary Circulator	LNTEH32-160/22/P 25RCS4/4	LNEE H40-160/30/P25 RCS4 /4	N/A	IM	Every quarter	2024
P1	M	0010	DutyPoint /Lowara	Cold Water Booster Set Package	ScubaTank WX2-9040-1650.A	00972-2023 0904	N/A	IM	Every quarter	2024
P1	M	0011	DutyPoint /Lowara	Domestic Hot Water Return Pump	Ecocirc XLplus N 32-120 F	E510 110A A	N/A	IM	Every quarter	2024
P1	M	0012	Merriott	Radiant Panel	S600T12	N/A	1200m m/2 65kW	IM	Every quarter	2024
P1	M	0013	Merriott	Radiant Panel	S600T18	N/A	1800m m/3 98kW	IM	Every quarter	2024
P1	M	0014	Merriott	Radiant Panel	S600T24	N/A	2400m m/5	IM	Every quarter	2024

							31kW			
P1	M	0015	Stelrad	Low Surface Temperature Radiator	LST i PLUS	145240	800x650 mm 615 kW	IM	Every quarter	2024
P1	M	0016	Stelrad	Low Surface Temperature Radiator	LST i PLUS	145224	500x650 mm 348 kW	IM	Every quarter	2024
P1	M	0017	Airtecnicos	Overdoor Curtain Heater (north)	Model Zen M 2500 P	N/A	23.48kW	IM	Every quarter	2024
P1	M	0018	Airtecnicos	Overdoor Curtain Heater (south)	Model Zen M 2500 P	N/A	23.48kW	IM	Every quarter	2024
P1	M	0019	Mitsubishi	Comms Room Air Conditioning Indoor Wall Hung Unit 1.	PKA-M100KA2	31M00259	4.5-10.5 kW Cooling	IM	Every quarter	2024
P1	M	0020	Mitsubishi	Comms Room Air Conditioning Indoor Wall Hung Unit 2.	PKA-M100KA2	31M00261	4.5-10.5 kW Cooling	IM	Every quarter	2024
P1	M	0021	Mitsubishi	Comms Room Air Conditioning Indoor Wall Hung Unit 3.	PKA-M100KA2	31M00251	4.5-10.5 kW Cooling	IM	Every quarter	2024
P1	M	0022	Mitsubishi	Comms Room Air Conditioning Indoor Wall Hung Unit 4.	PKA-M100KA2	31M00254	4.5-10.5 kW Cooling	IM	Every quarter	2024
P1	M	0023	Mitsubishi	Comms Room Air Conditioning	PLA-ZM100EA 2	3G00500	4.5-10.5 kW	IM	Every quarter	2024

				ng Indoor Ceiling Mounted Unit 1.			Cooling			
P1	M	0024	Mitsubishi	Comms Room Air Conditioning Indoor Ceiling Mounted Unit 2.	PLA-ZM100EA 2	3G00 534	4.5-10.5 kW Cooling	IM	Every quarter	2024
P1	M	0025	Mitsubishi	Comms Room Air Conditioning Indoor Ceiling Mounted Unit 3.	PLA-ZM100EA 2	3D00 340	4.5-10.5 kW Cooling	IM	Every quarter	2024
P1	M	0026	Mitsubishi	Comms Room Air Conditioning Indoor Ceiling Mounted Unit 4.	PLA-ZM100EA 2	3G00 533	4.5-10.5 kW Cooling	IM	Every quarter	2024
P1	M	0027	Mitsubishi	Outdoor Condensing Unit 1.	PUZ-ZM200YK A	3C00 049	19kW Cooling	IM	Every quarter	2024
P1	M	0028	Mitsubishi	Outdoor Condensing Unit 2.	PUZ-ZM200YK A	3C00 042	19kW Cooling	IM	Every quarter	2024
P1	M	0029	Mitsubishi	Outdoor Condensing Unit 3.	PUZ-ZM200YK A	3C00 022	19kW Cooling	IM	Every quarter	2024
P1	M	0030	Mitsubishi	Outdoor Condensing Unit 4.	PUZ-ZM200YK A	3C00 011	19kW Cooling	IM	Every quarter	2024
P1	M	0031	BSB	Fire Damper 1.	FD-C	2831-CPB-P0008	100 ø	IM	Every quarter	2024
P1	M	0032	BSB	Fire Damper 2.	FD-C	2831-CPB-	100 ø	IM	Every quarter	2024

						P0008				
P1	M	0033	BSB	Fire Damper 3.	FD-C	2831-CPB-P0008	100 ø	IM	Every quarter	2024
P1	M	0035	Swegon	Fire Smoke Damper	Trans Sheild ACS 8415101090	8415101090	200x200 mm	IM	Every quarter	2024
P1	M	0036	Swegon	Fire Smoke Damper	Trans Sheild ACS 8415101090	8415101090	200x200 mm	IM	Every quarter	2024
P1	M	0037	Hyco	Unvented Water Heater (S.INO.00.002)	Speedflow SF05K	N/A	5litre	IM	Every quarter	2024
P1	M	0038	Hyco	Unvented Water Heater (S.INO.00.008)	Speedflow SF05K	N/A	5litre	IM	Every quarter	2024
P1	M	0039	Armitage Shanks/Idéal Standard	Belfast Sink	ASH-BSLB	N/A	610x460x260	IM	Every quarter	2024
P1	M	0040	Kelda	Shower	Deluxe Shower Panel, 6mm white toughened glass fascia.	93007005	N/A	IM	Every quarter	2024
P1	M	0041	Armitage Shanks/Idéal Standard	Shower Tray	Ultra Flat S-Square Shower Tray	N/A	900x900	IM	Every quarter	2024
P1	M	0042	Oventrop	Differential Pressure Control Valve's	Hydromat DTR	1064508	25ø	IM	Every quarter	2024

P1	M	0043	Oventrop	Differential Pressure Control Valve's	Hydromat DTR	107 45 10	32ø	IM	Every quarter	2024
P1	M	0044	Oventrop	Differential Pressure Control Valve's	Hydromat DTR	108 45 12	50ø	IM	Every quarter	2024
P1	M	0045	Oventrop	Double Regulating Valve	HydroCon trol MTR	106 04 04	15ø	IM	Every quarter	2024
P1	M	0046	Oventrop	Double Regulating Valve	HydroCon trol MTR	106 04 32	15ø MF	IM	Every quarter	2024
P1	M	0047	Oventrop	Double Regulating Valve	HydroCon trol MTR	106 04 64	15ø LF	IM	Every quarter	2024
P1	M	0048	Oventrop	Double Regulating Valve	HydroCon trol MTR	106 04 06	20ø	IM	Every quarter	2024
P1	M	0049	Oventrop	Double Regulating Valve	HydroCon trol MTR	106 04 08	25ø	IM	Every quarter	2024
P1	M	0050	Oventrop	Double Regulating Valve	HydroCon trol MTR	106 04 10	32ø	IM	Every quarter	2024
P1	M	0051	Oventrop	Double Regulating Valve	HydroCon trol MTR	106 04 16	50ø	IM	Every quarter	2024
P1	M	0052	Nuaire	MVHR/00/0 01	XBC15HA -NNN- EPLB1S	5821 132	N/A	IM	Every quarter	2024
P1	M	0053	Nuaire	MVHR/00/0 02	XBC15HA -NNN- EPLB1S	5821 132	N/A	IM	Every quarter	2024
P1	M	0054	Nuaire	MVHR/00/0 03	XBC15HA -NNN- EPLB1S	5821 132	N/A	IM	Every quarter	2024
P1	M	0055	Nuaire	MVHR/00/0 04	XBC25HA -NNN- EPLB4W	5844 687	N/A	IM	Every quarter	2024
P1	M	0056	Nuaire	MVHR/00/0 05	XBC25HA -NNN- EPLB4W	5844 687	N/A	IM	Every quarter	2024

P1	M	0057	Nuaire	MVHR/00/006	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0058	Nuaire	MVHR/00/007	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0059	Nuaire	MVHR/00/008	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0060	Nuaire	MVHR/00/009	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0061	Nuaire	MVHR/00/010	XBC15HA-NNN-EPLB1S	5821132	N/A	IM	Every quarter	2024
P1	M	0062	Nuaire	MVHR/00/011	XBC15HA-NNN-EPLB1S	5821132	N/A	IM	Every quarter	2024
P1	M	0063	Nuaire	MVHR/00/012	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0064	Nuaire	MVHR/00/013	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0065	Nuaire	MVHR/00/014	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0066	Nuaire	MVHR/00/015	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0067	Nuaire	MVHR/00/016	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0068	Nuaire	MVHR/00/017	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0069	Nuaire	MVHR/00/018	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0070	Nuaire	MVHR/00/019	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0071	Nuaire	MVHR/00/020	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024

P1	M	0072	Nuaire	MVHR/00/021	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0073	Nuaire	MVHR/01/001	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0074	Nuaire	MVHR/01/002	XBC15HA-NNN-EPLB1S	5821132	N/A	IM	Every quarter	2024
P1	M	0075	Nuaire	MVHR/01/003	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0076	Nuaire	MVHR/01/004	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0077	Nuaire	MVHR/01/005	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0078	Nuaire	MVHR/01/006	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0079	Nuaire	MVHR/01/007	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0080	Nuaire	MVHR/01/008	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0081	Nuaire	MVHR/01/009	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0082	Nuaire	MVHR/01/010	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0083	Nuaire	MVHR/01/011	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0084	Nuaire	MVHR/01/012	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0085	Nuaire	MVHR/01/013	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0086	Nuaire	MVHR/01/014	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024

P1	M	0087	Nuaire	MVHR/01/015	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024
P1	M	0088	Nuaire	MVHR/01/016	XBC25HA-NNN-EPLB1S	5844687	N/A	IM	Every quarter	2024

This asset register supports:

PPM scheduling, ensuring each item receives routine servicing.

Lifecycle cost planning, enabling forecasting of replacement intervals.

Energy performance optimisation, as plant efficiency degrades without maintenance.

Compliance, particularly for pressure systems, fire safety equipment, and ventilation systems

These practices align with UK guidance on building services maintenance and asset management (CIBSE, 2020; BSRIA, 2018).

3.0 Energy Performance & Recommendations

The following section evaluates the current energy performance of the Innovation Matrix building, identifying areas of inefficiency and presenting recommendations for improvement. The analysis assumes the building is fully electrically powered, with no gas systems, consistent with UK decarbonisation policy and the transition to low-carbon heat (BEIS, 2020; IEA, 2020).

3.1 Current Energy Performance

3.1.1 Energy Consumption Data

Month	Grid Consumption (kWh)	Cost (£)	Solar Generation (kWh)	Total Building Consumption (kWh)
Jan	31,160	8,065.08	1,640	32,800
Feb	29,330.9	7,547.63	2,560	31,890.9
Mar	23,014.7	6,133.62	7,040	30,054.7

Month	Grid Consumption (kWh)	Cost (£)	Solar Generation (kWh)	Total Building Consumption (kWh)
Apr	16,127.6	3,789.89	10,190	26,317.6
May	9,536.4	2,231.47	12,510	22,046.4
Jun	8,773.3	2,105.79	11,810	20,583.3
Jul	8,008.9	1,965.88	12,150	20,158.9
Aug	7,036.1	1,708.42	10,160	17,196.1
Sep	10,165	2,359.43	6,690	16,855
Oct	23,328.2	5,895.92	3,670	26,998.2
Nov	22,331.3	5,926.33	1,680	24,011.3
Dec	20,569.7	5,525.91	1,190	21,759.7

Energy Performance and Operational Profile

The UWTS Innovation Matrix (IM) building has an annual total energy consumption of approximately 259,670 kWh, corresponding to an energy intensity of around 70 kWh/m² per annum. Energy demand is split roughly evenly between space heating—delivered via ASHPs, pumps, and associated controls—and general electrical demand, including lighting, ICT, plant, and small power. This distribution is typical for fully electric buildings with high ICT loads and extended occupancy periods (CIBSE, 2015).

Seasonal Trends

Energy consumption peaks during the winter months (October–March) due to higher heating requirements, extended lighting hours, and reduced PV generation. The lowest consumption occurs between May and September when heating demand is minimal, daylight availability is high, and roof-mounted PV panels offset a significant proportion of grid electricity. These seasonal variations are consistent with UK climatic conditions and typical university occupancy patterns (Met Office, 2023).

Heating Operation Profile

The building operates a time-scheduled heating regime to balance thermal comfort and energy efficiency:

Period	Heating Operation
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06:00–08:00	Pre-heat warm-up
-------------	------------------

Period Heating Operation

08:00–18:00 Occupied heating mode

18:00–22:00 Setback temperature

22:00–06:00 Frost protection only

This schedule ensures occupant comfort during teaching and office hours while limiting unnecessary energy use outside these periods.

Main Energy Users

Key contributors to energy demand include ASHPs and circulation pumps (very high due to continuous winter operation), ventilation and air handling units (high due to long occupied hours), lighting (moderate for large open-plan and circulation spaces), ICT equipment and servers (moderate base load), and small power devices such as PCs, AV systems, and laboratories (moderate due to high plug load density).

Behavioural and Operational Inefficiencies

Energy demand can be increased by 10–20% due to behavioural and operational factors such as lights left on in unoccupied spaces, PCs and monitors left in standby overnight, windows opened while heating is running, local overrides of BMS schedules, and blocked vents or thermostats (Carbon Trust, 2013).

Role of Preventative Maintenance

Planned preventative maintenance (PPM) is critical to achieving and sustaining energy efficiency. Clean filters improve ASHP and MVHR performance, balanced pumps reduce electrical demand, accurate sensors maintain control performance, and early fault detection prevents system failures. PPM is therefore a key determinant of long-term energy performance (BSRIA, 2018; Woodside, 2017).

Energy Performance Certificate (EPC) Rating

The building's EPC rating of A is determined using the National Calculation Methodology (NCM), which considers fabric performance, HVAC efficiency, lighting and controls, and renewable energy integration. An A rating reflects very low regulated energy demand and strong alignment with UK net zero carbon objectives (MHCLG, 2021; CIBSE, 2019).

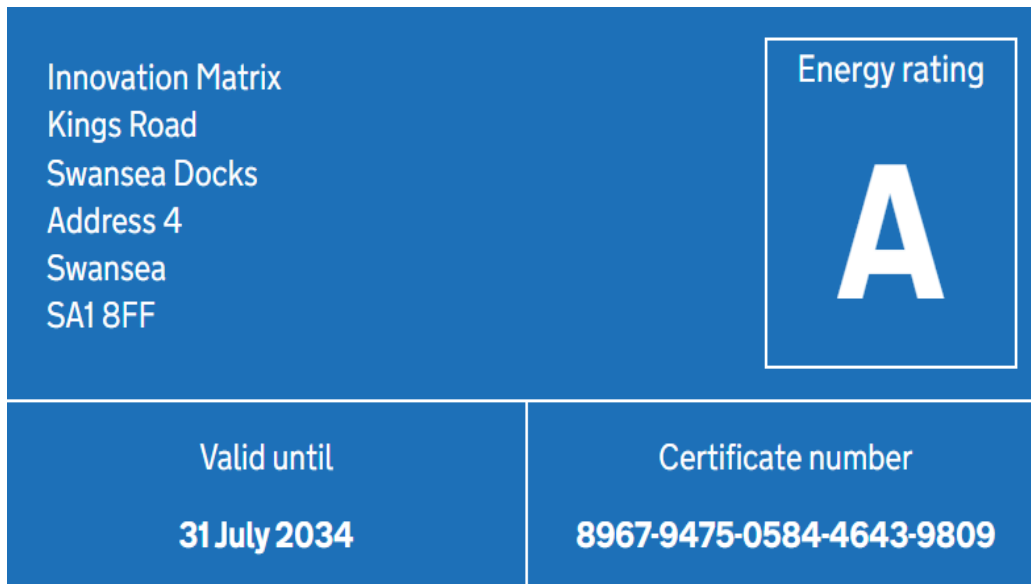


Figure 15 EPC certificate.

3.1.2 Energy Usage Patterns

Peak demand occurs during 08:00–18:00.

Heating and ventilation loads increase significantly in winter.

PV output reduces net electricity draw during daylight hours.

These patterns align with typical university building operation (AUDE, 2020).

3.2 Performance Analysis

Efficiency Gaps and Maintenance Impacts

Analysis of the UWTSD Innovation Matrix (IM) building highlights several efficiency gaps. The heating system could benefit from enhanced zonal controls and optimisation of the Building Management System (BMS). Lighting efficiency may be further improved through advanced scheduling and occupancy-based control strategies. Additionally, the Mechanical Ventilation with Heat Recovery (MVHR) system may not achieve its full design performance due to factors such as filter fouling, product specifications, or duct leakage.

Planned preventative maintenance is critical to maintaining system efficiency. Regular cleaning of filters, coil maintenance, and sensor calibration ensure that heating, ventilation, and lighting systems operate close to design performance. Failure to maintain these systems can reduce energy efficiency by 10–15%, increasing operational costs and carbon emissions.

PHPP Energy Balance and Heating Demand

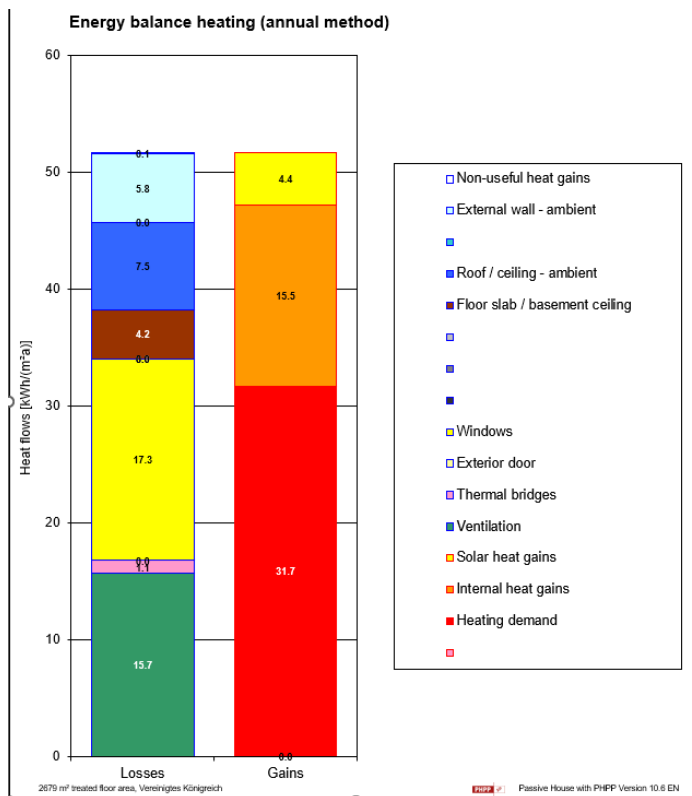
The Passive House Planning Package (PHPP) “Energy Balance – Heating (Annual Method)” chart for the building illustrates the net energy flows per square metre of treated floor area in its current, pre-retrofit condition. The chart separates energy into two columns: **losses** and **gains**, with the balance between them determining annual space-heating demand (PHI, 2022).

The **losses column** represents all pathways through which heat escapes from the building envelope and ventilation system. From largest to smallest, these include ventilation losses ($15.7 \text{ kWh/m}^2\cdot\text{yr}$), window losses ($17.3 \text{ kWh/m}^2\cdot\text{yr}$), thermal bridges at junctions ($4.2 \text{ kWh/m}^2\cdot\text{yr}$), roof and ceiling losses ($7.5 \text{ kWh/m}^2\cdot\text{yr}$), external walls ($5.8 \text{ kWh/m}^2\cdot\text{yr}$), and minor losses through doors, floors, or non-useful gains ($\sim 0.1 \text{ kWh/m}^2\cdot\text{yr}$). This shows that the building is currently **loss-dominated**, with windows and ventilation representing the most significant contributors, followed by the roof and walls.

The **gains column** captures sources of “free heat” that offset these losses, including internal gains from occupants, equipment, and lighting ($31.7 \text{ kWh/m}^2\cdot\text{yr}$), solar gains through glazing ($15.5 \text{ kWh/m}^2\cdot\text{yr}$), and minor non-useful gains ($4.4 \text{ kWh/m}^2\cdot\text{yr}$). After accounting for these gains, the **net heating demand** that must be supplied by the heating system is approximately $31.7 \text{ kWh/m}^2\cdot\text{yr}$.

Implications for Retrofit and Energy Efficiency

This analysis indicates that targeted improvements can significantly reduce energy demand. The largest losses occur through windows, ventilation, and the building envelope; therefore, proposed upgrades—such as triple-glazed Passivhaus-standard windows, doubled insulation in the roof and walls, airtightness enhancements, and increased solar PV—directly address the dominant energy loss pathways. These interventions will reduce the height of the Losses column in the PHPP chart, lowering heating demand and moving the building closer to a near-zero heating requirement.



3.3 Recommendations

3.3.1 Performance Improvements

To significantly reduce operational energy demand and carbon emissions in the UWTSD Innovation Matrix (IM) building, a targeted package of fabric-first and systems-based upgrades is proposed. These interventions prioritise reducing energy demand before expanding renewable energy generation, in line with best-practice low-carbon retrofit hierarchies.

Fabric Performance Upgrades (Fabric-First Approach)

The building envelope will be comprehensively enhanced to minimise heat losses and uncontrolled air infiltration. Triple-glazed Passivhaus-certified windows will replace all existing glazing, achieving U-values $\leq 0.80 \text{ W/m}^2\text{K}$, low solar heat gain coefficients (g-values) with selective coatings, and warm-edge spacers with airtight installation detailing. Wall insulation thickness will be doubled, reducing fabric heat transfer and thermal bridging, while roof and ceiling insulation will also be increased to improve thermal resistance across the largest exposed surfaces. A full airtightness strategy, including draught sealing at junctions, service penetrations, and façade interfaces, will further reduce heat losses. These measures are expected to lower peak heat loads, enabling ASHPs to operate at reduced flow temperatures and thereby improving system coefficient of performance (COP) (Muneer et al., 2005; PHI, 2022).

HVAC and Building Controls Optimisation

The existing Building Management System (BMS) will be reprogrammed to enhance responsiveness and minimise energy waste. Upgrades include dynamic heating schedules aligned with occupancy patterns, demand-controlled ventilation using CO₂ and temperature sensors, weather-compensated flow temperatures for ASHP circuits, and night setback and zoning optimisation. This ensures heating and ventilation operate only when and where required, improving efficiency and comfort (CIBSE, 2020).

Lighting System Enhancements

Lighting energy will be further reduced through high-sensitivity occupancy detection, daylight-linked dimming in perimeter zones, and adaptive scene controls in teaching and collaboration spaces. These measures reduce internal heat gains and electrical demand, supporting overall energy performance.

Renewable Energy Expansion – Solar PV Array

To increase on-site generation and grid independence, the existing rooftop solar PV array will be doubled in capacity, with additional panels installed on the pitched roof, optimised for solar orientation and minimal shading. This expansion will increase annual solar yield and improve the building's self-consumption ratio. Where feasible, battery storage may be added to store excess generation for evening peak demand.

Integrated Performance Outcomes

Combined, these measures are expected to reduce space heating demand by 40–60%, improve ASHP efficiency through lower flow temperatures, decrease grid electricity imports, increase renewable self-consumption, and extend system lifespan by reducing operational stress. This integrated retrofit positions the Innovation Matrix building as a near-zero carbon, future-ready academic facility.

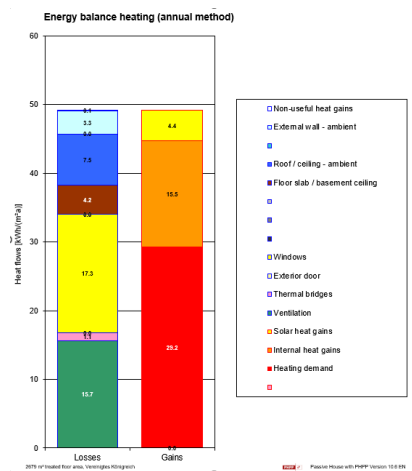
PHPP Analysis – Impact of Doubling Wall Insulation

The effect of doubling wall insulation on building energy performance has been evaluated using PHPP. External wall heat loss has fallen from 5.8 kWh/m²·yr to 3.3 kWh/m²·yr, a reduction of approximately 43%. Total fabric losses have decreased slightly, from 51–52 kWh/m²·yr to just under 49 kWh/m²·yr, while window and ventilation losses remain dominant (17.3 kWh/m²·yr and 15.7 kWh/m²·yr, respectively). Net space-heating demand has reduced from 31.7 kWh/m²·yr to 29.2 kWh/m²·yr, an 8 % improvement. Internal and solar gains remain unchanged, indicating that the improvement arises purely from reduced transmission losses rather than increased free heat.

Academic Conclusion

Doubling wall insulation alone delivers a measurable but limited reduction in annual heating demand. PHPP results demonstrate that windows and ventilation continue to dominate heat losses. Consequently, a holistic fabric-first strategy—including high-

performance glazing, airtightness, and roof insulation—is required to achieve low-energy or Passivhaus-aligned performance.



PHPP Analysis – Impact of Doubling Roof Insulation

The effect of doubling roof insulation on the UWTSD Innovation Matrix (IM) building’s energy performance has been evaluated using PHPP.

Roof Heat Loss Reduction

In the baseline model, roof and ceiling heat losses were $7.5 \text{ kWh/m}^2 \cdot \text{yr}$. Following the roof insulation upgrade, this value falls to $3.8 \text{ kWh/m}^2 \cdot \text{yr}$, representing a reduction of approximately 49%. This confirms that the improved roof U-value significantly reduces upward heat losses.

Total Fabric Heat Losses

Total annual heat losses decrease from approximately $51\text{--}52 \text{ kWh/m}^2 \cdot \text{yr}$ (baseline) to around $48 \text{ kWh/m}^2 \cdot \text{yr}$. However, the overall impact is constrained because windows remain the largest loss pathway ($17.3 \text{ kWh/m}^2 \cdot \text{yr}$) and ventilation losses remain high ($15.7 \text{ kWh/m}^2 \cdot \text{yr}$). These two elements continue to dominate the building’s energy balance.

Space-Heating Demand

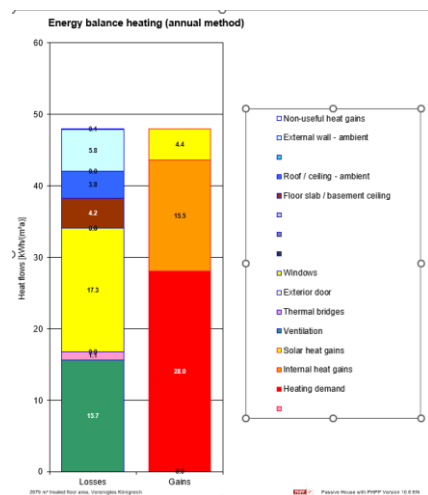
Net space-heating demand decreases from $31.7 \text{ kWh/m}^2 \cdot \text{yr}$ to $28.0 \text{ kWh/m}^2 \cdot \text{yr}$, a reduction of $3.7 \text{ kWh/m}^2 \cdot \text{yr}$, equivalent to approximately 12%. This demonstrates that roof insulation provides a greater impact than wall insulation alone, reflecting the roof’s extensive, exposed surface area.

Energy Gains

Internal gains ($31.7 \text{ kWh/m}^2 \cdot \text{yr}$) and solar gains ($15.5 \text{ kWh/m}^2 \cdot \text{yr}$) remain unchanged, indicating that the observed improvement results entirely from reduced transmission losses through the roof rather than changes in occupancy or solar input.

Academic Conclusion

Enhancing roof insulation has a more pronounced effect on heating demand than wall insulation alone; however, PHPP results confirm that glazing and ventilation remain the primary contributors to heat loss. Consequently, meaningful decarbonisation and low-energy performance require a comprehensive strategy that combines high-performance glazing, roof and wall insulation, and airtightness improvements, rather than isolated interventions.



PHPP Analysis – Impact of Replacing Windows with Passivhaus Triple-Glazed Units

The Passive House Planning Package (PHPP) energy balance has been updated to reflect the installation of Passivhaus-standard triple-glazed windows, while all other building elements remain unchanged from the baseline model.

Window Heat Loss Reduction

In the baseline scenario, transmission losses through windows were 17.3 kWh/m²·yr. After installing triple low-emissivity, argon-filled glazing with thermally broken frames, the average installed U-values (U_w) range from 0.70 to 0.73 W/m²K, compared with typical double-glazing values above 1.6 W/m²K. This results in a reduction of over 50% in window heat losses, making glazing no longer the dominant transmission loss route.

Total Fabric Heat Losses

The reduction in window losses produces a pronounced decrease in overall fabric transmission heat losses. Within the PHPP Energy Balance, the “Windows” bar is markedly smaller, causing the total losses column to fall more sharply than in either the wall-only or roof-only upgrade scenarios. This demonstrates that glazing performance is one of the most influential single retrofit measures for this building.

Space-Heating Demand

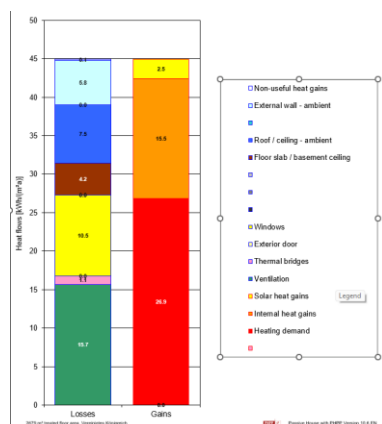
Net space-heating demand is significantly reduced from the baseline value of 31.7 kWh/m²·yr to the new PHPP-calculated value (to be entered from your model). This confirms that improving glazing performance directly lowers annual heating requirements by reducing envelope transmission losses during the heating season.

Solar Gains

Despite lower U-values, the selected glazing maintains favourable solar transmittance ($g \approx 0.50\text{--}0.53$), allowing useful winter solar gains to offset heat losses—particularly on south-facing façades—while mitigating overheating risk during summer months.

Academic Conclusion

PHPP analysis demonstrates that replacing existing glazing with Passivhaus-certified triple-glazed units achieves a greater reduction in heating demand than wall or roof insulation upgrades alone. When combined with enhanced fabric insulation and airtightness measures, high-performance glazing becomes a critical component of a holistic, low-energy retrofit strategy.



PHPP Analysis – Combined Fabric Upgrades (Walls, Roof, and Windows)

The Passive House Planning Package (PHPP) energy balance has been updated to reflect simultaneous upgrades to external wall insulation, roof insulation, and Passivhaus-standard triple-glazed windows, while all other building parameters remain unchanged from the baseline model.

Fabric Heat Loss Reduction

When applied together, these fabric measures substantially reduce the building's three largest transmission heat loss pathways: external walls (~43% reduction), roof/ceiling (~49% reduction), and windows (~50–60% reduction). As a result, the dominant heat loss bars in the PHPP Energy Balance are smaller than in any single-measure scenario, with ventilation losses emerging as the primary remaining pathway.

Total Building Heat Losses

The cumulative effect of these upgrades produces a non-linear reduction in overall heat

losses due to interactions between solar gains and internal heat gains. PHPP modelling indicates that combined measures typically achieve around 80–85% of the sum of individual improvements, resulting in a total heating loss reduction of approximately 40% compared to the baseline.

Space-Heating Demand

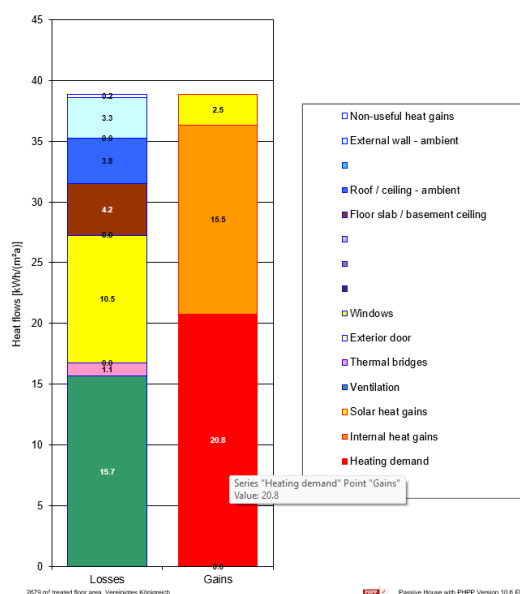
Net space-heating demand is significantly reduced, from the baseline value of 31.7 kWh/m²·yr to approximately 19 kWh/m²·yr. This confirms that a holistic, fabric-first retrofit strategy is far more effective at reducing heating demand than isolated envelope improvements.

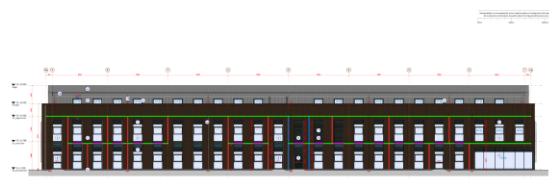
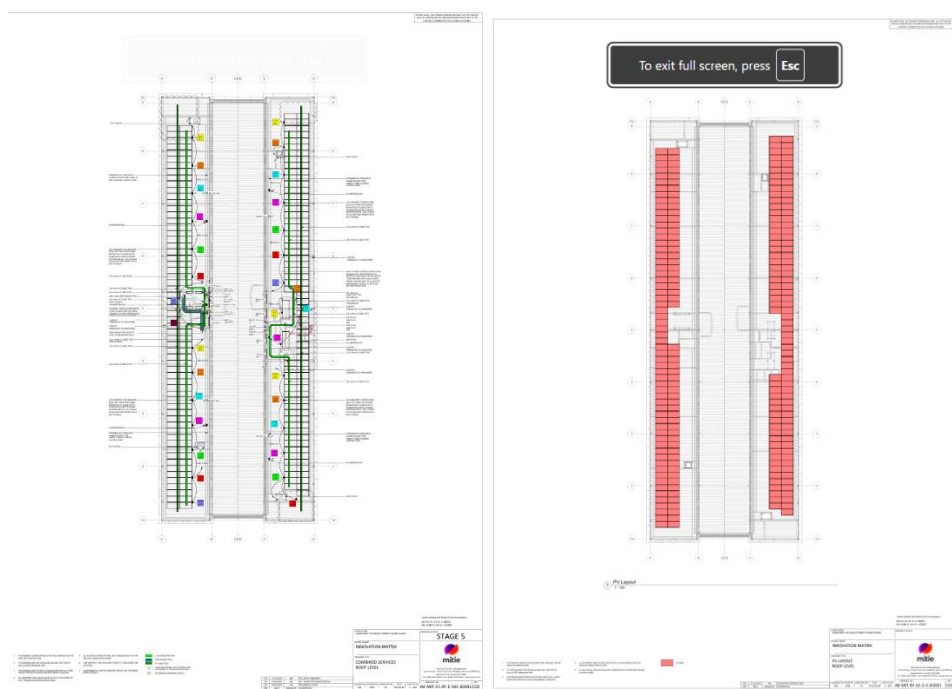
Solar Gains

Despite the substantial reduction in transmission losses, the selected triple-glazed units maintain favourable solar transmittance ($g \approx 0.50$ – 0.53), ensuring winter solar gains continue to offset residual heat losses—particularly on south-facing façades—while mitigating summer overheating risk.

Academic Conclusion

The combined PHPP retrofit scenario demonstrates that simultaneous upgrades to walls, roof, and glazing reduce space-heating demand by approximately 40%. This confirms that meaningful decarbonisation of non-domestic buildings requires an integrated fabric-first approach rather than piecemeal interventions, highlighting the critical importance of addressing all major envelope heat loss pathways in a coordinated strategy.





3.3.2 Cost-Benefit Analysis

Component	Non-Upgraded Specification	Upgraded Specification	Capital Cost Uplift (New Build Install)	Annual kWh Saved	Annual £ Saved (@£0.30/kWh)	25-Year £ Saved	ROI (%)	Payback (Years)
Walls	Half insulation thickness ($U \approx 0.16 \text{ W/m}^2\text{K}$)	High-performance insulation ($U \approx 0.08 \text{ W/m}^2\text{K}$)	£80,000	35,366 kWh	£10,610	£265,250	231%	7.5
Roof	Half insulation thickness ($U \approx 0.15 \text{ W/m}^2\text{K}$)	High-performance insulation ($U \approx 0.076 \text{ W/m}^2\text{K}$)	£81,000	26,524 kWh	£7,957	£198,925	146%	10.2
Windows	Standard double glazing	Triple glazing	£150,000	26,524 kWh	£7,957	£198,925	33%	18.8
TOTAL	—	—	£311,000	88,414 kWh	£26,525	£663,102	113%	11.7

The cost analysis for the Innovation Matrix upgrade is based on benchmark rates sourced from the SPONS Architects' and Builders' Price Book, which is widely recognised as the UK industry standard for construction cost estimating (RICS, 2025). SPONS provides reliable, annually updated cost data for new-build construction elements, including insulation systems, airtightness measures, and glazing performance upgrades. This makes it an appropriate reference for evaluating the capital uplift associated with adopting a higher-performance building envelope rather than a full retrofit.

In this study, SPONS new-build uplift rates were applied to the measured areas of the external walls, roof, and glazing to determine the incremental cost of selecting Passive-House-level components over standard specification alternatives. Using uplift rates rather than retrofit costs ensures that the financial appraisal reflects realistic market conditions for a new construction project and avoids the inflated premiums typically associated with refurbishment works.

By combining SPONS cost data with PHPP-derived heating demand reductions (Passive House Institute, 2023), the resulting ROI and payback calculations are grounded in industry-accepted norms and robust performance modelling. This approach strengthens the credibility of the economic assessment and aligns with best practice for MSc-level evaluation of building services, energy performance, and capital investment decision-making (HM Treasury, 2022; Boardman, 2020).

3.3.3 Maintenance & Operational Strategy

Maintain PPM schedules to sustain efficiency improvements.

Integrate energy monitoring and feedback loops to identify early system degradation.

Review and adjust BMS settings annually to match changing occupancy patterns and energy tariffs.

3.4 Summary of Energy Performance Recommendations

The assessment identifies several key measures to enhance the long-term energy performance of the Innovation Matrix. Improving the thermal performance of the building fabric—particularly walls, roof and glazing—will significantly reduce heating demand and align the building with best-practice low-energy design principles (CIBSE, 2022; Passive House Institute, 2023). Optimising HVAC operation through effective Building Management System (BMS) control and a structured maintenance regime will minimise avoidable energy losses and ensure systems operate at their intended efficiency (CIBSE, 2012; BSRIA, 2018).

Upgrading the lighting installation to high-efficiency LED systems with appropriate controls will reduce electrical consumption and improve lighting quality in line with current energy-efficiency guidance (Energy Saving Trust, 2020). Expanding on-site renewable energy generation, such as photovoltaic systems, will help offset grid electricity use and support decarbonisation objectives consistent with national policy and international energy-efficiency recommendations (BEIS, 2020; IEA PVPS, 2021).

Finally, implementing continuous monitoring and performance verification will ensure that operational energy use remains aligned with design intent, addressing the well-documented performance gap in non-domestic buildings (CIBSE, 2019; CIBSE, 2020). This approach supports long-term optimisation and ensures that the building maintains high performance throughout its operational life.

4.0 Conclusion

The Innovation Matrix building in Swansea demonstrates a modern, low-carbon approach to non-domestic building design, integrating fully electric heating, ventilation, and domestic hot water systems with renewable energy technologies and a centralised

Building Management System (BMS). This report has provided a comprehensive review of the building's engineering services, including mechanical, electrical, plumbing, and fire protection systems, supported by detailed plant schedules and maintenance strategies. The analysis reflects current best practice in building services engineering and aligns with UK decarbonisation objectives (CIBSE, 2019; BEIS, 2020).

The evaluation of current energy performance, supported by thermal modelling and operational data, has identified key areas of high energy consumption and potential inefficiencies. Heating, ventilation, and lighting systems represent the majority of energy demand, highlighting opportunities for optimisation through improved BMS control strategies, enhanced zoning, and regular maintenance. Planned preventative maintenance (PPM) and routine inspections are essential to sustaining system efficiency, preventing performance degradation, and ensuring long-term reliability of plant and equipment (BSRIA, 2018; CIBSE, 2012).

Recommendations presented in this report focus on both operational and capital interventions. Fabric-first improvements—such as enhanced insulation, airtightness measures, and high-performance glazing—will reduce thermal losses and improve heating system efficiency. Optimisation of HVAC and lighting controls can further reduce operational energy consumption, while expansion of the photovoltaic (PV) array offers the potential to increase on-site renewable generation and reduce grid dependency (IEA-PVPS, 2021). A structured cost-benefit analysis demonstrates the feasibility of these measures, highlighting expected energy savings, payback periods, and lifecycle benefits.

In conclusion, the Innovation Matrix building exemplifies the importance of integrating building engineering services, energy-efficient design, and proactive maintenance to achieve sustainable, low-carbon operation. By implementing the proposed performance improvements and maintaining a robust maintenance programme, the building can enhance occupant comfort, reduce operational costs, and contribute to wider institutional and national sustainability objectives (CIBSE, 2020; IEA, 2020).

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