Passivhaus Stage 3 Design Report Including Energy Statement

POLARIS
PASSIVHAUS CONSULT + CONSTRUCT

79 Riddlesdown Road, Purley

9th August 2024

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Revision History

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Distribution

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This report, created by Polaris Passivhaus Consult + Construct Limited, pertains to the 79 Riddlesdown Road, Purley project. Its exclusive focus is on presenting the outcomes derived from the initial Passivhaus Planning Package (PHPP) modelling of the scheme and delivering a compliant Energy Statement.

Contents

Section 1

Executive Summary

1.0 Executive Summary

1.1 Who we are?

1.1.1 Polaris Passivhaus Consult + Construct specialises in providing end-to-end consultancy and contracting services for Passivhaus, EnerPHit, or Low Energy Building projects. Our expertise spans across the construction spectrum, catering to individual homes and intricate mixed-use developments. We offer comprehensive support from initial concept design to project management, on-site execution, and final handover.

1.1.2 At the heart of our company's values lie sustainability, ecological enhancement, community involvement, innovation, and construction excellence. These principles are integral to all our consultancy and delivery roles, forming essential criteria in our operations.

1.1.3 For us, Passivhaus principles (and EnerPHit for retrofit projects) epitomise sustainable design and development. Leveraging established techniques available for over a quarter-century, we craft energy-efficient, comfortable, healthy, and premium living and working spaces.

1.2 About the Author

1.2.1 Liam Brennan is a seasoned Construction Professional, boasting a rich background as a Quantity Surveyor and Project Manager. He has made his mark collaborating with prominent Main Contractors and Developers, contributing to renowned projects across central London. Additionally, Liam is the founder and proprietor of Polaris Construction Consultants, an SME business offering construction consultancy services.

1.2.2 Driven by a vision to revolutionise Sustainable Development, Liam is dedicated to reshaping the conventional approach by prioritising sustainability in the business framework. His profound love for the environment, coupled with an enthusiasm for innovative and eco-friendly development, modern construction methods, and biophilic design, prompted the establishment of both Polaris Passivhaus Developments and Polaris Passivhaus Consult + Construct.

1.2.3 Acknowledging the significance of sustainable development and possessing a deep understanding of various modern construction methods and practices, he intends to utilise these in the growth of both companies.

1.2.4 Liam is an enthusiastic advocate who firmly believes that our built environment, crucial for our survival and prosperity, should be constructed in the most efficient way conceivable, employing minimal energy consumption throughout its lifespan. Moreover, he is committed to reducing our impact on ecosystems and striving to enhance them whenever feasible.

1.2.5 Qualifications include being a **Certified Passivhaus Consultant** (see Figure 1), a HNC in Construction, BSc in Quantity Surveying, PRINCE2 Practitioner Certification and Chartered Construction Manager (MCIOB) status with the Chartered Institute of Building.

Certificate

Passive House Consultant

Passive House Institute

Dr. Wolfgang Feist
64283 Darmstadt
Germany
www.passivehouse.com

Valid until 25th April 2027

Liam Brennan

Date of birth: 23rd Octo[redacted]

is entitled to use the seal below during the five year validity of the certificate and is listed during this period in the list of Certified Passive House Designers/Consultants at www.passivehouse-designer.org

The qualification was obtained according to the valid examination regulations

at: **University of Strathclyde**

in: **Online exam**

CONSULTANT
CERTIFIED PASSIVE HOUSE CONSULTANT

Darmstadt, 25th April 2022

Prof. Dr. Wolfgang Feist

This certificate does not qualify the recipient for authentication under public law and therefore does not replace any official authorisation to present building documents.

Figure 1 - Certified Passivhaus Consultant Certificate

1.3 Executive Summary (Energy Statement)

1.3.1 The outcome of the comprehensive analysis and assessment between the Passivhaus Plus standards and the Baseline Part L (Building Regulations) for this development has yielded striking and commendable results. The data obtained from this meticulous examination underscores a revolutionary leap in sustainable construction practices, positioning Passivhaus Plus as an exemplar of innovation and environmental responsibility.

1.3.2 Target Emission Rate ($kgCO_2/(m^2a)$):

- **Baseline Part L:** 14.45 $kgCO_2/(m^2a)$
- **Passivhaus Plus:** 0.65 $kgCO_2/(m^2a)$
- **% Improvement:** The Passivhaus Plus standard demonstrates a remarkable improvement in CO_2 emissions, achieving an extraordinary **95.5% reduction**. This is a truly incredible advancement over the baseline Part L requirements, showcasing a commitment to sustainability and energy efficiency far beyond conventional standards. This substantial reduction reflects the meticulous focus on superior insulation, airtightness, and thermal performance within the Passivhaus Plus framework. Such an achievement not only drastically lowers the carbon footprint of the building but also ensures optimal comfort and minimal energy consumption for occupants, setting a new benchmark in sustainable building design.

1.3.3 Target Primary Energy Rate ($kWh/(m^2a)$):

- **Baseline Part L:** 122.40 $kWh/(m^2a)$
- **Passivhaus Plus:** 68.30 $kWh/(m^2a)$
- **% Improvement:** Passivhaus Plus demonstrates a remarkable **44.20% decrease** in primary energy consumption compared to Baseline Part L. The stringent energy conservation measures, advanced insulation techniques, and efficient systems integrated into Passivhaus Plus designs substantially reduce energy demand, contributing to a more sustainable and energy-efficient development.

1.3.4 Target Fabric Energy Efficiency Rate ($kWh/(m^2a)$):

- **Baseline Part L:** 34.30 $kWh/(m^2a)$
- **Passivhaus Plus:** 24.90 $kWh/(m^2a)$
- **% Improvement:** The standards showcases an impressive **27.40% enhancement** in fabric energy efficiency compared to Baseline Part L. This achievement signifies

the meticulous attention to detail in insulation, airtightness, and thermal performance of building elements. Passivhaus Plus exemplifies superior fabric efficiency, reducing heat demand and ensuring optimal comfort for occupants while minimising energy consumption.

1.3.5 The adoption of Passivhaus Plus standards signifies a paradigm shift towards sustainable construction practices and high-performance building design. These standards not only exceed the benchmarks set by Baseline Part L but also set a new standard for energy efficiency, environmental responsibility, and occupant comfort. The substantial percentage improvements in CO_2 emissions, primary energy consumption, and fabric efficiency underscore the exceptional benefits and transformative potential of embracing Passivhaus Plus standards in modern construction projects, heralding a greener and more sustainable future for the built environment.

3.14.6 Summary Table:

#	Description	Baseline Part L	Passivhaus Plus	Difference	Reduction	Planning Compliant
1	Target Emission Rate $kgCO_2/(m^2a)$	14.45	0.65	-13.80	95.50%	☑
2	Target Primary Energy Rate $kWh/(m^2a)$	122.40	68.30	-54.10	44.20%	☑
3	Target Fabric Energy Efficiency Rate $kWh/(m^2a)$	34.30	24.90	-9.40	27.40%	☑

1.3 Executive Summary (Passivhaus Plus)

1.3.1 This report provides an overview of the PHPP Pre-Assessment conducted for the 79 Riddlesdown Road, Purley project. It encompasses a comprehensive Energy Statement supporting the project, available in Section 3.

1.3.2 Based on the reviewed design data, meeting the Passivhaus Plus Standard is feasible. However, achieving a true net-zero position concerning CO_2 emissions will necessitate further incorporation of renewable technologies. To realise the Applicant's goal of true net-zero emissions in operation, an additional reduction of 259.40 $kgCO_2$/year is required.

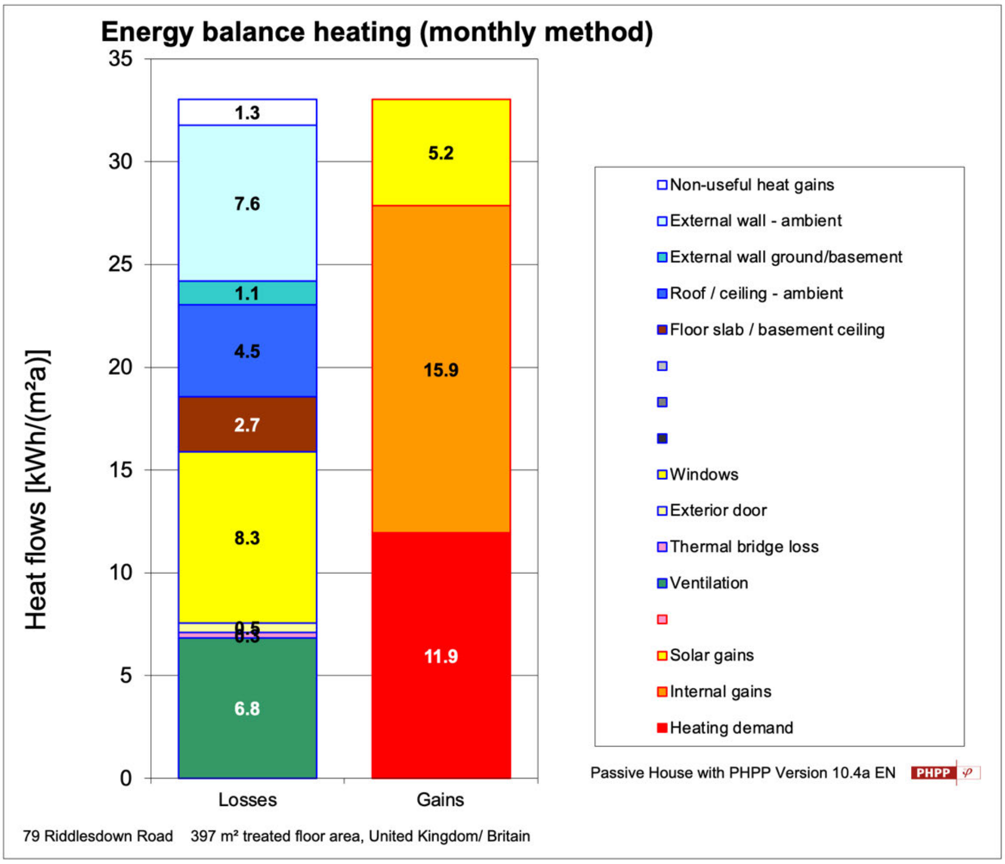
1.3.3 Close attention is vital regarding the development of the PHPP. Detailed information regarding this aspect is expanded upon in Section 4. Further refinement in the design of the building fabric composition and interfaces, along with the mechanical and electrical systems, is needed. The simulation has been constructed based on assumptions detailed in Section 4, grounded in guidance from the Passivhaus Institute.

1.3.4 All modelling outcomes are subject to verification during subsequent design stages when more precise information becomes available. This verification is crucial to confirm the performance accuracy of the finalised building design.

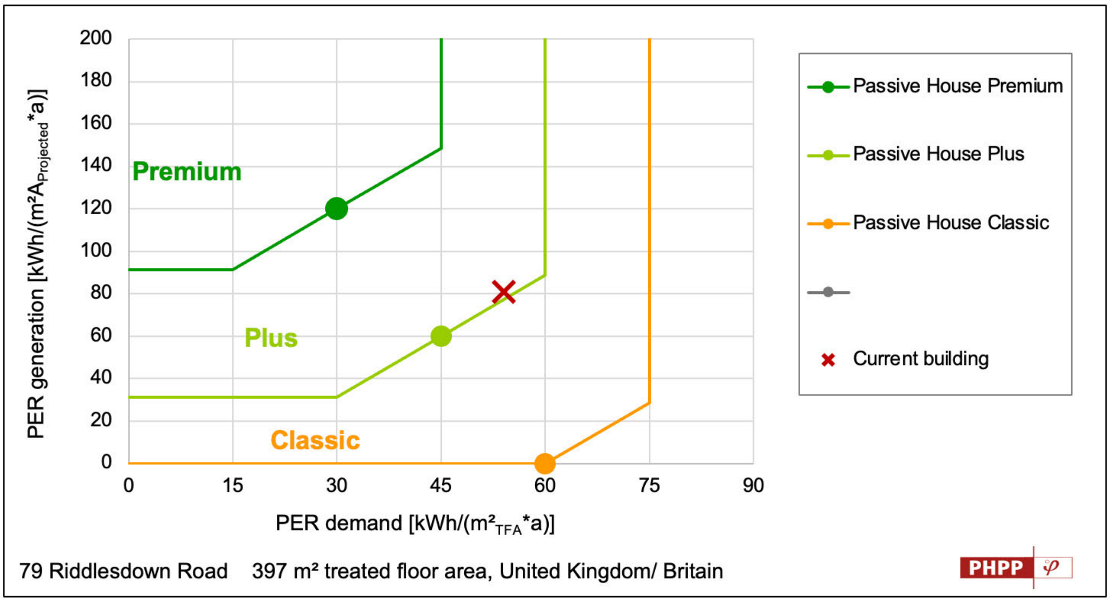
1.3.5 Below is a summarised table extracted from the PHPP:

Specific building characteristics with reference to the treated floor area					Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	397.1				
Space heating	Heating demand	kWh/(m²a)	12	≤	15	-	Yes
	Heating load	W/m²	8	≤	-	10	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	-	≤			
	Frequency of overheating (> 24 °C)	%	3	≤			
	Frequency of excessively high humidity (> 12 g/kg)	%	0	≤	20		Yes
Airtightness	Pressurisation test result n_{50}	1/h	0.6	≤	0.6		Yes
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	68	≤	-		-
Primary Energy Renewable (PER)	PER demand	kWh/(m²a)	54	≤	45	54	Yes
	Renew. energy generation (in rel. to projected building footprint area)	kWh/(m²a)	81	≥	60	77	

1.3.6 Below is the Energy Balance extract:



1.3.7 Verification Passive House Plus extract:



Section 2

The Passivhaus Standards

2.0 The Passivhaus Standards

2.1 The Passivhaus Standards

2.1.1 Passivhaus (also known as Passive House) is a scientifically validated design methodology for new construction projects, ensuring exceptionally comfortable and healthy living and working conditions within our built environment. The term 'haus' directly denotes building, implying that the same principles can be applied to non-residential projects as well.

2.1.2 Passivhaus structures offer superior occupant comfort while using minimal energy for heating and cooling. They are crafted with meticulous attention to detail and stringent design and construction quality control, aligning with the principles, tools, and training established by the Passivhaus Institut in Germany.

2.2.3 These buildings achieve a remarkable reduction of over 75% in space heating requirements compared to current standard practices for new constructions. They create exceptionally comfortable spaces of unparalleled quality, while also providing up to 90% reductions in occupants' energy bills.

2.2.4 To attain Passivhaus standards, typical measures include:

- Precise design modelling using the Passive House Planning Package (PHPP).
- Highly effective insulation.
- Exceptionally performing windows with insulated frames.
- An airtight building structure.
- Construction that eliminates thermal bridges.
- A mechanical ventilation system with extremely efficient heat recovery.

2.2.5 As Passivhaus gains traction across the UK, Europe, and globally, some projects are surpassing the original Passivhaus standard to meet net-zero targets. Alongside the established 'Passivhaus Classic,' there are 'Passivhaus Plus' and 'Passivhaus Premium' standards that integrate renewable energy generation in the certification assessment.

2.2.6 Passivhaus Plus certification signifies a monumental achievement in building design and energy efficiency. Beyond significantly reducing energy consumption, a Passivhaus Plus certified building demonstrates an exceptional feat—it generates an equivalent amount of renewable energy to match the energy consumed by its occupants. This means the building operates on a net-zero energy balance, producing as much clean, renewable energy as it consumes over the course of a year.

2.27 Achieving Passivhaus Plus certification necessitates an extensive commitment to renewable energy sources, ensuring that the energy generated is exclusively derived from sustainable, renewable sources like solar panels, wind turbines, or other eco-friendly means. This renewable energy production must be substantial enough to meet the building's total energy demands across all seasons and weather conditions throughout the entire year.

2.2.8 The Passivhaus Plus certification represents a paradigm shift towards sustainable architecture, as it not only focuses on energy efficiency but also actively contributes to environmental conservation by minimising reliance on non-renewable energy sources. Passivhaus Plus buildings epitomise a holistic approach to sustainable living, setting a high standard for energy-conscious construction by effectively balancing energy consumption and renewable energy generation, ultimately fostering self-sufficiency and environmental responsibility.

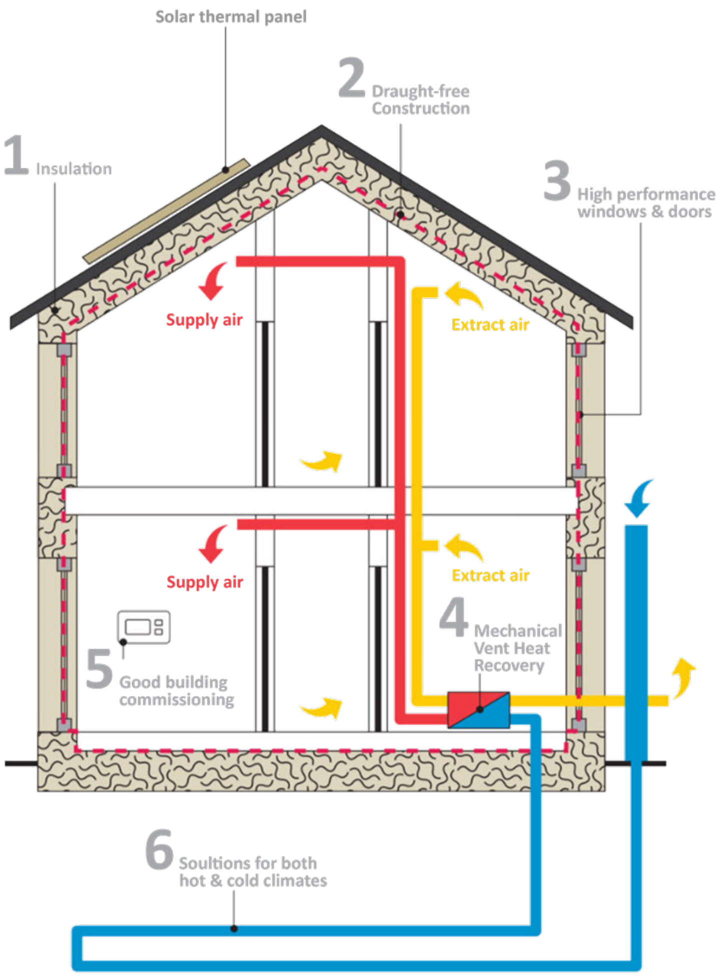
2.2.7 Passivhaus Premium certification represents an ambitious and remarkable achievement in sustainable building design, surpassing the standards set by Passivhaus Plus. In this exceptional designation, the building not only fulfils its operational energy requirements but actually generates a surplus of energy, far exceeding its own operational needs.

2.2.8 This certification sets a notably high bar, demanding an extraordinary commitment to energy efficiency and renewable energy generation. The goal is to produce a substantial surplus of renewable energy that vastly exceeds the building's energy consumption. This surplus energy is then channelled back into the grid or stored for future use, contributing positively to the local energy supply and environment.

2.2.9 Attaining **Passivhaus Premium** certification requires a holistic approach to design, incorporating cutting-edge technologies, meticulous planning, and exceptionally high-quality construction materials and methods. It underscores an unwavering dedication to achieving an unparalleled level of energy efficiency and sustainability, setting a new standard for environmentally conscious architecture.

2.2.10 This certification is a testament to the commitment of architects, builders, and owners to not merely meet energy efficiency requirements but to excel in sustainability by substantially surpassing energy production standards, making **Passivhaus Premium** a pinnacle of eco-friendly building design.

2.2 Key Elements to Passivhaus Design & Construction



2.2.1 To achieve the multitude of benefits offered by both Passivhaus and EnerPHit, the Passive House Planning Package (PHPP), the software employed to model both construction types, stipulates a comprehensive set of detailed requirements. These criteria must be met to attain the necessary standards for certification in comfort, health, and energy efficiency.

2.2.2 The essential elements integral to Passivhaus and EnerPHit designs encompass:

(i) Insulation
(ii) Draught-free construction
(iii) High performance windows & doors
(iv) Mechanical Vent Heat Recovery (MVHR)
(v) Good building commissioning
(vi) Solutions for hot & cold climates

2.2.3 Insulation: Typically, insulation ranging from 200 to 400mm in thickness (slightly less for EnerPHit) is required, ensuring continuity throughout the entire envelope to eliminate or significantly reduce thermal bridges. Thermal bridges are pathways for heat loss across construction elements like external balcony connections or the ground floor meeting foundations.

2.2.4 Draught-free Construction: Traditional and older houses often waste heat due to draughts caused by leaky fabric (walls, roof, etc.), outdated bathroom extractor fans, and primitive 'trickle' vents on window frames, still allowed by UK Building Regulations. Achieving near-airtight conditions is crucial and must be carefully considered early in the design phase.

2.2.5 High Performance Windows & Doors: Utilising high-performing windows and doors is essential to maintain thermal comfort and prevent condensation, which in turn inhibits conditions ideal for dust mite and mould growth. Passivhaus Certified triple glazed window units are recommended in both Passivhaus and EnerPHit designs for their precision engineering and rigorous performance testing.

2.2.6 Mechanical Vent Heat Recovery (MVHR): Proficiently designed, installed, and commissioned MVHR systems extract warm, moist stale air, recover its heat, and expel it from the building while supplying fresh, filtered, pre-warmed air through a heat exchanger. This process significantly reduces CO_2 levels and other particulate build-ups, controlling humidity and temperature.

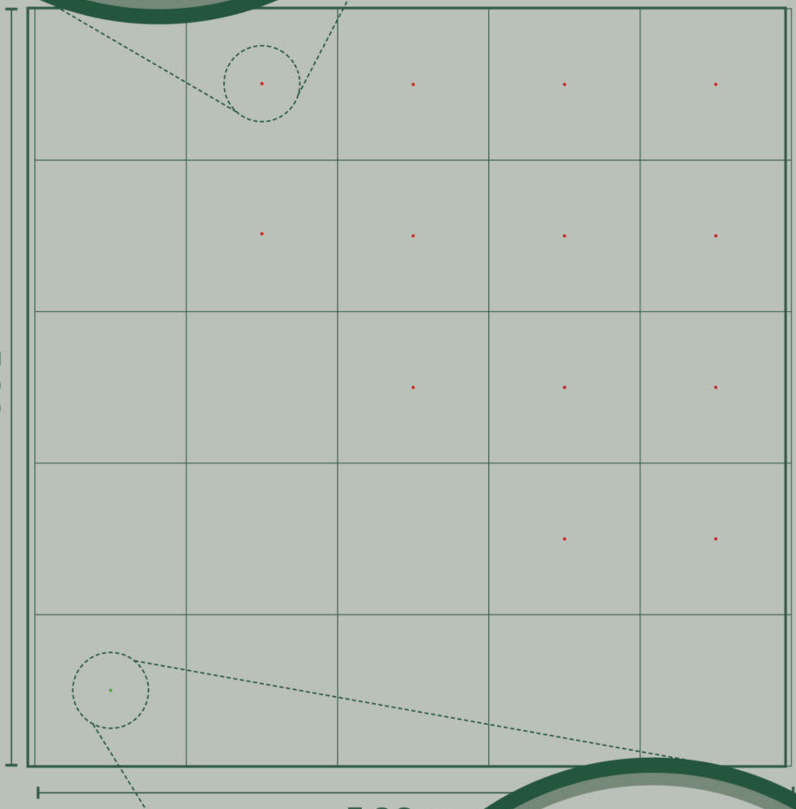
2.2.7 **Good building commissioning:** Designing mechanical and electrical systems for simplicity is crucial. After installation, testing critical elements like energy/water consumption and ventilation flow rates is essential. While not mandatory, Building Management Systems (BMS) could simplify operations.

2.2.8 **Solutions for hot & cold climates:** Passivhaus and EnerPHit standards consider location-specific climate data, significantly influencing the design and orientation. Properly detailed Passivhaus buildings can effectively reduce heating-energy demand in cooler climates or cooling-energy demand in warmer climates, showcasing their versatile applicability.

Airtightness Comparison

Building Regs Part L (2021)
vs.
Passivhaus Standard

The updated **Part L** of the Building Regs, effective 15th June 2022 onwards, allows a max air permeability rating (e.g. the amount of air allowed to pass through your walls) of anything up to **5m³ per hour per m² area** at 50pascals.



If we assume **5m³/hr** is achieved this would be the equivalent to a **hole the size of a 20p coin in every 2m²**!!

With the **Passivhaus Standards** you are required to achieve an air permeability rating of less than 0.7m³ per hour per m² area at 50pascals.

That is the equivalent to a **hole less than the size of a 5p coin in every 5m²**!!

"Air Permeability": this is the amount of air that is allowed to pass through a known area/ surface under a certain air pressure difference (i.e. 50pascals)

2.2 Passive House Planning Package (PHPP)

2.2.1 The Passive House Planning Package (PHPP) is an exhaustive tool encompassing all essentials for designing a fully functional Passive House. It orchestrates an energy balance and computes the building's yearly energy demand based on user-input information concerning its attributes.

2.2.2 Key outputs of the software encompass:

- (i) Annual heating demand [kWh/(m²a)] and maximum heating load [W/m²].
- (ii) Summer thermal comfort with active cooling: cooling demand [kWh/(m²a)] and maximum cooling load [W/m²].
- (iii) Summer thermal comfort with passive cooling: frequency of overheating events [measured as a %].
- (iv) Annual primary energy demand for the entire building [kWh/(m²a)].

2.2.3 The PHPP, built on MS Excel, includes distinct worksheets housing various inputs and calculations for different components. It manages several aspects:

- (i) Sizing individual components (such as building assemblies, U-value calculation, window quality, shading, ventilation, etc.) and their impact on the building's energy balance in both winter and summer.
- (ii) Sizing heating and cooling loads.
- (iii) Estimating domestic hot water (DHW) demand and designing DHW systems.
- (iv) Sizing mechanical systems for the whole building: heating, cooling, hot water provision.
- (v) Verifying the overall energy efficiency of the building concept.

2.2.4 Calculations are immediate, allowing users to instantly observe the impact of modifications on the building's energy balance. This facilitates comparison of components with varying qualities to optimise specific construction projects, whether new builds or refurbishments, systematically enhancing energy efficiency.

2.2.5 The PHPP also integrates systematic variant management. It adopts typical monthly climatic conditions for the building's location (temperature and solar radiation), computing monthly heating or cooling demands based on this data. Thus, it caters to diverse climatic regions worldwide.

2.2.6 The PHPP is rooted in the laws of physics, often resorting to current international standards where possible. It utilises established algorithms for shading, but due to the ultra-low energy demand of Passive Houses, occasional deviations or adaptations may be necessary, particularly for ventilation system dimensioning, where internationally relevant standards might be lacking. This meticulous approach results in a globally reliable calculation tool for more accurate evaluation of construction projects compared to conventional methods.

2.2.7 The PHPP forms the basis for quality assurance and certification of buildings as Passive Houses or EnerPHit retrofits. Its calculation outcomes are structured in a verification sheet. In addition to fundamental components, it offers supplementary features for users' convenience, simplifying the preparation of energy performance certificates for projects.

2.3 PHPP vs SAP

2.3.1 The Passive House Planning Package (PHPP) and the Standard Assessment Procedure (SAP) serve as crucial tools in evaluating building energy efficiency, albeit with notable differences in approach, scope, and application. Expanding on their comparison underscores the unique advantages of the PHPP, advocating its preference over SAP in specific scenarios.

2.3.2 Methodology and Objectives:

(i) PHPP: Designed for ultra-low energy consumption, superior comfort, and optimal indoor air quality, PHPP operates on a meticulous design strategy. It evaluates a building's energy balance based on comprehensive inputs and delivers real-time feedback on modifications, emphasising quality and comfort alongside efficiency.

(ii) SAP: SAP primarily functions as a regulatory compliance tool for building regulations and Energy Performance Certificates (EPCs). It focuses on assessing standard energy performance metrics to meet minimum regulatory requirements rather than aiming for exceptional energy efficiency and comfort.

2.3.3 Scope of Application:

(i) PHPP: Tailored for Passivhaus and EnerPHit projects, PHPP excels in evaluating diverse and innovative designs, offering solutions for non-standard building methods. It's suitable for a wide range of buildings, from residential dwellings to complex non-residential structures, focusing on achieving high-performance standards.

(ii) SAP: Predominantly used in the UK for regulatory compliance and EPC generation, SAP is suitable for various building types, but its standardised approach might lack the sophistication required for highly energy-efficient designs.

2.3.4 Energy Efficiency and Comfort Optimisation:

(i) PHPP: PHPP's core emphasis lies in achieving top-tier energy efficiency, often resulting in over 75% reduction in heating requirements compared to standard practices. It meticulously assesses factors such as insulation, airtightness, high-performance windows, and ventilation systems to achieve unparalleled indoor comfort.

(ii) SAP: While SAP is effective for meeting minimum regulatory standards, its focus is more on compliance rather than achieving exceptional energy efficiency. It might overlook specific design nuances that significantly impact energy consumption and indoor comfort levels.

2.3.5 Flexibility and Customisation:

(i) PHPP: Known for its adaptability and detailed calculations, PHPP offers a high degree of customisation. It allows iterative design optimisation, accommodating various building components and design variations, providing immediate feedback for refinement.

(ii) SAP: SAP operates on standardised parameters, which might limit its ability to comprehensively assess innovative designs or unconventional building methods. Its focus on standardisation might not capture the intricate details necessary for optimising energy efficiency to the highest standards.

2.3.6 In essence, while SAP remains a regulatory compliance tool, the PHPP emerges as a platform tailored for achieving exceptional energy efficiency and comfort. Its comprehensive calculations, flexibility, and focus on Passivhaus standards position it as the preferred choice for projects seeking outstanding energy efficiency and comfort levels.

2.4 Introduction to Energy Balance Calculations

2.4.1 Passivhaus structures represent well-insulated, draught-free buildings with an incredibly low demand for space heating, allowing conventional heating systems to be omitted. Any necessary heating is supplied to individual rooms by warming the air circulated through the ventilation system.

2.4.2 In these buildings, the heating load typically averages about 10 W/m2, depending on required airflows. The annual space heating energy demand usually stays within 15 kWh/(m2a) (kilowatt-hours per square meter of treated floor area per annum). For warmer climates, similar principles apply to indoor cooling and dehumidification, with minimal annual energy consumption.

2.4.3 Constructing Passivhaus buildings necessitates high-quality components selected in line with the specific climate. For the cool-temperate climate, reference values include:

(i) Exterior building elements with a U-value below 0.15 $W/(m^2K)$.

(ii) Constructing the external envelope without thermal bridges.

(iii) Ensuring airtightness verified by an air leakage test according to standard EN 13829, where the measured air leakage shouldn't exceed 0.6 h^{-1} at a pressure differential of 50 Pa (both over and under-pressure).

(iv) Glazing meeting U-values below 0.8 $W/(m^2K)$ according to EN 673 and a total solar energy transmittance (g-value) of at least 50% per EN 410 for net heat gains in winter.

(v) Windows with total U-values under 0.8 $W/(m^2K)$ as per EN 10077.

(vi) Ventilation systems designed with energy recovery efficiency of $\eta HR \geq 75\%$ (subtracted by 12 percentage points from standard testing procedures). Additionally, minimal electricity consumption ($\leq$ 0.45 Wh/m^3 of supplied air volume) is required.

(vii) Domestic hot water systems with minimal heat losses.

(viii) Maximising the efficient use of household electricity.

2.4.4 These stringent standards ensure exceptional performance in energy efficiency, thermal comfort, and sustainability within Passivhaus structures, providing an unparalleled living and working environment.

Mere assembly of suitable components doesn't guarantee a building meeting the Passivhaus criteria. The synergy among components demands a comprehensive plan to attain the Passivhaus Standard. This is precisely the objective of the Passive House Planning Package (PHPP).

2.5 Thermal Assessment + Calculation

2.5.1 The building design has been modelled using the Passivhaus Planning Package (PHPP). This software contains everything necessary for designing a properly functioning Passive House. The PHPP prepares an energy balance and calculates the annual energy demand of the building based on the user input relating to the building's characteristics.

2.5.2 The main results provided by this software programme include:

- (i) The annual heating demand (kWh/(m^2a)) and maximum heating load (W/m^2)
- (ii) Summer thermal comfort with active cooling: cooling demand (kWh/(m^2a)) and maximum cooling load (W/m^2)
- (iii) Summer thermal comfort with passive cooling: frequency of overheating events (measured as a %)
- (iv) Annual primary energy demand for the whole building (kWh/(m^2a))

2.5.3 Among other things, the PHPP deals with the following aspects:

- (i) Dimensioning of individual components (building component assemblies including U-value calculation, quality of windows, shading, ventilation etc.) and their influence on the energy balance of the building in winter as well as in summer
- (ii) Dimensioning of the heating load and cooling load
- (iii) Calculating domestic hot water (DHW) demand and design of DHW systems
- (iv) Dimensioning of the mechanical systems for the entire building: heating, cooling, hot water provision
- (v) Verification of the energy efficiency of the building concept in its entirety

2.6 Heat Loss Methodology

2.6.1 The methodology used for simulating heat loss involves a comprehensive approach that encompasses various critical aspects described below.

2.6.2 Monthly Energy Balances Calculation: This methodology calculates and analyses energy balances on a monthly basis. By doing so, it provides a nuanced understanding of the building's thermal performance across different months, considering variations in climate conditions, solar exposure, and internal thermal dynamics throughout the year.

2.6.3 Unified Building Zone Consideration: The simulation treats the entire building as a singular zone, allowing for an integrated assessment of heat loss dynamics within the structure. This approach acknowledges the interconnectedness of different areas within the building and how their thermal behaviours collectively impact energy efficiency.

2.6.4 Inclusion of Internal Heat and Solar Gains: It factors in internal heat contributions stemming from occupants, appliances, and activities within the building. Additionally, it accounts for solar gains, considering how sunlight penetration and thermal radiation influence temperature regulation and heat transfer within the structure.

2.6.5 Utilisation of Local Weather Data: The simulation relies on locally specific weather data to conduct a more accurate and contextually relevant assessment of heat loss dynamics. By integrating data related to temperature variations, precipitation, humidity levels, and prevailing climatic patterns specific to the building's geographical location, the analysis becomes tailored to its environmental context.

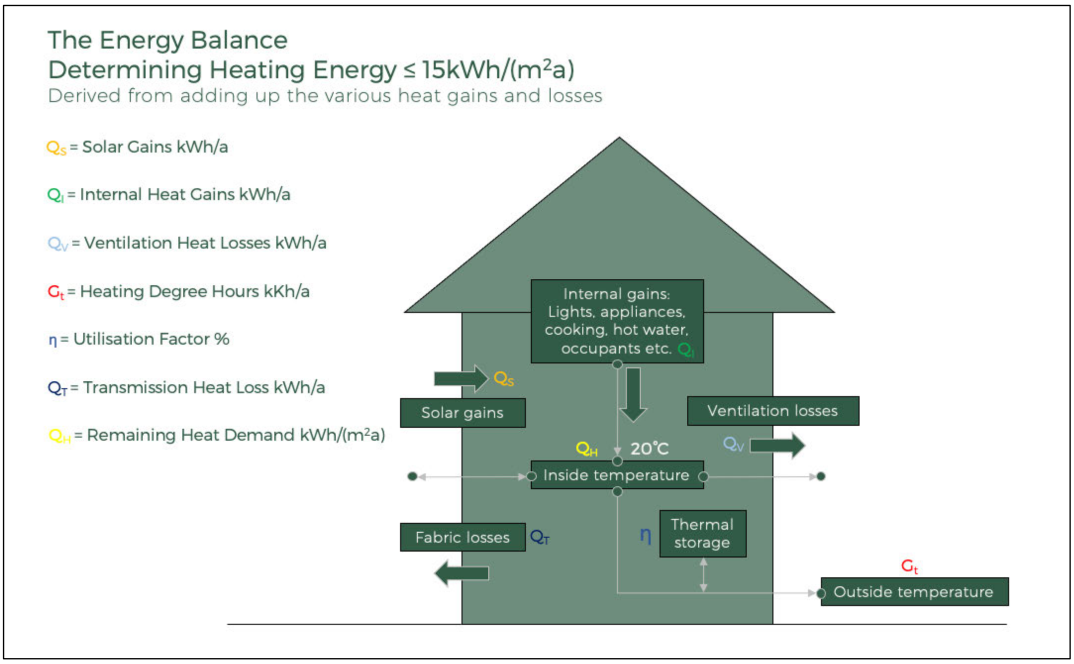
2.6.7 This multifaceted approach to heat loss simulation enables a thorough examination of the building's thermal performance, considering internal, external, and environmental factors that collectively influence its energy efficiency and thermal comfort.

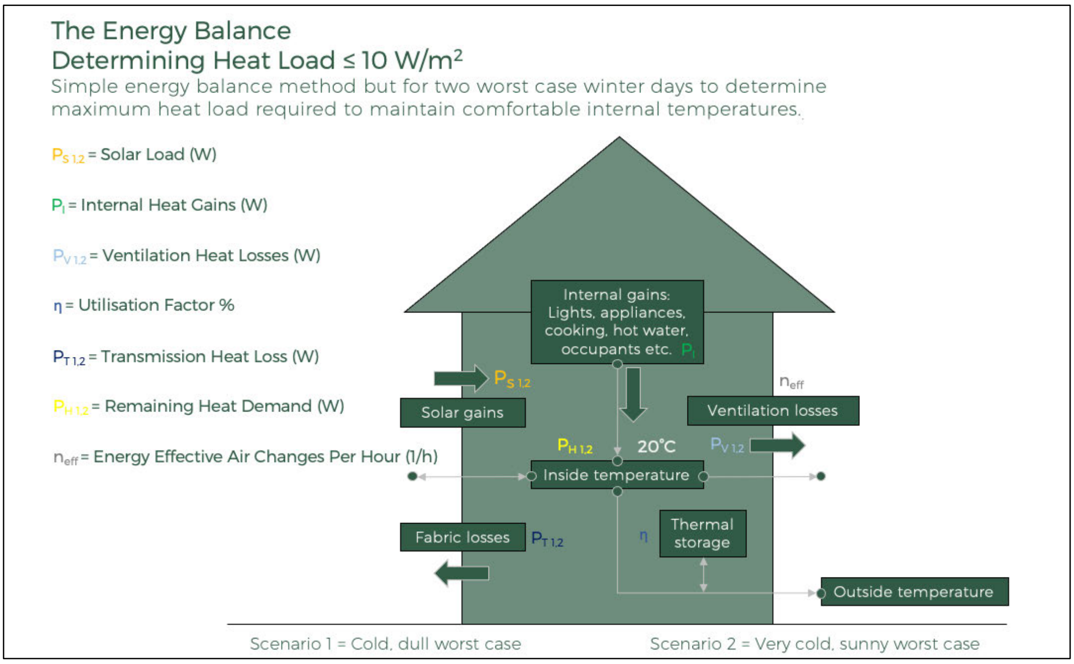
2.7 Standardised Calculation Method: Monthly Method

2.7.1 The Passive House Planning Package (PHPP) adopts the monthly method as outlined in EN ISO 52016 to calculate the heating demand. This method is highly regarded for its precision in assessing energy needs and offers a more detailed analysis compared to the annual method specified in EN ISO 13790. Despite both methods yielding fairly comparable results, the monthly approach stands out for its heightened accuracy in evaluating heating requirements.

2.7.2 The monthly methodology, as endorsed by EN ISO 52016, delves into a more granular examination of the building's thermal dynamics. By breaking down the assessment into monthly increments, it accounts for nuanced variations in climatic conditions, solar exposure, and internal thermal influences across different periods of the year. This meticulous breakdown enables a closer examination of how seasonal changes impact the building's heat demand, providing more precise insights into the heating requirements during varying weather conditions.

2.7.3 In contrast, the annual method described in EN ISO 13790 offers a broader overview of the building's energy performance by averaging data across the entire year. While this method offers useful insights, the monthly approach, as implemented in the PHPP, surpasses it in accuracy by considering the fluctuations in weather and internal conditions throughout individual months. Consequently, the monthly method, due to its finer granularity, is known to provide more accurate estimations of heating demands, enhancing the reliability of the assessment in determining the building's energy needs.





2.8 The ‘Performance Gap’

2.8.1 The 'Performance Gap' stands as a term widely used in the UK Construction Industry, representing a significant challenge faced by the sector in the forthcoming years. This issue is intricate and often linked to the loss of information between the design, construction, and operational phases.

2.8.2 Efforts to address this challenge involve enhancing the techniques used to simulate and anticipate building energy performance during the design phase. This includes placing greater emphasis on buildability assessments during the design process and on-site monitoring during construction. These challenges are deeply embedded in the ethos of Passivhaus, offering valuable insights and lessons for the industry to absorb.

2.8.3 Employing the Passive House Planning Package (PHPP) from the initial design stages up to the certification phase post-construction ensures comprehensive awareness among all stakeholders regarding the strengths and weaknesses inherent in the project.

2.8.4 Monitoring data collected from newly constructed houses consistently demonstrates that the estimated energy usage during the design phase often surpasses the actual usage during occupation—sometimes substantially. A study by the Centre for the Built Environment at Leeds Metropolitan University (now Leeds Beckett) in 2015 highlighted significant differences between the expected and actual performances of newly built homes. Heat loss was identified as a primary contributor to this 'performance gap,' ranging from 10% to 125% of the predicted design calculations.

2.8.5 More recent research from Innovate UK's Building Performance Evaluation Programme analysed 76 low-carbon homes. It revealed that the carbon emissions from these homes were, on average, two to three times higher than the initial design estimates. This variation spanned a wide range, with the least efficient home consuming 29 times more energy than the design estimate for regulated energy alone. Notably, these homes were all designed to achieve better-than-average energy performance.

2.8.6 In contrast, Passivhaus buildings consistently exhibit performances that closely align with their intended designs. Post-occupancy research conducted by Leeds Beckett University assessed 33 dwellings using the co-heating test method to evaluate building fabric. Among these, the six Passivhaus dwellings not only outperformed others at the design stage but also substantially reduced the performance gap.

2.8.7 Further, an independent report commissioned by the Passivhaus Trust from the University of Bath in 2017 examined post-occupancy data from an additional 31 Passivhaus dwellings. It concluded that, on average, these homes performed better than the predicted design energy usage of 15 kWh/m^2.a.

2.8.8 Consequently, the evidence suggests that most newly constructed dwellings tend to consume notably more energy than projected by their Standard Assessment Procedure (SAP) analysis. On the other hand, a new-build Passivhaus demonstrates a close match between the forecasted energy use from the Passive House Planning Package (PHPP) modelling and actual consumption.

2.8.9 However, defining an 'average' performance gap for overall emissions poses challenges as studies have focused on specific elements such as heat loss variations and comparisons between predicted unregulated energy and overall energy use in practice.

The Key Benefits to Passivhaus Certified Buildings

- Resilient
- Long term affordability
- Keep the wild things out
- Quiet and calm spaces
- Balanced
- Healthier environment
- Durability
- Predictable performance
- No dust
- Improved comfortability
- Energy efficient
- No unwanted moisture/odours

Section 3

Energy Statement

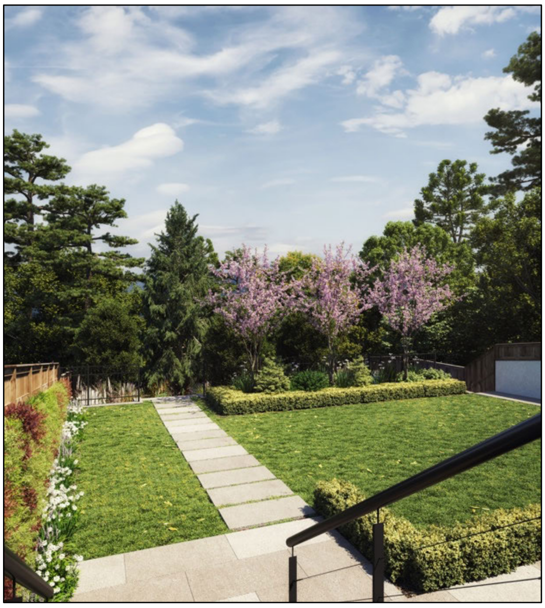
3.0 Energy Statement

3.1 Introduction to this Development

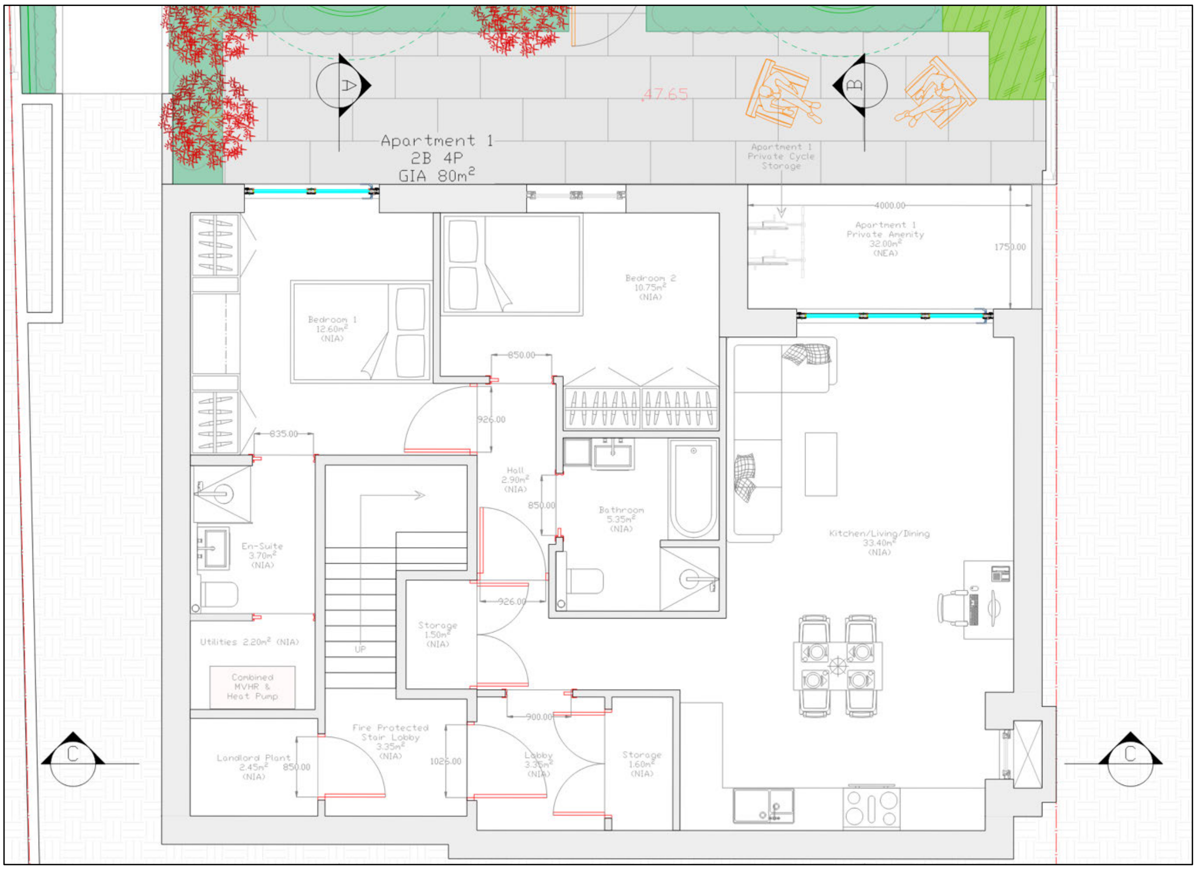
3.1.1 Polaris Passivhaus Consult + Construct have been instructed to prepare this Energy Statement by Polaris Passivhaus Developments in support of the proposed new build residential development at 79 Riddlesdown Road, Purley, CR8 1DH.

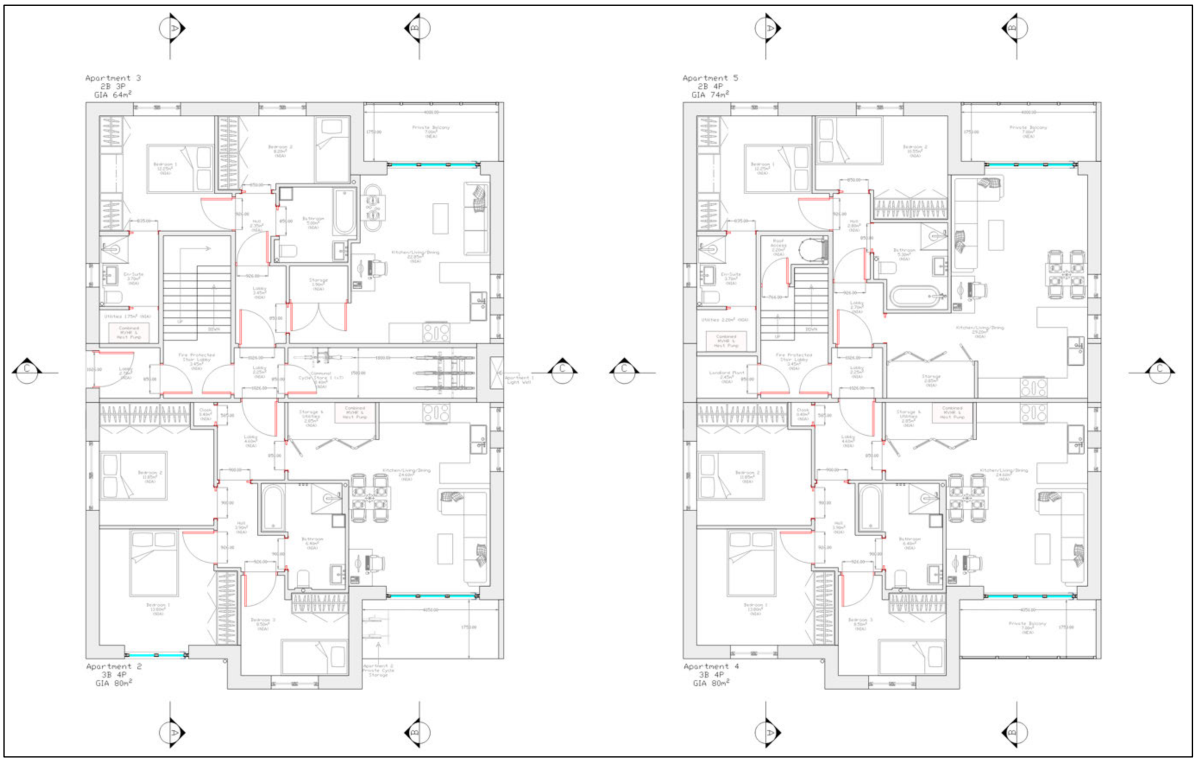
3.1.2 The project includes *"demolition of the existing structure and construction of Croydon's first biophilic designed, Passivhaus Certified residential development, delivering 5 new homes in a range of 2-beds and 3-beds, in addition to all associated hard and soft landscaping and off-street parking"*. The site is located in a residential area of Purley, South London and falls under Croydon Council's authority.

3.1.3 Project CGI's:



3.1.3 Proposed Development Floor Plans (see Appendix 1):





3.1.4 Treated Floor Area Calculations:

Apartment 1 - 2B 4P					
Item	Description	NIA (m^2)	NEA (m^2)	NIA (ft^2)	NEA (ft^2)
1	Kitchen / Living / Dining	33.40		359.51	
2	Hall	2.90		31.22	
3	Lobby	3.35		36.06	
3	Utilities	2.20		23.68	
4	Storage Cupboard(s)	3.10		33.37	
5	Bathroom	5.35		57.59	
6	Bedroom 1	12.60		135.63	
7	Bedroom 1 - En-Suite	3.70		39.83	
8	Bedroom 2	10.75		115.71	
9	Private Balcony & Courtyard Garden		32.00		344.44
	Totals:	77.35	32.00	832.59	344.44

Apartment 2 - 3B 4P					
Item	Description	NIA (m^2)	NEA (m^2)	NIA (ft^2)	NEA (ft^2)
1	Kitchen / Living / Dining	24.60		264.79	
2	Hall	3.90		41.98	
3	Lobby	4.60		49.51	
4	Storage Cupboard(s) and Utilities	3.25		34.98	
5	Bathroom	6.40		68.89	
6	Bedroom 1	13.80		148.54	
7	Bedroom 2	11.85		127.55	
8	Bedroom 3	8.50		91.49	
9	Private Balcony & Courtyard Garden(s)		20.50		220.66
	Totals:	76.90	20.50	827.74	220.66

Apartment 3 - 2B 3P					
Item	Description	NIA (m^2)	NEA (m^2)	NIA (ft^2)	NEA (ft^2)
1	Kitchen / Living / Dining	22.85		245.96	
2	Hall	2.35		25.30	
3	Lobby	3.45		37.14	
4	Utilities	1.75		18.84	
5	Storage Cupboard(s)	1.90		20.45	
6	Bathroom	5.00		53.82	
7	Bedroom 1	12.25		131.86	
8	Bedroom 1 - En-Suite	3.70		39.83	
9	Bedroom 2	8.20		88.26	
10	Private Balcony		7.00		75.35
	Totals:	61.45	7.00	661.44	75.35

Apartment 4 -3B 4P					
Item	Description	NIA (m^2)	NEA (m^2)	NIA (ft^2)	NEA (ft^2)
1	Kitchen / Living / Dining	24.60		264.79	
2	Hall	3.90		41.98	
3	Lobby	4.60		49.51	
4	Storage Cupboard(s) and Utilities	3.25		34.98	
5	Bathroom	6.40		68.89	
6	Bedroom 1	13.80		148.54	
7	Bedroom 2	11.85		127.55	
8	Bedroom 3	8.50		91.49	
9	Private Balcony		7.00		75.35
	Totals:	76.90	7.00	827.74	75.35

Apartment 5 - 2B 4P					
Item	Description	NIA (m^2)	NEA (m^2)	NIA (ft^2)	NEA (ft^2)
1	Kitchen / Living / Dining	29.20		314.31	
2	Hall	2.80		30.14	
3	Lobby	2.70		29.06	
4	Utilities	2.20		23.68	
5	Storage Cupboard(s)	2.85		30.68	
6	Bathroom	5.30		57.05	
7	Bedroom 1	12.25		131.86	
8	Bedroom 1 - En-Suite	3.70		39.83	
9	Bedroom 2	10.55		113.56	
10	Private Balcony		7.00		75.35
	Totals:	71.55	7.00	770.16	75.35

Communal Areas					
Item	Description	NIA (m^2)	NEA (m^2)	NIA (ft^2)	NEA (ft^2)
1	B | Fire Protected Stair Lobby	3.35		36.06	
2	B | Landlord Plant	2.45		26.37	
3	G | Lobby 1	2.70		29.06	
4	G | Fire Protected Stair Lobby	3.45		37.14	
5	G | Lobby 2	2.25		24.22	
6	G | Communal Cycle Store	8.40		90.42	
7	1 | Fire Protected Stair Lobby	3.45		37.14	
8	1 | Landlord Plant	2.45		26.37	
9	1 | Lobby	2.25		24.22	
10	1 | Roof Access Room	2.20		23.68	
	Totals:	32.95	0.00	354.67	0.00

Totals				
	NIA (m^2)	NEA (m^2)	NIA (ft^2)	NEA (ft^2)
Totals:	397.10	73.50	4274.34	791.15

3.2 Design Information

3.2.1 The drawings provided to us and utilised in the creation of the PHPP are listed below:

Polaris Passivhaus Developments Limited						
Item	Document Title	Doc. Nr	Rev	Page Size	Scale	Format
1	Proposed Basement Plan	P-001	B	A3	1:100	PDF
2	Proposed Ground and First Floor Plan	P-002	D	A3	1:100	PDF
3	Proposed Roof Plan	P-003	D	A3	1:100	PDF
4	Proposed Elevations	P-004	C	A3	1:100	PDF
5	Proposed Elevations	P-005	D	A3	1:100	PDF
6	Proposed Section AA & BB	P-006	C	A3	1:100	PDF
7	Proposed Section CC	P-008	C	A3	1:100	PDF

3.2.2 Please refer to Appendix 1 of this document to view the proposed development plans.

3.3 Relevant Planning Policy

3.3.1 The following Energy/CO_2 related planning policies are applicable to this development:

The London Plan 2021

Policy SI 2 Minimising greenhouse gas emissions

A Major development should be net zero-carbon.[151] This means reducing greenhouse gas emissions in operation and minimising both annual and peak energy demand in accordance with the following energy hierarchy:

1) be lean: use less energy and manage demand during operation
2) be clean: exploit local energy resources (such as secondary heat) and supply energy efficiently and cleanly
3) be green: maximise opportunities for renewable energy by producing, storing and using renewable energy on-site
4) be seen: monitor, verify and report on energy performance.

B Major development proposals should include a detailed energy strategy to demonstrate how the zero-carbon target will be met within the framework of the energy hierarchy.

C A minimum on-site reduction of at least 35 per cent beyond Building Regulations[152] is required for major development. Residential development should achieve 10 per cent, and non-residential development should achieve 15 per cent through energy efficiency measures. Where it is clearly demonstrated that the zero-carbon target cannot be fully achieved on-site, any shortfall should be provided, in agreement with the borough, either:

1) through a cash in lieu contribution to the borough's carbon offset fund, or
2) off-site provided that an alternative proposal is identified and delivery is certain.

D Boroughs must establish and administer a carbon offset fund. Offset fund payments must be ring-fenced to implement projects that deliver carbon reductions. The operation of offset funds should be monitored and reported on annually.

151 Where zero-carbon is used in the Plan it refers to net zero-carbon – see Glossary for definition.

152 Building Regulations 2013. If these are updated, the policy threshold will be reviewed. https://www.gov.uk/government/publications/conservation-of-fuel-and-power-approved-document-l

E Major development proposals should calculate and minimise carbon emissions from any other part of the development, including plant or equipment, that are not covered by Building Regulations, i.e. unregulated emissions.

F Development proposals referable to the Mayor should calculate whole life-cycle carbon emissions through a nationally recognised Whole Life-Cycle Carbon Assessment and demonstrate actions taken to reduce life-cycle carbon emissions.

3.3.2 In addition to the above policies outlined by the London Plan, the **Croydon Local Plan 2018 (Revised 2021)** also sets out the following targets;

Policy SP6: Sustainable Design and Construction

SP6.1 In order to reduce greenhouse gas emissions and deliver development that is adaptable in a changing climate, the Council will apply a presumption in favour of development provided applications meet the requirements of Policy SP6 and other applicable policies of the development plan.

Energy and carbon dioxide (CO_2) reduction

SP6.2 The Council will ensure that future development makes the fullest contribution to minimising carbon dioxide emissions in accordance with the London Plan energy hierarchy (use less energy, supply energy efficiently and use renewable energy), to assist in meeting local, London Plan and national CO_2 reduction targets. The Council will promote the development of district energy networks where opportunities exist due to high heat density or an increase in heat density brought about by new development. This will be achieved by:

a. Requiring high density residential developments of 20 or more units to incorporate site wide communal heating systems

b. Requiring major development to be enabled for district energy connection unless demonstrated not to be feasible or financially viable to do so.

Sustainable design and construction

SP6.3 The Council will seek high standards of sustainable design and construction from new development, conversion and refurbishment to assist in meeting local and national CO_2 reduction targets. This will be achieved by:

a. Requiring new-build residential development of fewer than 10 units to achieve the national technical standard for energy efficiency in new homes (2015). This is set at a minimum of 19% CO_2 reduction beyond the Building Regulations Part L (2013);

b. Requiring all major development to achieve the London Plan requirements or National Technical Standards (2015) for energy performance, whichever the higher standard;

c. Requiring all new-build residential development to meet a minimum water efficiency standard of 110 litres/person/day as set out in Building Regulations Part G;

d. Requiring conversions and changes of use of existing buildings providing more than 10 new residential units to achieve a minimum of BREEAM Domestic Refurbishment Very Good rating or equivalent;

e. Requiring new build non-residential development of 500m^2 and above to achieve a minimum of BREEAM Excellent standard or equivalent;

f. Requiring conversions and changes of use to non-residential uses with an internal floor area of 500m^2 and above to achieve a minimum of BREEAM Very Good standard or equivalent;

g. Requiring new build, non-residential development of 1000m^2 and above to achieve a minimum of 35% CO_2 reduction beyond the Building Regulations Part L (2016);

h. Requiring development to positively contribute to improving air, land, noise, and water quality by minimising pollution and

i. Taking a bespoke approach to the sustainability of historic buildings and heritage assets, giving consideration to their particular construction, fabric and character.

Flooding, urban blue corridors and water management

SP6.4 The Council, as a Lead Local Flood Authority, will work in partnership with the Environment Agency, community groups, water and highways infrastructure providers, developers and other Lead Local Flood Authorities to reduce flood risk, protect groundwater and aquifers, and minimise the impact of all forms of flooding in the borough. This will be achieved by:

a. Applying the Sequential Test and Exception Test where required by Policy DM25;

b. Requiring major developments in Flood Zone 1 and all new development within Flood Zones 2 and 3 to provide site specific Flood Risk Assessments proportionate with the degree of flood risk posed to and by the development, taking account of the advice and recommendations within the Council's Strategic Flood Risk Assessment and Surface Water Management Plan;

c. Requiring all development, including refurbishment and conversions, to utilise sustainable drainage systems (SuDs) to reduce surface water run-off and provide water treatment on site; and

d. Requiring development proposals to account for possible groundwater contamination in Source Protection Zones 1 and 2.

SP6.5 The Council and its partners will promote the implementation of 'Urban Blue Corridors', enabling a network of multifunctional spaces and corridors that provide safe routes and storage for flood water within the urban environment. This will be achieved by:

a. Supporting schemes that make space for water in flood events;

b. Supporting schemes to de-culvert sections of the River Wandle, Norbury Brook and Caterham Bourne;

c. Preserving and enhancing landscape, heritage and culture through protection and access improvements to the borough's ponds, open water and water heritage sites; and

d. Maximising opportunities to establish overland flow paths, surface water ponding areas, urban watercourse buffer areas and multi-use flood storage areas in locations of high surface water flood risk and critical drainage areas.

Waste management

SP6.6 The Council supports the objectives of sustainable waste management set out in the London Plan and national policy. The Council will identify the necessary capacity in collaboration with the neighbouring boroughs of Merton, Kingston and Sutton to maximise self-sufficiency in managing the waste generated within the four boroughs. This will be achieved through the South London Waste Plan DPD and any further revisions.

Minerals

SP6.7 The Council will support schemes for aggregate recycling facilities within the borough and seek to reduce the environmental impact of aggregates by supporting the enhancement and development of aggregate recycling facilities where there is no significant detriment to local amenity (see Policy SP8 regarding freight movement and railheads).

3.3.3 As the scheme is below the 10-unit threshold, The London Plan calls for a mere 10% reduction in CO_2 emissions beyond the Building Regulation Part L requirements[1]. The Croydon Plan calls for an improvement to this position, at 19% CO_2 reduction beyond Building Regulation Part L requirements[1].

[1] When comparison is calculated against a Part L compliant baseline.

3.3.4 On the following page, is an extract from the National Planning Policy Framework (NPPF). Section 2.11 calls for a '**presumption in favour of sustainable development**'.

The presumption in favour of sustainable development

11. Plans and decisions should apply a presumption in favour of sustainable development.

For **plan-making** this means that:

a) all plans should promote a sustainable pattern of development that seeks to: meet the development needs of their area; align growth and infrastructure; improve the environment; mitigate climate change (including by making effective use of land in urban areas) and adapt to its effects;

b) strategic policies should, as a minimum, provide for objectively assessed needs for housing and other uses, as well as any needs that cannot be met within neighbouring areas[6], unless:

   i. the application of policies in this Framework that protect areas or assets of particular importance provides a strong reason for restricting the overall scale, type or distribution of development in the plan area[7]; or

   ii. any adverse impacts of doing so would significantly and demonstrably outweigh the benefits, when assessed against the policies in this Framework taken as a whole.

For **decision-taking** this means:

c) approving development proposals that accord with an up-to-date development plan without delay; or

d) where there are no relevant development plan policies, or the policies which are most important for determining the application are out-of-date[8], granting permission unless:

   i. the application of policies in this Framework that protect areas or assets of particular importance provides a clear reason for refusing the development proposed[7]; or

   ii. any adverse impacts of doing so would significantly and demonstrably outweigh the benefits, when assessed against the policies in this Framework taken as a whole.

---

[6] As established through statements of common ground (see paragraph 27).
[7] The policies referred to are those in this Framework (rather than those in development plans) relating to: habitats sites (and those sites listed in paragraph 181) and/or designated as Sites of Special Scientific Interest; land designated as Green Belt, Local Green Space, an Area of Outstanding Natural Beauty, a National Park (or within the Broads Authority) or defined as Heritage Coast; irreplaceable habitats; designated heritage assets (and other heritage assets of archaeological interest referred to in footnote 68); and areas at risk of flooding or coastal change.
[8] This includes, for applications involving the provision of housing, situations where the local planning authority cannot demonstrate a five year supply of deliverable housing sites (with the appropriate buffer, as set out in paragraph 74); or where the Housing Delivery Test indicates that the delivery of housing was substantially below (less than 75% of) the housing requirement over the previous three years.

3.4 Assessment Methodology

3.4.1 Polaris Passivhaus Developments have acknowledged the necessity to significantly enhance the energy performance of the project, striving for a genuine net-zero position in CO_2 emissions, without relying on offset payments, albeit not mandatory under the project's policies.

3.4.2 The London Plan defines 'Zero-carbon' as:
"Activity that results in no net release of carbon dioxide and other greenhouse gas emissions into the atmosphere."

3.4.3 As outlined in Section 2 of this report, aligning with the Passivhaus Standards will propel the development towards achieving nearly 90% of the objective for a genuine net-zero position. To reach the ultimate goal, the Applicant aims to attain a Passivhaus Plus scheme.

3.4.4 The approach employed in this report involves:

(i) Establishing the 'Baseline' energy performance calculation using PHPP software, in compliance with Part L of the Building Regulations, to determine the baseline CO_2 emissions for the proposed development.

(ii) Conducting additional energy performance calculations, using PHPP software, meeting the Passivhaus Institute's requirements for achieving the Passivhaus Plus standard. This encompasses the 'Be Lean, Be Clean, Be Green' methodology provided by the Greater London Authority.

(iii) Assessing the percentage reduction in CO_2 emissions using PHPP and carbon factors specified by the Department for Energy Security and Net Zero and the Department for Environment, Food, and Rural Affairs.

3.4.5 For clarity, the 'kgCO_2e/kWh' values offered by the governing bodies mentioned in point 4 above are itemised below:

Item	Energy Supply	kgCO_2e/kWh
1	Gas	0.200
2	Electricity	0.207

3.4.6 Section 1 of the Approved Document L, Conservation of fuel and power, Volume 1: Dwellings, 2021 edition incorporating 2023 amendments states the following:

> ## Section 1: Calculating the target primary energy rate, target emission rate and target fabric energy efficiency rate
>
> **1.1** A new dwelling must be built to a minimum standard of total energy performance. This is evaluated by comparing calculations of the performance of the 'actual dwelling' against calculations of the performance of a theoretical dwelling called the 'notional dwelling'. This must be carried out both at the design stage and when work is complete.
>
> The notional dwelling is the same size and shape as the actual dwelling and has standardised properties for fabric and services. The full properties of the notional dwelling are set out in the Government's Standard Assessment Procedure (SAP) for energy rating of dwellings.
>
> **1.2** The energy performance of the notional dwelling is described using the following metrics.
>
> a. The target primary energy rate, in kWh_{PE}/m^2 per year: this is influenced by the fabric and fuel.
>
> b. The target emission rate, in $kgCO_2/m^2$ per year: this is influenced by the fabric and fuel.
>
> c. The target fabric energy efficiency rate, in kWh/m^2 per year: this is influenced by the fabric only.
>
> **1.3** The target primary energy rate, target emission rate and target fabric energy efficiency rate for individual dwellings must be calculated using the Government's Standard Assessment Procedure, Appendix R. The standardised properties are summarised in Table 1.1.
>
> **NOTE:** For an up-to-date list of approved software, follow the link to SAP 10 at: https://www.gov.uk/guidance/standard-assessment-procedure.

3.4.7 As identified by item 1.2 of the above, the energy performance of the notional dwelling is described by the following key metrics:

(i) The target emission rate, in $kgCO_2/m^2$ per year: this is influenced by the fabric and fuel (see Section 3.6 of this report).

(ii) The target primary energy rate, in kWh_{PE}/m^2 per year: this is influenced by the fabric and fuel (see Section 3.7 of this report).

(iii) The target fabric energy efficiency rate, in kWh/m^2 per year: this is influenced by the fabric only (see Section 3.8 of this report).

3.4.8 While SAP was not utilised in our assessment, we've relied on the Passive House Planning Package (PHPP), recognised as a superior and precise energy design modelling tool. Notably, the PHPP can generate the metrics essential for compliance with Part L of the Building Regulations. Section 3.10 provides a detailed comparison of the aforementioned metrics between Building Regulations Part L and Passivhaus Plus.

3.5 Baseline Specification (Part L Compliance)

3.5.1 Baseline PHPP calculations were prepared based on the construction specification shown within table 1.1 from Approved Document L, Conservation of fuel and power, Volume 1: Dwellings, 2021 edition incorporating 2023 amendments:

Table 1.1 Summary of notional dwelling specification for new dwelling[1]

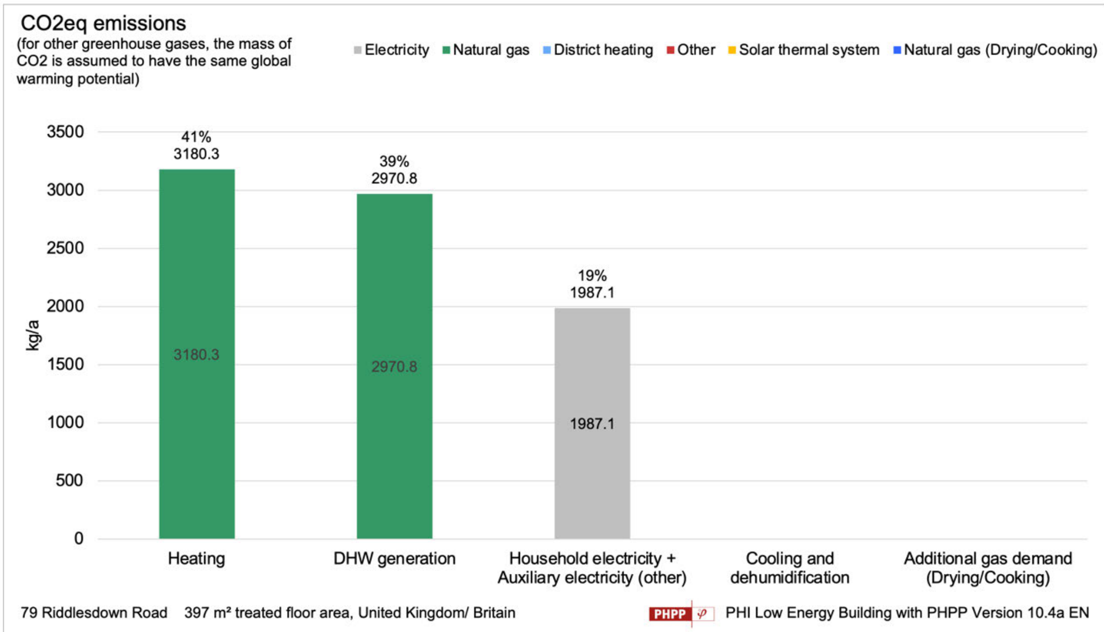
Element or system	Reference value for target setting
Opening areas (windows, roof windows, rooflights and doors)	Same as for actual dwelling not exceeding a total area of openings of 25% of total floor area[2]
External walls including semi-exposed walls	U = 0.18 W/(m²·K)
Party walls	U = 0
Floors	U = 0.13 W/(m²·K)
Roofs	U = 0.11 W/(m²·K)
Opaque door (less than 30% glazed area)	U = 1.0 W/(m²·K)
Semi-glazed door (30–60% glazed area)	U = 1.0 W/(m²·K)
Windows and glazed doors with greater than 60% glazed area	U = 1.2 W/(m²·K) Frame factor = 0.7
Roof windows	U = 1.2 W/(m²·K), when in vertical position (for correction due to angle, see specification in SAP 10 Appendix R)
Rooflights	U = 1.7 W/(m²·K), when in horizontal position (for correction due to angle, see specification in SAP 10 Appendix R)
Ventilation system	Natural ventilation with intermittent extract fans
Air permeability	5 m³/(h·m²) at 50 Pa
Main heating fuel (space and water)	Mains gas
Heating system	Boiler and radiators Central heating pump 2013 or later, in heated space Design flow temperature = 55 °C
Boiler	Efficiency, SEDBUK 2009 = 89.5%
Heating system controls	Boiler interlock, ErP Class V Either: – single storey dwelling in which the living area is greater than 70% of the total floor area: programmer and room thermostat – any other dwelling: time and temperature zone control, thermostatic radiator valves
Hot water system	Heated by boiler (regular or combi as above) Separate time control for space and water heating
Wastewater heat recovery (WWHR)	All showers connected to WWHR, including showers over baths Instantaneous WWHR with 36% recovery efficiency utilisation of 0.98
Hot water cylinder	If cylinder, declared loss factor = $0.85 \times (0.2 + 0.051\ V^{2/3})$ kWh/day where V is the volume of the cylinder in litres
Lighting	Fixed lighting capacity (lm) = 185 × total floor area Efficacy of all fixed lighting = 80 lm/W
Air conditioning	None
Photovoltaic (PV) system	For houses: kWp = 40% of ground floor area, including unheated spaces / 6.5 For flats: kWp = 40% of dwelling floor area / (6.5 × number of storeys in block) System facing south-east or south-west

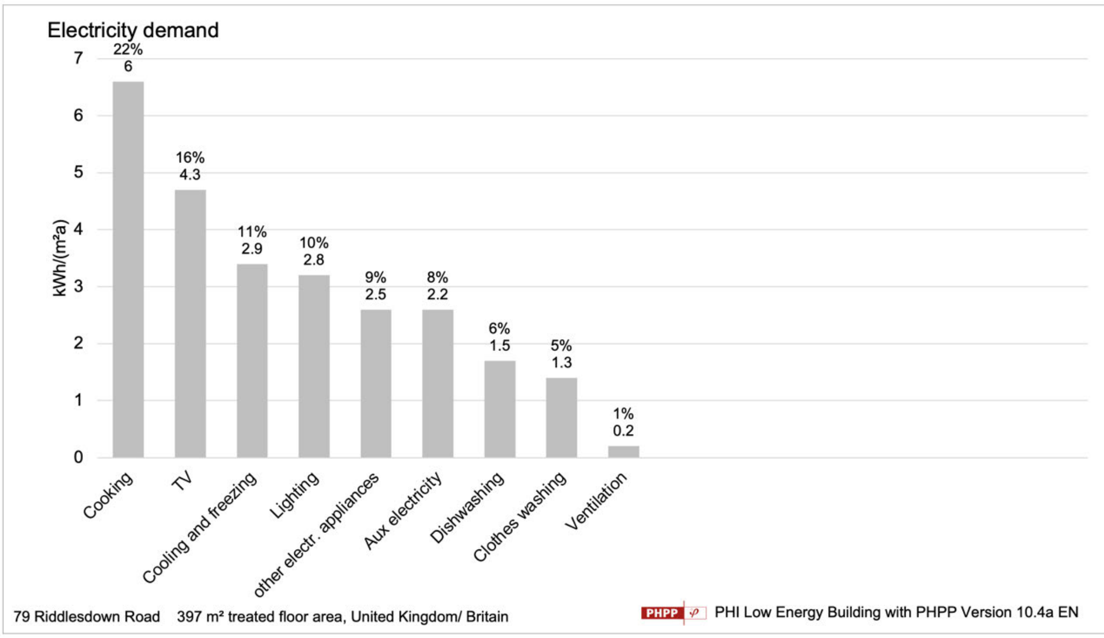
NOTE:
1. For a dwelling connected to an existing district heat network, an alternative notional building is used. See paragraph 1.8 and SAP 10.
2. See SAP 10 for details.

3.6 Baseline Target Emission Rate - $kgCO_2/(m^2a)$

3.6.1 The conducted PHPP calculations have shown the proposed development, at baseline, will generate 8,138.20 $kgCO_2$/year. With the Photovoltaic (PV) System, a requirement set by the table on the previous page, stipulates that the system should equate to 40% of the dwelling floor area or 204.60m² x 40% = 81.84m². Including the PV system reduces the CO_2 emissions by 2,401 $kgCO_2$/year, providing a grand total of **5,737.20 $kgCO_2$/year**. The key metric as identified in Section 3.4 is highlighted below.

Description	$kgCO_2$/year	m² Area	$kgCO_2/(m^2a)$
Target Emission Rate $kgCO_2/(m^2a)$	5,737.20	397.10	14.45





Energy generation referred to projected building footprint	Final energy		PER		PE		CO_2		
	Final energy generation kWh/a	**Final energy generation** **kWh/(m²A$_{Projected}$*a)**	PER factor kWh/kWh	**PER generation** kWh/(m²A$_{Projected}$a)	PE factor kWh/kWh	PE generation kWh/(m²A$_{Projected}$a)	Emission factor (CO_2-eq) kg/kWh	Emissions generated kg/a	Emissions saved kg/a
PV electricity	11601	55.8	1.00	55.8	0.00	0.0	0 I 0.207	0	2401
Solar thermal system	0	0.0	-	0.0	0.00	0.0			
		0.0							
Total energy production kWh/(m²$_{Projected\ building\ footprint}$ a)			**PER:**	**55.77**	**PE:**	**0.00**	**CO_2:**	**0**	**2401**

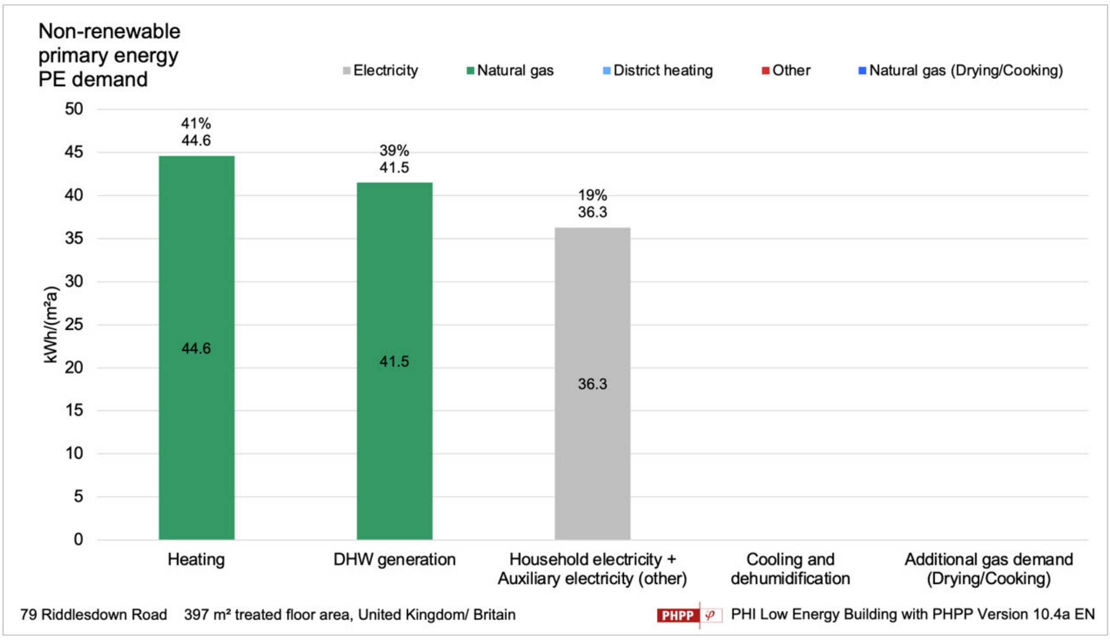
3.6.2 To align with the CO_2 reduction planning policies, the Applicant is dedicated to significantly lowering anticipated site-wide CO_2 emissions, surpassing the mandatory 19% reduction outlined in the Croydon Plan for residential assessments.

3.6.3 At a predicted 14.45 kgCO_2/(m^{2}a) for the development's CO_2 emissions, the minimum 19% reduction goal translates to 2.75 kgCO_2/(m^{2}a), in essence, achieving a total site emissions reduction to **11.70 kgCO_2/(m^{2}a)**. Incorporating the Passivhaus Standards into calculations will demonstrate compliance with the mandated 19% reduction target.

3.6.4 However, aiming for Passivhaus Plus standards remains the Applicant's objective to attain a genuine net-zero position, as previously indicated.

3.7 Baseline Target Primary Energy Rate - kWh/(m^{2}a)

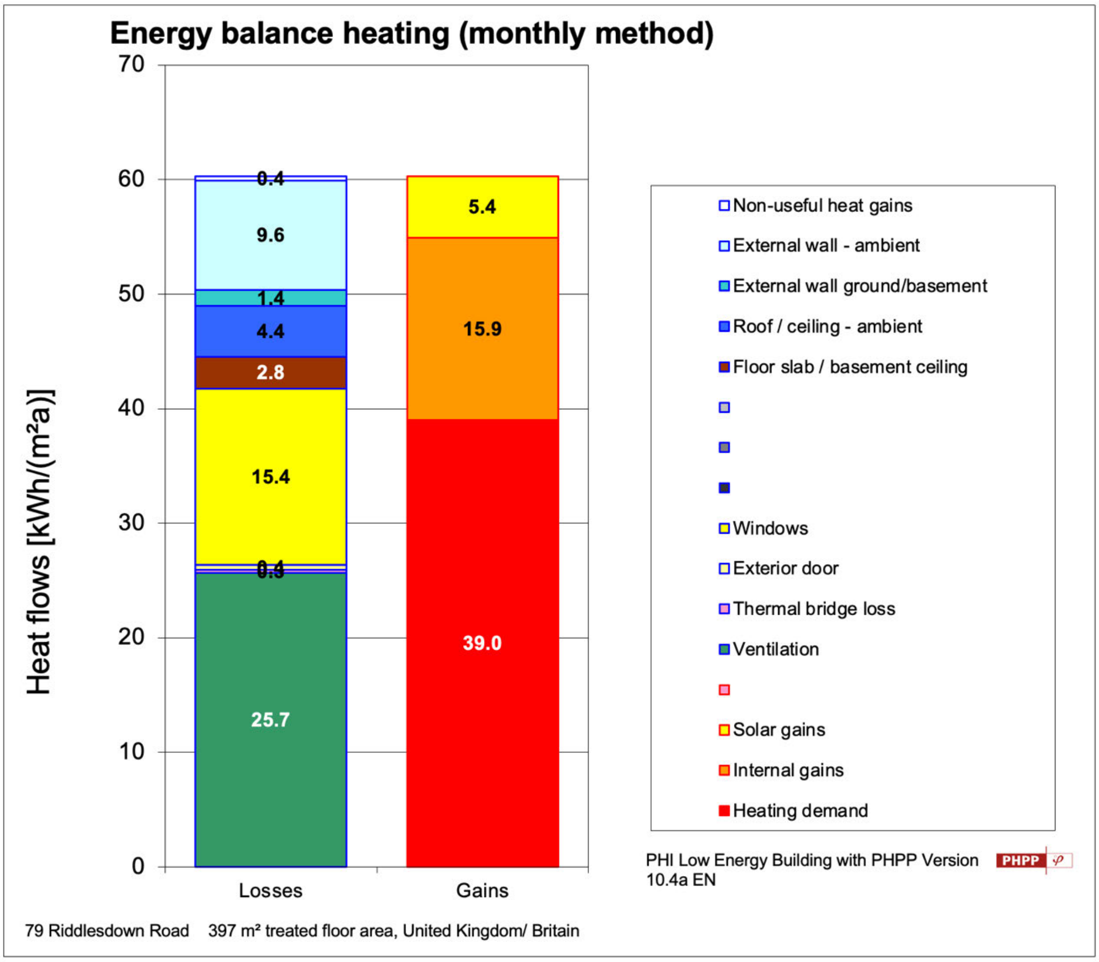
37.1 Based on using the specification outlined in Section 3.5, this would create a total predicted energy demand for the development of **122.40 kWh/(m^{2}a)**. The breakdown of this predicted energy demand can be seen below. The figures quoted have been derived from the PHPP calculations for the development.



3.7.2 Since the development's predicted energy rate is 122.40 kWh/(m²a), if we apply the same requirement for reduction of CO_2, the minimum 19% reduction target equates to 23.26 kWh/(m²a). In other words, providing the target energy rate reduces to **99.14 kWh/(m²a)** once implementing the Passivhaus Standards into the calculations, this would reinforce the position that the 19% CO_2 reduction target have been met.

3.8 Baseline Target Fabric Energy Efficiency Rate - kWh/(m²a)

3.8.1 Based on using the specification outlined in Section 3.5, this would create a total predicted Fabric Energy Efficiency Rate (or total transmission heat loss) for the development of **34.30 kWh/(m²a)**. The breakdown of this predicted fabric efficiency rate can be seen below. The figures quoted have been derived from the PHPP calculations for the development.



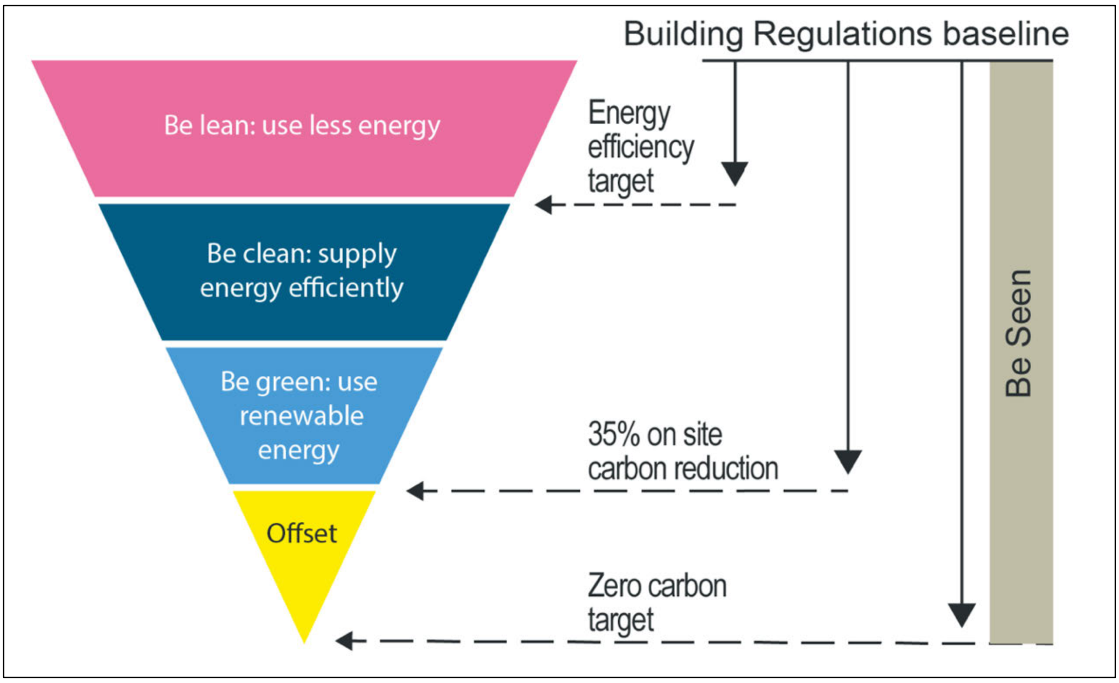
Transmission heat losses Q_T

Building assembly	Temperature zone	Area m²		U-value W/(m²K)		Temperature reduction factor		G_t kKh/a		kWh/a	Per m² of TFA
External wall - ambient	A	292.1	*	0.180	*	1.00	*	72	=	3797	9.56
External wall ground/basement	B	74.5	*	0.180	*	1.00	*	42	=	562	1.41
Roof / ceiling - ambient	A	220.3	*	0.110	*	1.00	*	72	=	1750	4.41
Floor slab / basement ceiling	B	204.6	*	0.130	*	1.00	*	42	=	1114	2.80
	A		*		*	1.00	*		=		
	A		*		*	1.00	*		=		
	A		*		*	1.00	*		=		
Windows	A	63.9	*	1.322	*	1.00	*	72	=	6104	15.37
Exterior door	A	2.5	*	1.000	*	1.00	*	72	=	178	0.45
Thermal bridges ambient (length/m)	A	10.0	*	0.142	*	1.00	*	72	=	103	0.26
Perimeter thermal bridges (length/m)	P		*		*	1.00	*		=		0.00
Thermal bridges ground (length/m)	B		*		*	1.00	*		=		0.00
											kWh/(m²a)
Sum of all areas of the building envelope		857.9				Total transmission heat losses Q_T			=	**13607**	**34.3**

3.8.2 Since the development's predicted Fabric Energy Efficiency Rate is 34.30 kWh/(m²a), if we apply the same requirement in reduction of CO_2, the minimum 19% reduction target equates to 6.52 kWh/(m²a). In other words, providing the Fabric Energy Efficiency Rate reduces to **27.78 kWh/(m²a)** once implementing the Passivhaus Standards into the calculations, this would reinforce the position that the 19% CO_2 reduction target have been met.

3.9 Reducing Carbon Emissions through Passivhaus Design & Construction

3.9.1 The Energy Hierarchy provided by The Greater London Authority sets out the most effective way to reduce a dwelling's CO_2 emissions. Firstly, by reducing energy demand, then by using energy efficiently and lastly by incorporating renewable technologies.



3.9.2 Passivhaus buildings are very well insulated and draught-proof buildings whose annual space heating demand is so low that the conventional heating system can be omitted. The small amount of heating still required can be delivered to the individual rooms simply by heating the air supplied by the ventilation system. The heating load accounts for around 10 W/m^2 depending on the necessary air flows, and the space heating energy demand is up to 15 $kWh/(m^2a)$.

3.9.3 The implementation of Passivhaus buildings places high demands on the components used. The quality standard of these components must be selected in accordance with the corresponding climate.

3.9.4 The following reference values apply to the cool-temperate climate. However, the principles are valid in other climates as well:

(i) Exterior building elements with a U-value below 0.15 $W/(m^2K)$.

(ii) Constructing the external envelope without thermal bridges.

(iii) Ensuring airtightness verified by an air leakage test according to standard EN 13829, where the measured air leakage shouldn't exceed 0.6 h^{-1} at a pressure differential of 50 Pa (both over and under-pressure).

(iv) Glazing meeting U-values below 0.8 $W/(m^2K)$ according to EN 673 and a total solar energy transmittance (g-value) of at least 50% per EN 410 for net heat gains in winter.

(v) Windows with total U-values under 0.8 $W/(m^2K)$ as per EN 10077.

(vi) Ventilation systems designed with energy recovery efficiency of $\eta HR \geq 75\%$ (subtracted by 12 percentage points from standard testing procedures). Additionally, minimal electricity consumption ($\leq$ 0.45 Wh/m^3 of supplied air volume) is required.

(vii) Domestic hot water systems with minimal heat losses.

(viii) Maximising the efficient use of household electricity.

3.9.5 The specification used in modelling the Passivhaus Plus version, that cover the above referenced requirements, is available in Section 4 of this report. The results are available within Section 3.11, 3.12 and 3.13 of this report. A summary position is available within Section 3.14.

3.10 Feasibility Study of Renewable Technologies

3.10.1 Integrating renewable technologies into new developments heralds a crucial stride towards sustainability and energy efficiency in the construction landscape. Embracing renewable technologies represents a paradigm shift, a move away from traditional reliance on fossil fuels towards clean and sustainable energy sources. This pivotal shift aligns with contemporary environmental imperatives, where reducing carbon footprints and mitigating the impacts of climate change are paramount. New developments have a unique opportunity to set a precedent for environmentally conscious construction, and the adoption of renewable technologies forms a cornerstone of this transformative journey.

3.10.2 At its core, the integration of renewable technologies in new developments presents an array of tangible benefits. Firstly, these technologies pave the way for reduced dependency on finite fossil fuel resources. Harnessing renewable sources like solar, wind, and geothermal energy offers an inexhaustible and clean energy supply. This not only helps mitigate the depletion of finite resources but also contributes to energy security and resilience. Moreover, by utilising renewable technologies, developments can significantly curb greenhouse gas emissions, thereby lessening their environmental impact. The resultant decrease in carbon emissions aligns with global efforts to combat climate change, ensuring a more sustainable and eco-friendly future.

3.10.3 Furthermore, the incorporation of renewable technologies into new developments reflects a commitment to long-term cost savings and energy efficiency. Although initial investments in these technologies may seem substantial, they offer considerable returns over time. Solar panels, wind turbines, geothermal heat pumps, and other renewable systems substantially reduce energy bills in the long run. Besides, these technologies are known for their longevity and low maintenance requirements, ensuring sustained cost-effectiveness throughout the lifespan of the development. Overall, the decision to integrate renewable technologies into new developments signifies a forward-thinking approach that not only adheres to environmental stewardship but also brings about tangible economic benefits.

3.10.4 Upon detailed assessment, several key findings have emerged concerning the technical viability of incorporating renewable energy technologies into this particular development. The evaluation indicates promising possibilities and some challenges in the integration process. It's essential to acknowledge the following observations when considering the adoption of these renewable systems.

3.10.5 Key: 🟢 = Adopted for this development. 🟡 = In consideration for the final scheme. 🔴 = Not adopted for this project.

3.10.6 Feasibility Study

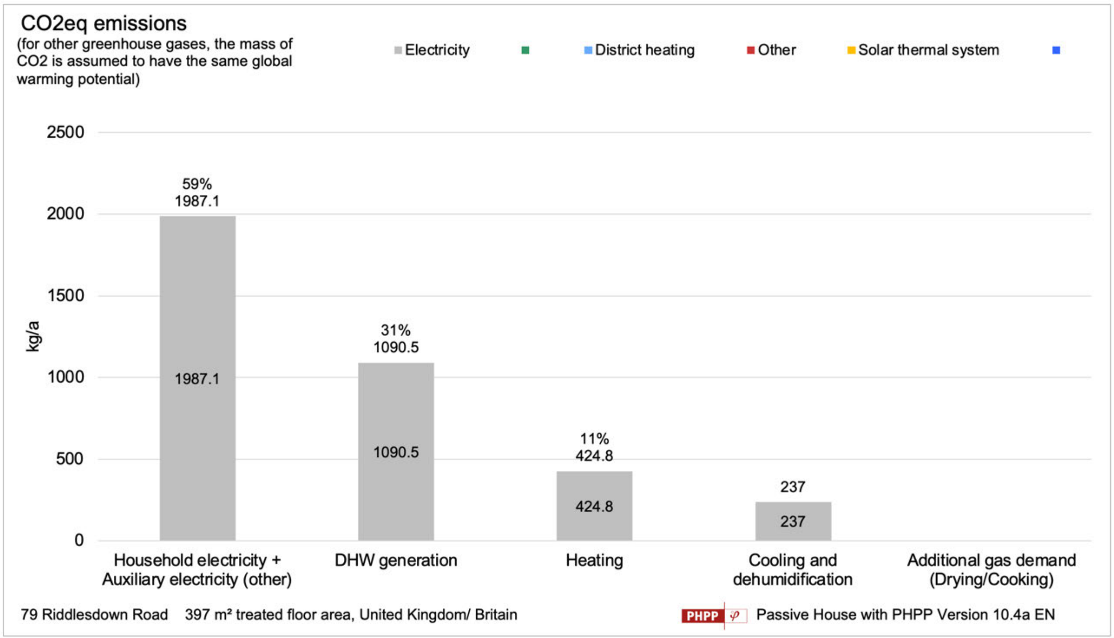
Adopted?	Renewable Technology	Positives	Negatives	Considerations
	Solar Photovoltaic (PV)	o Generates electricity silently and without emissions. o Low maintenance and long lifespan o Reduces electricity bills and provides energy independence. o Modular and scalable; can be installed on various surfaces. o Environmental friendliness and renewable energy source. o Financial incentives such as Feed-in Tariffs.	o Initial installation cost can be high. o Dependence on weather conditions (sunlight availability). o Requires sufficient roof space or suitable areas for installation. o Energy storage solutions might be necessary for full efficiency. o Efficiency reduction over time (degradation of panels).	o Orientation and inclination for optimal performance. o Available sunlight and potential shading issues. o Upfront investment versus long-term savings. o Battery storage or grid-tie options. o Maintenance costs and warranty coverage. o Local regulations and incentives.
	Solar Thermal Systems	o Provides hot water or space heating using renewable energy. o Low operating costs after initial installation. o Reduces reliance on fossil fuels for water heating. o Can be integrated with existing heating systems. o Long lifespan and relatively low maintenance. o Various types available: flat plate collectors, evacuated tubes, etc.	o Upfront costs can be relatively high. o Dependence on sunlight for heat generation. o Space required for installation (roof or ground-mounted). o Potential freezing issues in cold climates.	o Hot water demand and system size. o Suitability of the building for solar thermal installation. o Orientation and tilt angle for optimal performance. o Compatibility with existing heating systems. o Seasonal variations in performance. o Maintenance and potential repair costs.
	Wind Turbines	o Generates electricity using wind, a free and renewable resource. o Low operating costs once installed. o Can be installed in various sizes and types. o Suitable for rural and windy areas. o Produces zero emissions during operation. o Potential for income generation through Feed-in Tariffs.	o High initial costs and sometimes lengthy payback periods. o Noise and visual impact can be a concern. o Reliant on consistent wind speeds. o Zoning and permitting issues in residential areas.	o Wind speed analysis and site suitability. o Available space and local regulations. o Impact on wildlife and the local environment. o Maintenance requirements and associated costs. o Potential for integrating with other energy sources. O Noise levels and community acceptance.
	Geothermal Heat Pumps	o Efficient heating and cooling using renewable geothermal energy. o Low operational costs and long lifespan. o Reliable and consistent performance.	o High upfront installation costs. o Groundwork required for installation can be invasive. o Requires suitable land or space for installation.	o Ground conditions and geology for heat exchange. o Available space and property suitability. o Installation and drilling costs.

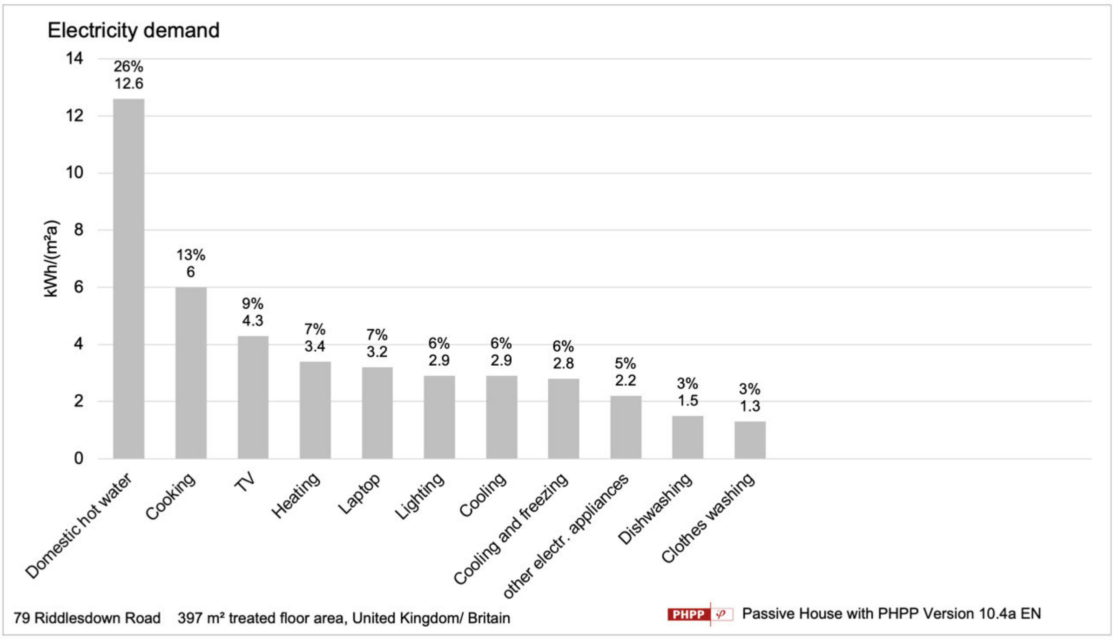
Adopted?	Renewable Technology	Positives	Negatives	Considerations
		o Minimal maintenance requirements. o Lower emissions compared to conventional heating systems. o Suitable for various climates.	o Complexity of installation and system design.	o System size and heating/cooling load requirements. o Permitting and environmental impact assessments. o Efficiency compared to other heating/cooling options.
	Hydroelectric Power	o Consistent and predictable energy production. o Long lifespan and low operating costs. o Zero emissions during operation. o Can provide off-grid electricity in suitable locations. o Potential for electricity generation and storage.	o High upfront installation and maintenance costs. o Limited to areas with suitable water resources. o Environmental impacts and habitat disruption. o Complex permitting and regulatory requirements.	o Water flow, head, and available resources. o Environmental impact assessments. o System design and size for electricity requirements. o Costs versus potential energy production. o Operational and maintenance considerations. o Legal and permitting challenges.
	Biomass	o Uses organic materials for heating or electricity. o Can be carbon-neutral when using sustainably sourced materials. o Provides a renewable energy source. o Can utilize waste or agricultural by-products.	o Space required for fuel storage. o Emissions and air quality concerns. o Efficiency highly dependent on fuel type and system design.	o Sustainable sourcing and storage of fuel. o Emissions and environmental impact. o Maintenance and operating costs compared to alternatives. o Heating/energy requirements and suitable system size. o Legal compliance and regulations. o Fuel availability and accessibility.
	Combined Heat & Power (CHP)	o Simultaneous generation of electricity and useful heat. o High overall energy efficiency. o Suitable for large-scale buildings or communities.	o High initial investment costs. o Requires consistent and high thermal loads for efficient operation. o Maintenance complexity due to combined systems. o Requires the use of fossil fuels (such as gas).	o Scale and demand for both electricity and heat. o Maintenance and operational costs. o Overall efficiency compared to separate systems. o Sourcing and storage of fuel or energy source. o Environmental impact and emissions. o Integration with existing systems and infrastructure.

3.11 Passivhaus Plus Primary Energy Rate - kWh/(m²a)

3.11.1 The conducted PHPP calculations have shown that the proposed development will generate 3,739.40 $kgCO_2$/year. A larger Photovoltaic (PV) System has been allowed for with the aim to attain a true net zero position. Including the PV system reduces the CO_2 emissions by 3,480.00 $kgCO_2$/year, providing a grand total of **259.40 $kgCO_2$/year**. The key metric as identified in Section 3.4 is highlighted below.

Description	$kgCO_2$/year	m^2 Area	$kgCO_2/(m^2a)$
Target Emission Rate $kgCO_2/(m^2a)$	259.40	397.10	0.65





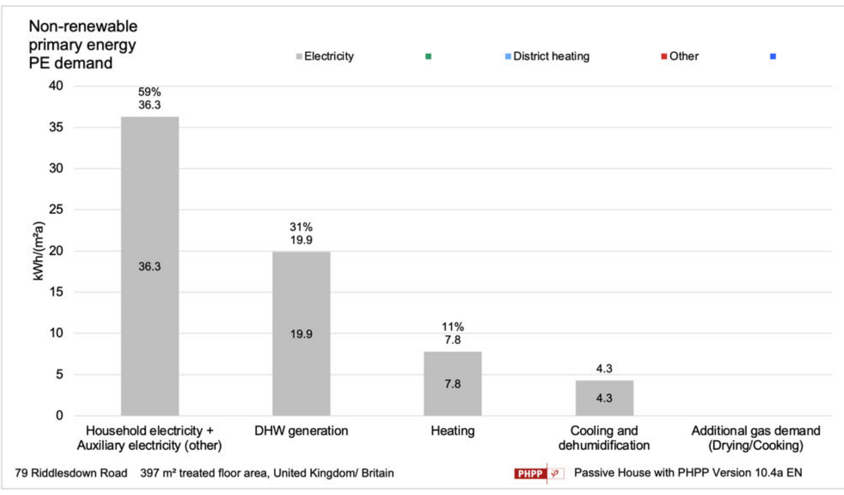
Energy generation referred to projected building footprint	Final energy		PER		PE		CO_2		
	Final energy generation	Final energy generation	PER factor	PER generation	PE factor	PE generation	Emission factor (CO_2-eq)	Emissions generated	Emissions saved
	kWh/a	kWh/(m²$A_{Projected}$*a)	kWh/kWh	kWh/(m²$A_{Projected}$a)	kWh/kWh	kWh/(m²$A_{Projected}$a)	kg/kWh	kg/a	kg/a
PV electricity	16813	80.8	1.00	80.8	0.00	0.0	0 I 0.207	0	3480
Solar thermal system	0	0.0	-	0.0	0.00	0.0			
		0.0							
Total energy production kWh/(m²$_{Projected\ building\ footprint}$ a)			PER:	80.83	PE:	0.00	CO_2:	0	3480

3.11.2 The findings indicate additional steps are needed to reach a genuine net-zero status concerning the CO_2 emissions throughout the building's operational lifespan. Integrating supplementary renewable sources like a solar thermal water system and electrical battery storage may pave the way towards this goal. Despite this, the progress made significantly exceeds the baseline data and aligns entirely with the planning policies governing this project.

3.11.3 The Passivhaus Plus standard demonstrates a remarkable improvement in CO_2 emissions, achieving an extraordinary 95.5% reduction from 14.45 kgCO2/(m²a) to just 0.65 kgCO2/(m²a). This is a truly incredible advancement over the baseline Part L requirements, showcasing a commitment to sustainability and energy efficiency far beyond conventional standards. This substantial reduction reflects the meticulous focus on superior insulation, airtightness, and thermal performance within the Passivhaus Plus framework. Such an achievement not only drastically lowers the carbon footprint of the building but also ensures optimal comfort and minimal energy consumption for occupants, setting a new benchmark in sustainable building design.

3.12 Passivhaus Plus Primary Energy Rate - kWh/(m²a)

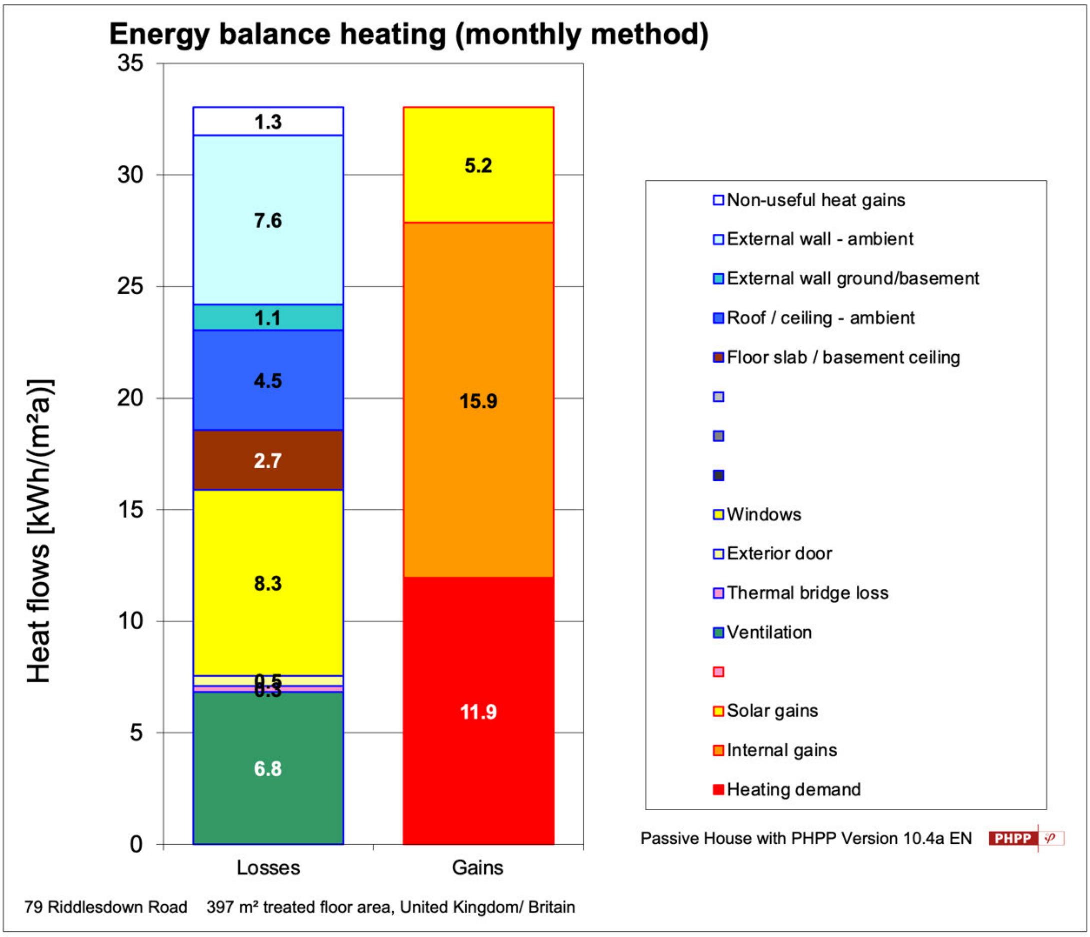
3.12.1 Using the specifications detailed in Section 4 would result in an anticipated total energy demand of 68.30 kWh/(m²a) for the development. The detailed breakdown of this projected energy demand is presented below, derived from the PHPP calculations conducted for this specific development.



3.12.2 Passivhaus Plus outperforms the Baseline Part L by an impressive **44.20% reduction** in the Primary Energy Rate. This significant reduction is achieved through highly efficient building design, innovative technology integration, and renewable energy generation. Passivhaus Plus showcases a clear commitment towards achieving carbon neutrality, ensuring minimal environmental impact during the building's operational phase.

3.13 Passivhaus Plus Fabric Energy Efficiency Rate - kWh/(m²a)

3.13.1 Utilising the specifications delineated in Section 4 would yield an estimated total Fabric Energy Efficiency Rate (or total transmission heat loss) of **24.90 kWh/(m²a)** for the development. The detailed breakdown of this anticipated fabric efficiency rate is presented below, derived from the PHPP calculations specifically conducted for the development.



Transmission heat losses Q_T

Building assembly	Temperature zone	Area m²		U-value W/(m²K)		Temperature reduction factor		G_t kKh/a		kWh/a	Per m² of TFA
External wall - ambient	A	292.1	*	0.140	*	1.00	*	74	=	3010	7.58
External wall ground/basement	B	74.5	*	0.140	*	1.00	*	43	=	453	1.14
Roof / ceiling - ambient	A	220.3	*	0.110	*	1.00	*	74	=	1784	4.49
Floor slab / basement ceiling	B	204.6	*	0.120	*	1.00	*	43	=	1066	2.68
	A		*		*	1.00	*		=		
	A		*		*	1.00	*		=		
	A		*		*	1.00	*		=		
Windows	A	63.9	*	0.703	*	1.00	*	74	=	3307	8.33
Exterior door	A	2.5	*	1.000	*	1.00	*	74	=	182	0.46
Thermal bridges ambient (length/m)	A	10.0	*	0.142	*	1.00	*	74	=	105	0.26
Perimeter thermal bridges (length/m)	P		*		*	1.00	*		=		0.00
Thermal bridges ground (length/m)	B		*		*	1.00	*		=		0.00
Sum of all areas of the building envelope		857.9				Total transmission heat losses Q_T			=	9906	kWh/(m²a) 24.9

3.13.2 Passivhaus Plus showcases an impressive **27.40% enhancement** in fabric energy efficiency compared to Baseline Part L. This achievement signifies the meticulous attention to detail in insulation, airtightness, and thermal performance of building elements. Passivhaus Plus exemplifies superior fabric efficiency, reducing heat demand and ensuring optimal comfort for occupants while minimising energy consumption.

3.14 Baseline Part L vs. Passivhaus Plus

3.14.1 The outcome of the comprehensive analysis and assessment between the Passivhaus Plus standards and the Baseline Part L (Building Regulations) for this development has yielded striking and commendable results. The data obtained from this meticulous examination underscores a revolutionary leap in sustainable construction practices, positioning Passivhaus Plus as an exemplar of innovation and environmental responsibility.

3.14.2 Target Emission Rate ($kgCO_2/(m^2a)$):

- **Baseline Part L:** 14.45 $kgCO_2/(m^2a)$
- **Passivhaus Plus:** 0.65 $kgCO_2/(m^2a)$
- **% Improvement:** The Passivhaus Plus standard demonstrates a remarkable improvement in CO_2 emissions, achieving an extraordinary **95.5% reduction**. This is a truly incredible advancement over the baseline Part L requirements, showcasing a commitment to sustainability and energy efficiency far beyond conventional standards. This substantial reduction reflects the meticulous focus on superior insulation, airtightness, and thermal performance within the Passivhaus Plus framework. Such an achievement not only drastically lowers the carbon footprint of the building but also ensures optimal comfort and minimal energy consumption for occupants, setting a new benchmark in sustainable building design.

3.14.3 Target Primary Energy Rate (kWh/(m^{2}a)):

- **Baseline Part L:** 122.40 kWh/(m^{2}a)
- **Passivhaus Plus:** 68.30 kWh/(m^{2}a)
- **% Improvement:** Passivhaus Plus demonstrates a remarkable **44.20% decrease** in primary energy consumption compared to Baseline Part L. The stringent energy conservation measures, advanced insulation techniques, and efficient systems integrated into Passivhaus Plus designs substantially reduce energy demand, contributing to a more sustainable and energy-efficient development.

3.14.4 Target Fabric Energy Efficiency Rate (kWh/(m^{2}a)):

- **Baseline Part L:** 34.30 kWh/(m^{2}a)
- **Passivhaus Plus:** 24.90 kWh/(m^{2}a)
- **% Improvement:** The standards showcases an impressive **27.40% enhancement** in fabric energy efficiency compared to Baseline Part L. This achievement signifies the meticulous attention to detail in insulation, airtightness, and thermal performance of building elements. Passivhaus Plus exemplifies superior fabric efficiency, reducing heat demand and ensuring optimal comfort for occupants while minimising energy consumption.

3.14.5 The adoption of Passivhaus Plus standards signifies a paradigm shift towards sustainable construction practices and high-performance building design. These standards not only exceed the benchmarks set by Baseline Part L but also set a new standard for energy efficiency, environmental responsibility, and occupant comfort. The substantial percentage improvements in CO_2 emissions, primary energy consumption, and fabric efficiency underscore the exceptional benefits and transformative potential of embracing Passivhaus Plus standards in modern construction projects, heralding a greener and more sustainable future for the built environment.

3.14.6 Summary Table:

#	Description	Baseline Part L	Passivhaus Plus	Difference	Reduction	Planning Compliant
1	Target Emission Rate kgCO_2/(m^{2}a)	14.45	0.65	-13.80	95.50%	☑
2	Target Primary Energy Rate kWh/(m^{2}a)	122.40	68.30	-54.10	44.20%	☑
3	Target Fabric Energy Efficiency Rate kWh/(m^{2}a)	34.30	24.90	-9.40	27.40%	☑

Section 4

Passivhaus Plus Data + Metrics

4.0 Passivhaus Plus Data + Metrics

4.1 Summary U-Value Specification

4.1.1

Walls (All)	Roof (Flat & Pitched)	Floor (Against Ground)
0.14 W/(m²K)	0.11 W/(m²K)	0.12 W/(m²K)

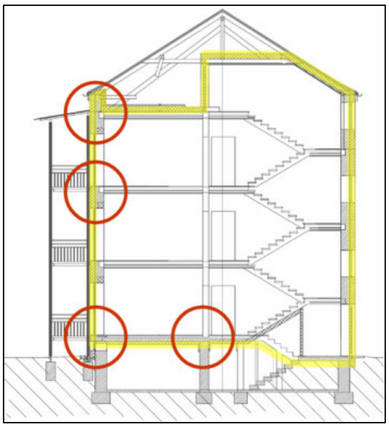
4.2 Thermal Bridges

4.2.1 Designing to eliminate thermal bridges is a fundamental principle of Passivhaus construction, constituting one of its five core tenets. Heat naturally travels from warm to cold areas, taking the path of least resistance. Thermal bridges represent localised sections within the building envelope where this heat flow diverges, typically resulting in an increased transfer of heat compared to neighbouring areas. Essentially, these thermal bridges act as conduits, directing heat directly outdoors. Consequently, the temperature of the interior surface in proximity to these thermal bridges' decreases. If this area becomes excessively cold, condensation and moisture accumulation may occur, potentially leading to the development of mould, which can cause structural damage over time.

4.2.2 Enhanced thermal protection generally results in higher surface temperatures, even near thermal bridges, making highly energy-efficient buildings less susceptible to these issues. To conduct a more thorough examination of the potential impacts of thermal bridges, collaboration and coordination with the Design Team are essential. This collaborative effort involves pinpointing critical sections prone to thermal bridging and devising optimal strategies to mitigate their effects, which necessitates precise calculations to determine the exact impact of these thermal bridges.

4.2.3 Typical design rules for Thermal Bridge reduction:

Rule	Description
Avoidance rule	Avoid penetrating the insulation layer if possible.
Penetration rule	If you must penetrate, then increase the thermal resistance at that point as much as possible.
Connection rule	When you connect components (e.g. insulation layers) do so without gaps and across the full area or length.
Geometry rule	Give preference to obtuse angled edges and corners.



4.2.4 Our Assessment:

To become 'Thermal Bridge Free', the Psi value (Ψ) needs to be less than or equal to 0.01 watts per metre kelvin (≤ 0.01 W/mK). Below is our assessment of the thermal bridges on the project. These have been allowed for within the PHPP.

Location of Thermal Bridge	Comments	Estimated Psi Value (Ψ)	Recommendations
Perimeter of Building	For the purposes of this report, we have assumed that the structural connections would generate a 'Thermal Bridge Free' design.	≤ 0.01 W/mK	Further detailed design required and product specification required.
Corners of Building	For the purposes of this report, we have assumed that the ICF system used would generate a 'Thermal Bridge Free' design.	≤ 0.01 W/mK	Further detailed design required and product specification required.
Connection detail of roof	For the purposes of this report, we have assumed that the structural connections would generate a 'Thermal Bridge Free' design.	≤ 0.01W/mK	Further detailed design required and product specification required. .
Balcony connection details	For the purposes of this report, we have assumed that the structural connections would generate a 'Thermal Bridge Free' design.	≤ 0.01W/mK	Further detailed design required and product specification required.

4.3 Airtightness

4.3.1 To diminish the heating demand and thwart the infiltration of warm, high-moisture air into the building structure, maintaining excellent airtightness levels is crucial. Achieving such levels necessitates the use of an airtight membrane or barrier in each component of the building. The selection of the airtight barrier depends on the construction type, which may involve a parging coat (on masonry), a vapor barrier membrane, or OSB-3 board.

4.3.2 Certain building systems such as concrete, ICF systems, prefabricated concrete panels, or boxes inherently possess good airtightness levels. However, attention is required at the junctions with other units or components, like windows and doors, where a suitable proprietary tape is employed to connect the airtight membrane to ensure its continuous coverage. It is essential to clearly define and specify the airtight layer in the Detailed Design stage and feature it in all production drawings.

4.3.3 Effective execution of these rigorous standards is primarily reliant on sound initial design. Correctly situating the airtight barrier within the construction reduces the necessity for multiple service penetrations, and where inevitable, specific gaskets and grommets are employed to maintain airtightness. The workmanship of site operatives significantly influences the building's airtightness, necessitating that airtightness details are executable on site. Contractors should be well-informed about their trades' impact on preserving the airtight barrier to achieve the Passivhaus standard.

4.3.4 A Passivhaus building's airtightness is determined by an n50 test, incorporating both under and over pressurisation assessments. Compliance requires the resultant air leakage at 50 Pascals pressure to be no greater than 0.6 air changes per hour (0.6 ac/h @50 Pa). Incorporating at least two airtightness tests into the construction schedule is highly recommended. The initial test should occur while the air barrier is exposed, ideally during the end of the first fix stage, followed by a final test upon completion by an ATTMA registered tester for inclusion in the Passivhaus certification documentation.

4.3.5 Further guidance on airtightness design and material selection:

Item	Description
Materials which are considered airtight	o Interior (traditional wet) plaster o Concrete o OSB-boards (with sealed joints and sufficient thickness of board) o Passive Purple – Liquid Applied Membrane
Airtightness trouble spots	o Power Sockets o Penetrations for cables, air ducts, services pipes, plumbing drain o Poorly designed component connections o Hidden installations (i.e. behind toilet cisterns)
Materials which are not considered airtight	o Un-plastered brickwork and mortar o Lightweight wood fibre boards o Perforated sheeting o Rigid foam boards o T&G boards and cladding

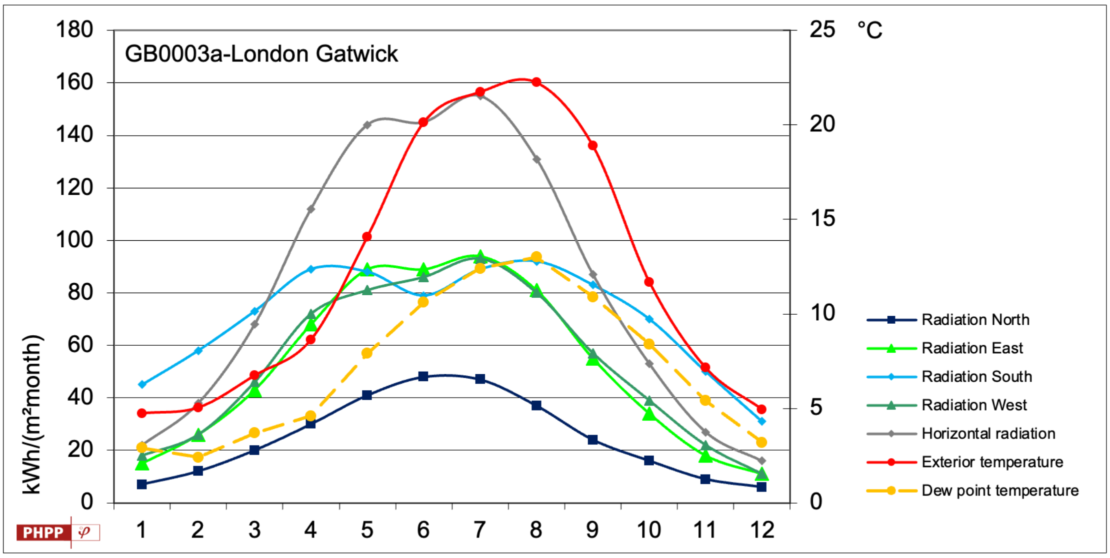
Item	Description
Connections which are not permanently airtight are	o Duct tape or parcel tape o Concrete with a poor mix (i.e. too dry/wet) o Films/membranes on unprimed brickwork o Polyurethane foam o Almost all silicon joints

4.3.6 In accordance with the standards set by the Passive House Planning Package (PHPP), we have included an Airtightness rating within the project specifications, meeting the stringent requirement of achieving 0.6 air changes per hour (0.6 ac/h). This critical measurement is an essential parameter for ensuring the building's envelope is effectively sealed to minimise air leakage and maintain superior energy efficiency. By reaching this level of airtightness, the structure aims to significantly reduce heat loss and optimise overall performance in line with Passivhaus standards.

4.4 Climate Data

4.4.1 The following Climate Data set has been used in the PHPP:

Country:	GB-United Kingdom/ Britain
Region:	Zone 03 – Southeast England
Climate data set:	GB0003a – London Gatwick
Climate zone:	3: Cool-temperate
Altitude weather station:	59 m
Altitude of building location:	119 m



4.5 Shading

4.5.1 Shading plays a crucial role in Passivhaus performance, influencing both positive and negative aspects of building energy efficiency and comfort.

4.5.2 Positive Effects:

- Solar Heat Gain Management: Properly designed shading prevents excessive solar heat gain during warmer months, reducing the need for mechanical cooling. It helps maintain comfortable indoor temperatures by blocking direct sunlight, thereby reducing overheating.
- Glare Reduction: Shading mitigates harsh glare caused by direct sunlight, creating a more visually comfortable and pleasant environment for occupants. It improves the usability of spaces by minimising discomfort caused by excessive brightness.
- Improved Comfort: By regulating solar radiation, shading contributes to a more consistent and comfortable indoor environment, diminishing temperature fluctuations and maintaining a stable, moderate temperature throughout the day.
- Energy Conservation: Efficient shading strategies significantly reduce the building's reliance on mechanical heating and cooling systems. This, in turn, lowers energy consumption and operating costs, aligning with Passivhaus principles of minimal energy use.

4.5.3 Negative Effects:

- Over-Shading: Excessive shading or improper design may lead to a lack of natural light penetration into the building, potentially resulting in darkened interiors and a need for artificial lighting during daylight hours.
- Complicated Design Considerations: Implementing shading systems requires careful planning and design integration. Complex shading systems might pose challenges during construction, maintenance, and operation if not executed properly.
- Aesthetics and Visual Appeal: Depending on the shading system used, it could impact the building's aesthetics and architectural design, potentially affecting the overall visual appeal and external appearance.
- Maintenance and Durability: Some shading systems may require periodic maintenance to ensure their proper functioning. Lack of maintenance could lead to malfunction or reduced efficiency over time, affecting the building's performance.

4.5.4 In summary, effective shading strategies are essential for Passivhaus buildings to maintain optimal thermal comfort, reduce energy consumption, and ensure overall occupant well-being. However, it's crucial to strike a balance between maximising the benefits of shading while avoiding potential drawbacks such as over-shading or compromising visual appeal. Efficient design and proper implementation are critical for achieving the desired performance outcomes.

4.5.5 Throughout the project's planning and design phases, meticulous attention has been devoted to evaluating and incorporating various shading factors that could influence the building's performance. Our comprehensive approach involved a thorough assessment of the surroundings, considering neighbouring buildings, landscape features, the site's orientation, and the building's positioning to optimise shading strategies.

4.5.6 Neighbouring structures were carefully analysed to understand their potential impact on shading patterns. By studying their height, distance, and orientation relative to our project site, we gained insights into how these structures might cast shadows at different times of the day or year. This evaluation helped anticipate shading effects and design appropriate responses to minimise their adverse impact on our building.

4.5.7 The existing landscape, encompassing trees, shrubbery, and natural topography, was meticulously examined to identify shading elements. By considering the foliage density, height, and seasonal changes, we planned to capitalise on natural shading benefits while avoiding obstructive shadows that could affect the building's energy performance or indoor comfort.

4.5.8 Additionally, the site's specific position and orientation were considered. Understanding how the building would interact with the sun's path throughout the day and across different seasons enabled us to implement shading solutions that optimise solar heat gain and control glare, ensuring a balanced and comfortable indoor environment.

4.5.9 By synthesizing these insights into our design process, we've integrated shading strategies that aim to harness natural light effectively, manage solar heat gain, and maintain thermal comfort. The holistic consideration of these shading factors aligns with our commitment to crafting a sustainable, energy-efficient, and occupant-centric building that harmonises with its environment while optimising performance and comfort.

4.6 Windows & External Doors

4.6.1 The following Window specification has been utilised in the PHPP:

Qty	Description	Orientation	Dimensions windows, doors etc. W	Dimensions windows, doors etc. H	Frames (all units to include for Triple low-E 16mm Argon glazing)	Window area	Glazing area	Glazing fraction per window	U_w	U_w installed
			m	m		m^2	m^2	%	$W/(m^2K)$	$W/(m^2K)$
1	Apartment 1	East	2.77	2.10	51ud-PH FRAMES: medium thermal quality	5.8	4.5	78%	0.579	0.646
1	Apartment 1	East	1.90	2.10	51ud-PH FRAMES: medium thermal quality	4.0	2.9	74%	0.587	0.668
1	Apartment 1	East	1.40	1.25	51ud-PH FRAMES: medium thermal quality	1.8	1.1	62%	0.613	0.735
1	Apartment 1	South	0.70	2.35	51ud-PH FRAMES: medium thermal quality	1.6	0.9	53%	0.634	0.782
1	Apartment 2	West	2.77	2.10	51ud-PH FRAMES: medium thermal quality	5.8	4.5	78%	0.579	0.646
1	Apartment 2	West	1.90	2.10	51ud-PH FRAMES: medium thermal quality	4.0	2.9	74%	0.587	0.668
2	Apartment 2	South	0.70	1.25	51ud-PH FRAMES: medium thermal quality	1.8	0.8	47%	0.648	0.826
1	Apartment 2	North	2.05	0.60	51ud-PH FRAMES: medium thermal quality	1.2	0.6	46%	0.649	0.821
1	Apartment 2	West	1.40	1.25	51ud-PH FRAMES: medium thermal quality	1.8	1.1	62%	0.613	0.735
1	Apartment 3	East	2.77	2.10	51ud-PH FRAMES: medium thermal quality	5.8	4.5	78%	0.579	0.646

Qty	Description	Orientation	Dimensions windows, doors etc. W (m)	H (m)	Frames (all units to include for Triple low-E 16mm Argon glazing)	Window area (m^2)	Glazing area (m^2)	Glazing fraction per window (%)	U_w (W/(m^2K))	U_w installed (W/(m^2K))
2	Apartment 3	East	1.40	1.25	51ud-PH FRAMES: medium thermal quality	3.5	2.2	62%	0.613	0.735
2	Apartment 3	South	0.70	1.25	51ud-PH FRAMES: medium thermal quality	1.8	0.8	47%	0.648	0.826
1	Apartment 3	North	0.70	1.25	51ud-PH FRAMES: medium thermal quality	0.9	0.4	47%	0.648	0.826
1	Apartment 4	West	2.77	2.10	51ud-PH FRAMES: medium thermal quality	5.8	4.5	78%	0.579	0.646
2	Apartment 4	South	0.70	1.25	51ud-PH FRAMES: medium thermal quality	1.8	0.8	47%	0.648	0.826
1	Apartment 4	North	2.05	0.60	51ud-PH FRAMES: medium thermal quality	1.2	0.6	46%	0.649	0.821
2	Apartment 4	West	1.40	1.25	51ud-PH FRAMES: medium thermal quality	3.5	2.2	62%	0.613	0.735
1	Apartment 5	East	2.77	2.10	51ud-PH FRAMES: medium thermal quality	5.8	4.5	78%	0.579	0.646
2	Apartment 5	East	1.40	1.25	51ud-PH FRAMES: medium thermal quality	3.5	2.2	62%	0.613	0.735
2	Apartment 5	South	0.70	1.25	51ud-PH FRAMES: medium thermal quality	1.8	0.8	47%	0.648	0.826
1	Apartment 5	North	0.70	1.25	51ud-PH FRAMES: medium thermal quality	0.9	0.4	47%	0.648	0.826

4.7 Ventilation + Summer Ventilation

4.7.1 In a building designed for low energy consumption, ventilation losses constitute a substantial portion of total heat loss. To further diminish these losses while ensuring indoor air quality, it becomes essential to recover some of the heat lost from the outgoing air. The use of natural ventilation, particularly through open windows in winter, results in the complete loss of heat from the warm air exiting the building. Additionally, natural ventilation during colder months can introduce unwelcome elements such as drafts, noise, and environmental pollutants into the indoor environment.

4.7.2 The most efficient method to tackle ventilation heat losses while consistently maintaining excellent air quality in an energy-efficient manner is through Mechanical Ventilation with Heat Recovery (MVHR). This system operates by extracting air from specific rooms and supplying fresh air to others. The extracted air, often warm indoor air from areas like kitchens and bathrooms, passes through a heat exchanger. This heat exchanger transfers the warmth from the outgoing air to the incoming fresh outdoor air. The prewarmed fresh air, now separated from the exhaust air, is then distributed to essential living spaces like bedrooms, living rooms, and dining areas.

4.7.3 Employing MVHR ensures a controlled and highly efficient means of delivering fresh air to habitable spaces. Typically, an MVHR unit incorporates a small heater coil or frost protection system to prevent freezing within the unit during severe winter conditions.

4.7.4 Adhering to Passivhaus standards necessitates that the efficiency of ventilation heat recovery must not fall below 75%. While many available MVHR units boast efficiencies exceeding 90%, it's crucial to consider the lengths of both insulated extract and intake ducts connecting with the building facade. Only ventilation units certified by the Passivhaus Institute should be specified, and stringent installation criteria are in place to restrict any unwanted noise transfer from the MVHR unit and sound transfer between rooms.

4.7.5 For the purposes of this report, our ventilation system is based on the Vaillant recoCOMPACT 3kW VWL 39/5 230V, a Passivhaus Certified Product that demonstrates exceptional heat recovery capabilities, achieving an impressive effective heat recovery rate of up to 90%. The proposed unit provides optimal performance aligned with the property's requirements, effectively delivering the necessary 30m^3 per person per hour of fresh, pre-warmed air.

4.7.6 This ventilation system offers superior heat recovery functionality, ensuring that up to 90% of the heat from the extracted indoor air is transferred to the incoming fresh outdoor air. This exceptional heat recovery rate significantly minimises heat loss during the ventilation process, enhancing the overall energy efficiency of the building. The unit is built to meet the stringent standards of Passivhaus certification, guaranteeing not only high-performance ventilation but also a sustainable approach towards maintaining a comfortable and energy-efficient indoor environment. Additionally, the system is equipped with a summer bypass function, a crucial feature that enables efficient cooling throughout the building during the warmer evenings of the summer months.

4.7.7 We have accounted for additional building cooling measures, particularly the potential implementation of strategies like opening windows during the cooler evening hours in the summer months to facilitate cross ventilation. This possibility has been considered in the design phase, and the specific approach will be determined once we have a clearer understanding of the type of windows intended for the project. Factors such as the sizes, direction of openings, and other window specifications will guide the decision-making process.

4.7.8 The inclusion of these cooling strategies can have a significant impact on reducing the overheating percentage within the building. By allowing for adequate cross ventilation during warmer periods, the internal temperature regulation can benefit substantially, potentially lowering the overall overheating percentages. Such measures aim to enhance occupant comfort by mitigating the risk of indoor spaces becoming excessively hot during periods of high external temperatures. This approach aligns with the principles of Passivhaus design, aiming not only to minimise heating demand but also to optimise the building's performance in regulating internal temperatures throughout varying climatic conditions.

4.8 Overheating

4.8.1 Achieving optimal summer comfort is as vital for a building to adhere to Passivhaus standards as attaining reduced space heating demands and excellent thermal comfort during winter. The Passivhaus criteria prescribe limitations on overheating during summer, quantified as the percentage of hours when the internal temperature surpasses 25°C while the building is in use. According to Passivhaus standards, it is permissible for up to 10% of occupied hours to exceed this threshold, considered acceptable for performance.

4.8.2 The principle of Passivhaus aims to harness solar gains in winter to minimise heating demands, potentially leading to increased summer temperatures, particularly with extensive south-facing glazing. Consequently, incorporating external shading becomes essential to mitigate direct solar heat gains during summer months.

4.8.3 Passivhaus certification necessitates that temperatures above 25°C should not persist for more than 10% of the occupied year (365 days for a dwelling). While 10% is within acceptable limits, best practice aims to limit overheating to 5%, and ideally, the goal should be 0%. Correct placement of fixed shading elements allows optimal utilisation of direct solar gains from the lower-angle winter sun, maximising its benefits when required most.

4.8.4 Various strategies are available to mitigate overheating risks in Passivhaus design, including conventional cross ventilation, night purge ventilation, and utilising the Heat Recovery Ventilation system in bypass mode.

4.8.5 Our building has demonstrated an exceptionally low overheating frequency, recording only 3%, well below the acceptable threshold stipulated by Passivhaus standards. Notably, our design has factored in cross ventilation provisions by incorporating openable windows. This deliberate inclusion enables additional cooling during summer evenings, effectively complementing the summer bypass ventilation provided by the MVHR system.

4.9 Space Heating & Domestic Hot Water

4.9.1 The Vaillant recoCOMPACT 3kW VWL 39/5 230V stands as an exemplary choice for meeting the space heating and domestic hot water demands within each apartment of the project. It operates as a robust, integrated heating and hot water solution, catering specifically to the stringent energy efficiency criteria mandated by Passivhaus standards.

4.9.2 Designed with a focus on efficiency and sustainability, this unit maximises the utilisation of energy while minimising wastage. Its innovative engineering ensures that every component works cohesively to deliver high-performance heating and hot water solutions with minimal environmental impact.

4.9.3 The system's space-saving design is a notable feature, making it an ideal fit for installations where space is at a premium. Despite its compact size, the recoCOMPACT unit doesn't compromise on functionality or performance. It provides a reliable, consistent heat supply for each apartment while meeting the demanding requirements for Passivhaus-certified systems.

4.9.4 One of its key highlights is its Passivhaus certification. This unit has undergone stringent testing and meets the rigorous standards set by the Passivhaus Institute. This certification guarantees that the recoCOMPACT unit adheres to the specific benchmarks and efficiency thresholds necessary for Passivhaus projects, ensuring that it contributes to the overall energy performance and sustainability goals of the development.

4.9.5 Additionally, the system boasts user-friendly control interfaces, allowing residents to easily manage and monitor their heating and hot water settings. The intuitive controls empower users to customise their comfort levels efficiently, promoting a seamless experience while maintaining energy efficiency.

4.9.6 Constructed with high-quality materials and components, the recoCOMPACT unit is built to last. Its reliability and durability ensure long-term performance, providing residents with a dependable and efficient heating and hot water solution for their individual apartments.

4.9.7 In summary, the Vaillant recoCOMPACT 3kW VWL 39/5 230V stands out as a top-tier Passivhaus-certified system, offering an amalgamation of energy-efficient performance, reliability, sustainability, and user convenience, making it an excellent choice for meeting the heating and hot water needs within each apartment of the development project.

4.9 Waste-Water Heat Recovery (WWHR)

4.9.1 Wastewater heat recovery (WWHR) is a technology that captures and repurposes thermal energy from the wastewater generated by showers, baths, sinks, and other household sources. This system involves the recovery of heat from the warm water that goes down drains and is usually wasted. Instead of letting this heat energy simply escape, WWHR units extract and reuse it for heating purposes within a building.

4.9.2 The process involves a heat exchanger or recovery unit installed in the wastewater pipes. As hot water runs down the drains, the heat exchanger captures the warmth from the outgoing wastewater. It transfers this captured heat to the incoming cold-water supply that feeds into the heating system, preheating it before it enters the water heating system or the domestic hot water supply. This preheating helps to reduce the energy required to raise the temperature of the water to the desired level, thereby enhancing the overall energy efficiency of the building.

4.9.3 Key Benefits of Wastewater Heat Recovery:

- Energy Efficiency: WWHR systems significantly improve energy efficiency by recycling heat that would otherwise be wasted. This reduces the demand on primary heating systems, leading to decreased energy consumption and lower utility bills.
- Cost Savings: By harnessing heat from wastewater, buildings equipped with WWHR systems can experience considerable cost savings on water heating bills due to the reduced energy required to heat water for domestic use.
- Environmental Impact: As a sustainable technology, WWHR systems contribute to reducing the carbon footprint of a building by conserving energy and lowering greenhouse gas emissions associated with water heating.
- Improved Comfort: The preheating of incoming cold-water results in warmer water entering the domestic hot water system, providing users with a more consistent and comfortable supply of hot water.
- Return on Investment: While the initial installation cost may be a consideration, the long-term benefits and energy savings can offer a favourable return on investment over the system's lifespan.
- Versatility: Wastewater heat recovery systems can be installed in various types of residential and commercial buildings, contributing to sustainable and energy-efficient heating solutions across different settings.

4.9.4 Overall, waste water heat recovery systems offer an effective way to tap into wasted thermal energy, enhance energy efficiency, reduce operational costs, and contribute to environmentally friendly building practices by effectively utilising available resources.

4.9.5 The ZYPHO PiPe DW65 is a Passivhaus-certified wastewater heat recovery system designed to recover thermal energy from domestic wastewater. It is specifically engineered to capture and reuse heat from shower water, providing an efficient way to recycle wasted heat and increase the overall energy efficiency of a building.

4.9.6 Key features of the ZYPHO PiPe DW65 include:

- Heat Exchanger Technology: The system incorporates an innovative heat exchanger that captures heat from warm water flowing down the drain. As the wastewater passes through the system, the heat exchanger efficiently transfers this thermal energy to the incoming cold-water supply.
- High Efficiency: Designed for optimal performance, the ZYPHO PiPe DW65 boasts high thermal efficiency, allowing it to recover a significant amount of heat from the wastewater. This recovered heat is then used to preheat the incoming cold water, reducing the energy required to heat the water to the desired temperature.
- Passivhaus Certification: The system has been certified by the Passivhaus Institute, meeting stringent energy efficiency and performance standards required for Passivhaus buildings. This certification ensures that the ZYPHO PiPe DW65 aligns with the energy-saving principles and sustainability goals of Passivhaus construction.
- Compatibility: The ZYPHO PiPe DW65 is designed to be compatible with standard plumbing systems, making it relatively easy to integrate into both new construction and retrofit projects without major modifications to the existing plumbing layout.
- Environmental Benefits: By efficiently recovering and reusing waste heat, this system helps to reduce the overall energy consumption associated with water heating. As a result, it contributes to lower energy bills, reduced carbon emissions, and enhanced environmental sustainability.

4.9.7 The ZYPHO PiPe DW65 offers an effective solution for capturing thermal energy from wastewater, contributing to energy conservation, cost savings, and environmental responsibility in buildings striving for high energy efficiency standards like Passivhaus certification. It is included within the PHPP assessment for this project.

4.10 Electricity Demand

4.10.1 Passivhaus properties are designed to significantly reduce the demand for electricity compared to conventional buildings. They achieve this by implementing a range of energy-efficient measures and strategies aimed at minimising electricity consumption for heating, cooling, lighting, and appliances. Here are some key aspects related to electricity demand in Passivhaus properties:

- Reduced Heating and Cooling Loads: Passivhaus design principles prioritise exceptional insulation, airtightness, and high-performance windows. This results in minimal heat loss during winters and reduced heat gain during summers. Consequently, the need for heating and cooling systems is drastically reduced, leading to lower electricity usage for HVAC (Heating, Ventilation, and Air Conditioning) systems.
- High-Efficiency Mechanical Systems: Passivhaus buildings often utilise energy-efficient mechanical systems, such as Mechanical Ventilation with Heat Recovery (MVHR). These systems ensure continuous fresh air circulation while recovering heat from the outgoing air, reducing the energy required to condition incoming fresh air.
- Energy-Efficient Appliances and Lighting: To further minimise electricity demand, Passivhaus projects incorporate energy-efficient appliances and LED lighting. These appliances are selected based on their high energy performance ratings, typically falling under the A++ or A+++ efficiency categories.
- Renewable Energy Integration: While Passivhaus focuses on reducing energy demand, some properties may integrate renewable energy sources like solar panels or wind turbines. These sources can generate clean electricity on-site, further offsetting energy consumption and reducing reliance on the grid.
- Monitoring and Optimisation: Passivhaus properties often incorporate smart energy monitoring systems that allow occupants to track electricity usage in real-time. This enables better understanding and control of energy consumption, encouraging responsible use and identifying opportunities for further efficiency improvements.

4.10.2 By integrating these strategies, Passivhaus buildings aim to significantly reduce their reliance on electricity from the grid, promoting energy conservation, sustainability, and lower operating costs for occupants.

4.11 Internal Heat Gains

4.11.1 Internal heat gains play a crucial role in the energy dynamics of Passivhaus properties. These gains refer to the heat produced by occupants, electrical appliances, lighting, and other internal sources within a building. In Passivhaus design, managing and utilising these internal heat gains effectively contribute to reducing the overall space heating requirements. Here are key aspects related to internal heat gains in Passivhaus properties:

- Occupant Heat: The heat generated by occupants within a building significantly contributes to internal gains. Passivhaus buildings account for this factor by considering the number of occupants and their activities when determining the overall heat gains. While this heat is beneficial in reducing the demand for space heating, it's essential to strike a balance to avoid overheating during certain seasons.
- Appliances and Equipment: Passivhaus properties typically incorporate energy-efficient appliances and equipment to minimise heat generation. However, these appliances still contribute to internal gains. By choosing energy-efficient models, the overall heat output from such devices is reduced, thus impacting the building's heating and cooling requirements.
- Lighting: The heat generated by lighting fixtures is also considered an internal heat gain. Passivhaus designs often utilise energy-efficient LED lighting, which not only consumes less electricity but also generates minimal heat compared to traditional incandescent bulbs. This approach helps in reducing unnecessary heat loads within the building.
- Seasonal Considerations: It is important to manage internal heat gains concerning seasonal variations. During colder seasons, harnessing internal heat gains is beneficial for reducing heating demands. Conversely, in warmer weather, measures are taken to minimise overheating, such as shading strategies or natural ventilation.

4.11.2 Balancing and managing internal heat gains effectively is essential in Passivhaus design to optimise energy performance, maintain comfort levels, and minimise reliance on mechanical heating and cooling systems.

4.12 Primary Energy Renewable (Demand + Generation)

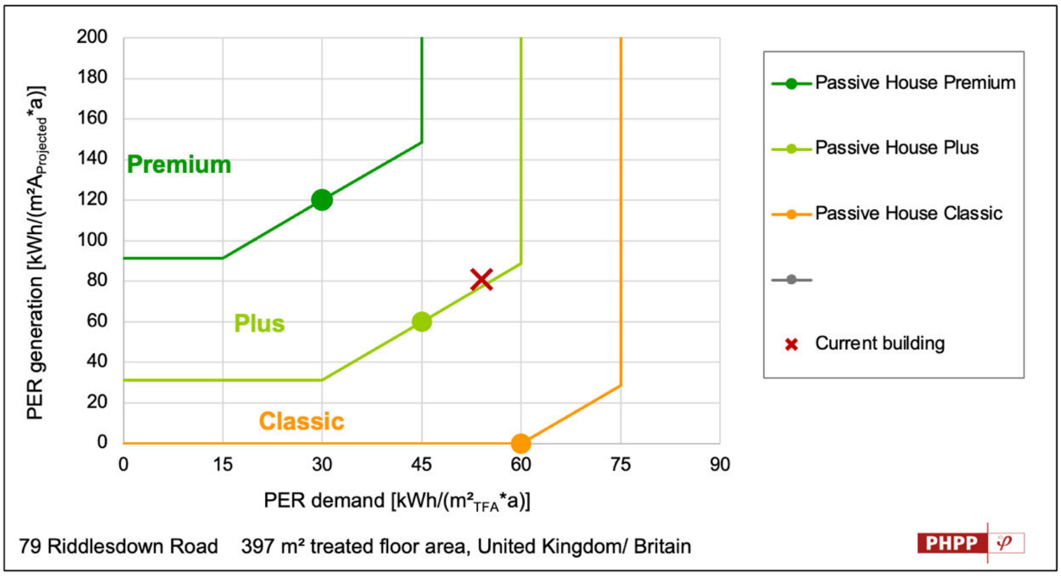
4.12.1 The Passivhaus Plus standards demand a stringent adherence to primary energy limitations, typically set at 49 kWh/(m²a) for the collective energy demands of heating, ventilation, hot water, and domestic electricity when incorporating renewable energy generation.

4.12.2 Primary energy encompasses the raw, unprocessed energy content derived from fuels at the point of extraction and renewable energy resources. This metric includes accounting for losses incurred during extraction, processing, transmission, and transportation stages of energy production.

4.12.3 To attain Passivhaus Plus certification, it's crucial to mitigate primary energy use, particularly focusing on energy-efficient appliances and equipment such as A++ rated devices like washing machines, dishwashers, fans, pumps, and lighting. Our current project successfully adheres to these standards, maintaining compliance within the primary energy demand limits outlined by Passivhaus Plus requirements.

4.12.4 As of our assessment, the project aligns with the primary energy demand criteria outlined for Passivhaus Plus certification. We've factored in the integration of renewable energy sources, such as the proposed photovoltaic system. This proactive inclusion of renewables has been instrumental in achieving compliance within the primary energy limitations established by Passivhaus Plus standards.

4.12.5 Notwithstanding our current compliance, we continue to explore opportunities to optimise energy efficiency and reduce heating demands further. As the project progresses through the design phase, ongoing assessments will evaluate the impact of these renewable technologies on overall energy performance, aiming to ensure continuous alignment with Passivhaus Plus requirements.



Section 5

Conclusion

5.0 Conclusion

5.1 PHPP Results

5.1.1 This report provides an overview of the PHPP Pre-Assessment conducted for the 79 Riddlesdown Road, Purley project. It encompasses a comprehensive Energy Statement supporting the project, available in Section 3.

5.1.2 Based on the reviewed design data, meeting the Passivhaus Plus Standard is feasible. However, achieving a true net-zero position concerning CO_2 emissions will necessitate further incorporation of renewable technologies. To realise the Applicant's goal of true net-zero emissions in operation, an additional reduction of 259.40kgCO_2/year is required.

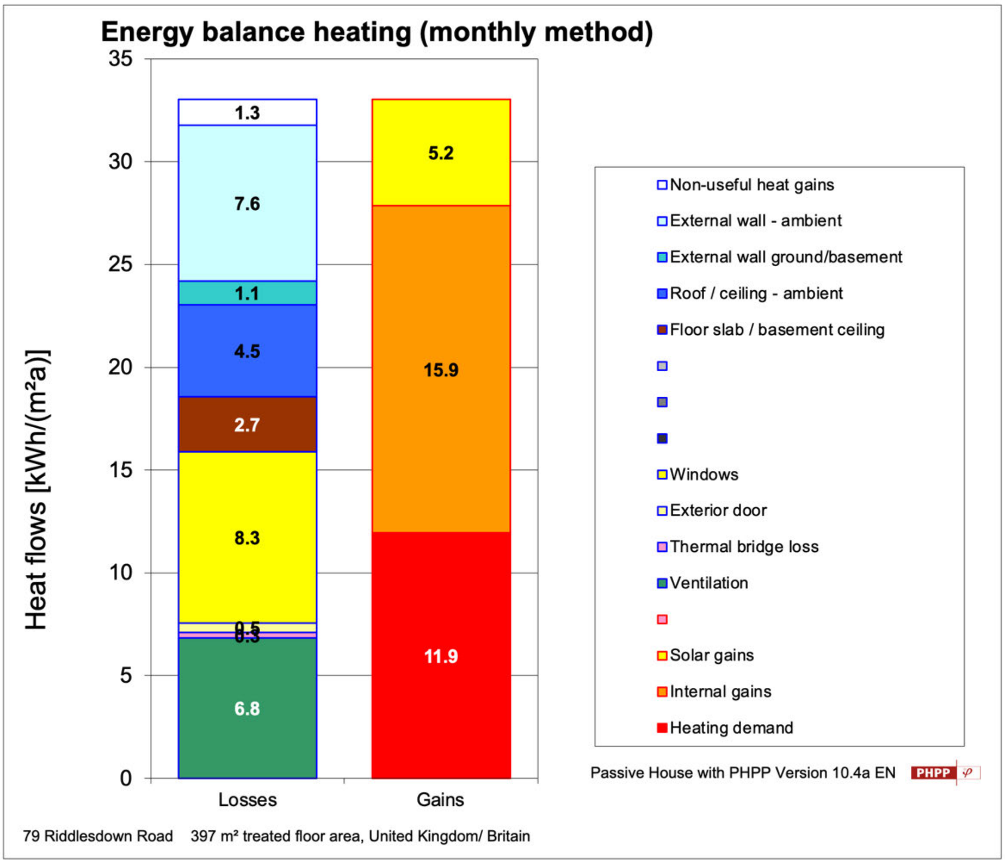
5.1.3 Close attention is vital regarding the development of the PHPP. Detailed information regarding this aspect is expanded upon in Section 4. Further refinement in the design of the building fabric composition and interfaces, along with the mechanical and electrical systems, is needed. The simulation has been constructed based on assumptions detailed in Section 4, grounded in guidance from the Passivhaus Institute.

5.1.4 All modelling outcomes are subject to verification during subsequent design stages when more precise information becomes available. This verification is crucial to confirm the performance accuracy of the finalised building design.

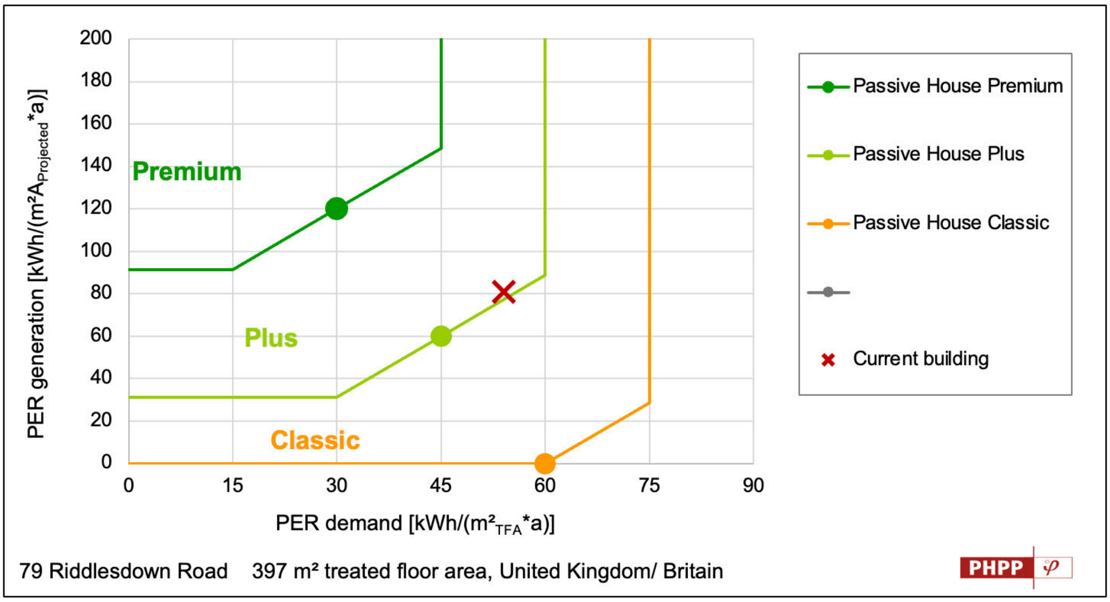
1.3.5 Below is a summarised table extracted from the PHPP:

Specific building characteristics with reference to the treated floor area					Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	397.1				
Space heating	Heating demand	kWh/(m²a)	12	≤	15	-	Yes
	Heating load	W/m²	8	≤	-	10	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	-	≤			
	Frequency of overheating (> 24 °C)	%	3	≤			
	Frequency of excessively high humidity (> 12 g/kg)	%	0	≤	20		Yes
Airtightness	Pressurisation test result n_{50}	1/h	0.6	≤	0.6		Yes
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	68	≤	-		-
Primary Energy Renewable (PER)	PER demand	kWh/(m²a)	54	≤	45	54	Yes
	Renew. energy generation (in rel. to projected building footprint area)	kWh/(m²a)	81	≥	60	77	

1.3.6 Below is the Energy Balance extract:



1.3.7 Verification Passive House Plus extract:



Section 6

Appendices

6.0 Appendices

6.1 Proposed Development Plans

Figured dimensions only are to be taken from this drawing. All dimensions are to be checked on site before commencement of any work.

This drawing must be read in conjunction with all other relevant documentation and drawings.

Notes

POLARIS
PASSIVHAUS DEVELOPMENTS

Drawing Issued For
Planning

Client Name
Polaris Passivhaus Developments

Project Address
79 Riddlesdown Road, Purley

Project Proposal
Re-development of 79 Riddlesdown Road. Including demolition of the existing structure and construction of Croydon's first biophilic designed, Passivhaus Certified residential development, delivering 5 new homes in a range of 2-beds and 3-beds in addition to all associated hard and soft landscaping.

Drawing Title
Proposed Basement Plan

Drawing No.	**Revision**
P-001	B
Scale	**Date**
1:50 @ A3	17/06/2024

0 1 1:100 5m

Figured dimensions only are to be taken from this drawing. All dimensions are to be checked on site before commencement of any work.

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Drawing Title

Proposed Ground and First Floor Plan

Drawing No.	**Revision**
P-002	D
Scale	**Date**
1:100 @ A3	17/06/2024

Notes

Visitor Bicycle Parking (x2)

Property Boundary

Drawing Issued For

Planning

Client Name

Polaris Passivhaus Developments

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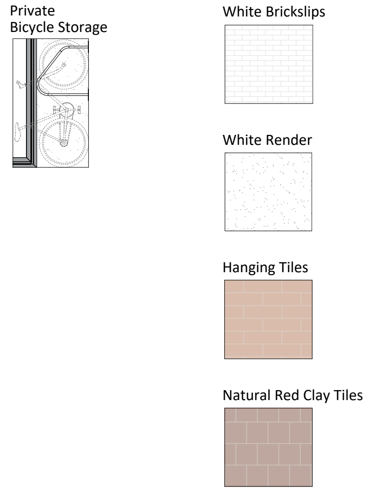
Drawing Title

Proposed Roof Plan + 45° Line of Sight

Drawing No.	**Revision**
P-003	D
Scale	**Date**
1:100 @ A3	17/06/2024

Notes



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Drawing Title

Proposed Front and Rear Building Elevations

Drawing No.	**Revision**
P-004	C
Scale	**Date**
1:100 @ A3	17/06/2024

0 1 1:100 5m

0 1 1:100 5m

Figured dimensions only are to be taken from this drawing. All dimensions are to be checked on site before commencement of any work.

This drawing must be read in conjunction with all other relevant documentation and drawings.

Notes

- Privacy Glazing
- White Brickslips
- Living Wall
- White Render
- Hanging Tiles
- Natural Red Clay Tiles

POLARIS
PASSIVHAUS DEVELOPMENTS

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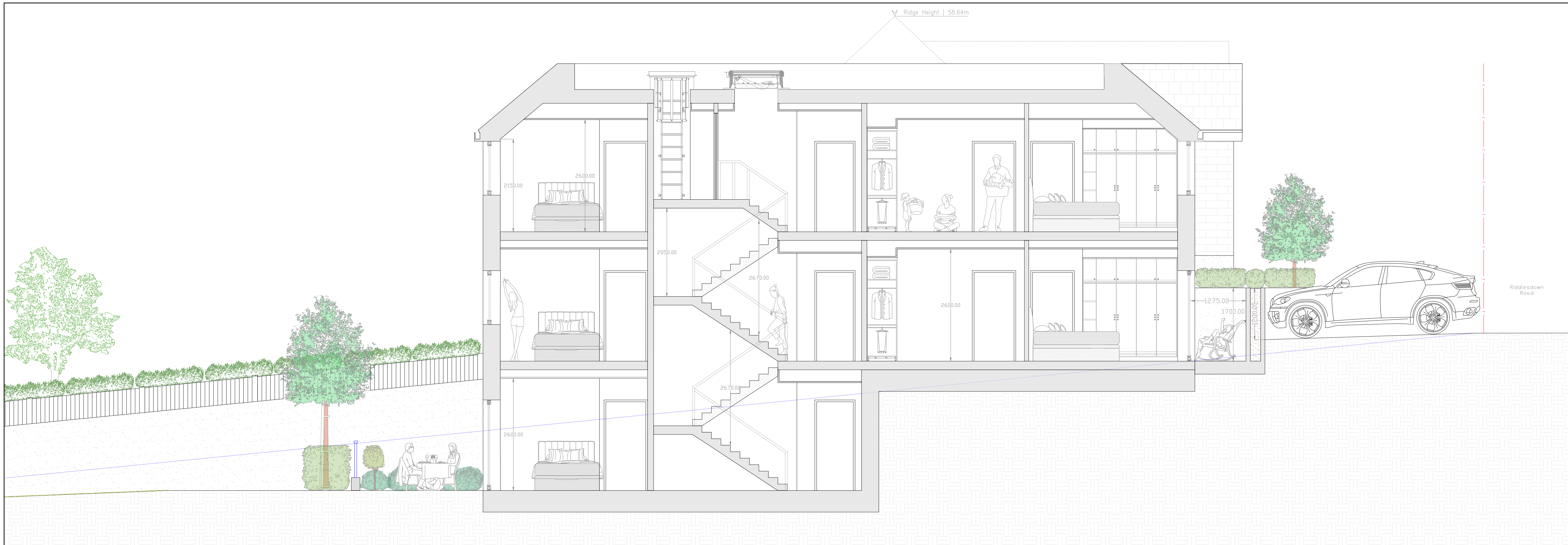
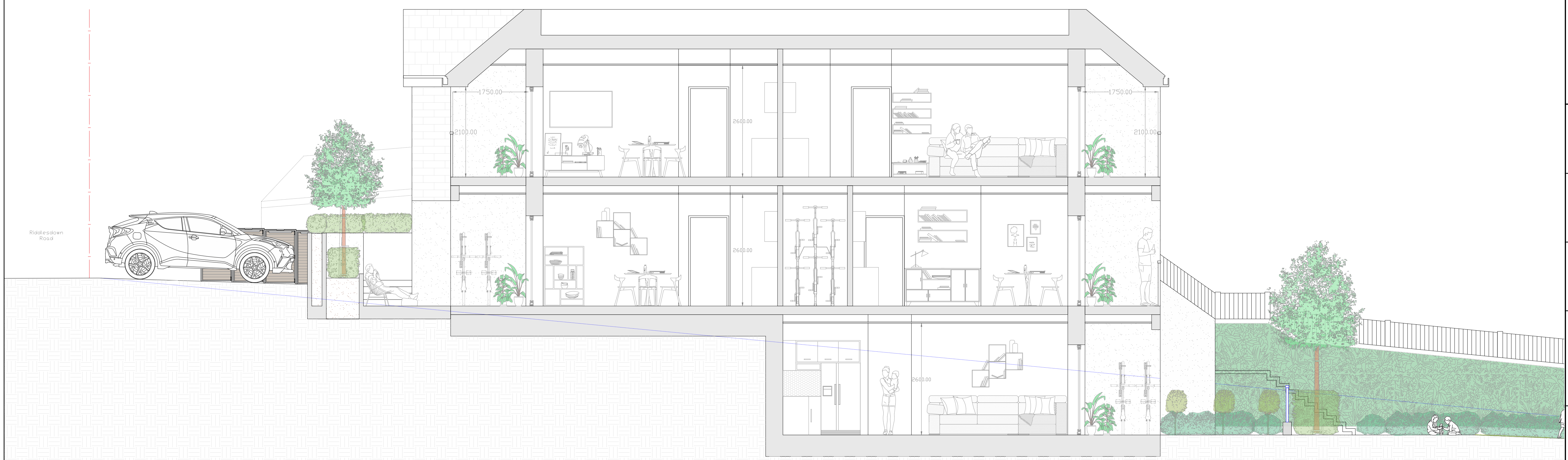
Drawing Title

Proposed Side Elevations

Drawing No.	Revision
P-005	D
Scale	**Date**
1:100 @ A3	17/06/2024





0 1 1:100 5m

Figured dimensions only are to be taken from this drawing. All dimensions are to be checked on site before commencement of any work.

This drawing must be read in conjunction with all other relevant documentation and drawings.

Notes

POLARIS
PASSIVHAUS DEVELOPMENTS

Drawing Issued For
Planning

Client Name
Polaris Passivhaus Developments

Project Address
79 Riddlesdown Road, Purley

Project Proposal
Re-development of 79 Riddlesdown Road. Including demolition of the existing structure and construction of Croydon's first biophilic designed, Passivhaus Certified residential development, delivering 5 new homes in a range of 2-beds and 3-beds in addition to all associated hard and soft landscaping.

Drawing Title
Proposed Section AA & BB

Drawing No.	Revision
P-006	C
Scale	**Date**
1:100 @ A3	17/06/2024

Notes

POLARIS
PASSIVHAUS DEVELOPMENTS

Drawing Issued For
Planning

Client Name
Polaris Passivhaus Developments

Project Address
79 Riddlesdown Road, Purley

Project Proposal
Re-development of 79 Riddlesdown Road. Including demolition of the existing structure and construction of Croydon's first biophilic designed, Passivhaus Certified residential development, delivering 5 new homes in a range of 2-beds and 3-beds in addition to all associated hard and soft landscaping.

Drawing Title
Proposed Section CC

Drawing No.	**Revision**
P-008	C
Scale	**Date**
1:50 @ A3	17/06/2024

6.2 Compact Heat Pump Proposed Specification

Certificate

Certified Passive House Component

For cool, temperate climates, valid until 31 December 2023

Passive House Institute
Dr. Wolfgang Feist
64283 Darmstadt
GERMANY

Category:	**Compact unit**
Manufacturer:	**Vaillant GmbH** **42859 Remscheid, GERMANY**
Product name:	**recoCOMPACT**

This certificate was awarded based on the following criteria:

Primary Energy Demand	$PE_{total} \leq 55$ kWh/(m²a)
Thermal comfort	$\theta_{supply\ air} \geq 16.5$ °C at $\theta_{outdoor\ air} = -10$ °C
Effective heat recovery rate	$\eta_{HR,eff} \geq 75$ %
Electric power consumption	$P_{el} \leq 0.45$ Wh/m³
Airtightness	Interior and exterior air leakage rates less than 3 % of nominal air flow rate
Balancing and adjustability	Air flow balancing possible: yes Automated air flow balancing: yes
Sound insulation	Sound level $L_w \leq 35$ dB(A) not met Here $L_w = 53.0$ dB(A) Unit should be installed so that it is acoustically separated from living areas
Indoor air quality	Outdoor air filter at least F7 Extract air filter at least G4
Frost protection	Frost protection for the heat exchanger with continuous fresh air supply down to $\theta_{outdoor\ air} = -15$ °C

Further information can be found in the appendix of this certificate.
(**) for heating, domestic hot water (DHW), ventilation, auxiliary electricity in the reference building, explanation see attachment.

Certified for air flow rates of

110 - 280 m³/h

$\eta_{HR,eff}$

83-87 %

Electric power consumption

0.33- 0.34 Wh/m³

Total Primary Energy Demand (**)

36.1- 48.7 kWh/(m²a)

cool, temperate climate
CERTIFIED COMPONENT
Passive House Institute

Appendix to the certificate Vaillant GmbH, **recoCOMPACT**

Manufacturer: Vaillant GmbH
Berghauser Str. 40, 42859 Remscheid, GERMANY
Tel: +49 (0) 2191 18 0
E-Mail: info@vaillant.de, www.vaillant.de

Measured values to be used in PHPP- recoCOMPACT 7kW VWL 79/5 230V (ID: 1324ch03) useful air flow rates 110 to 280 m³/h

Heating

		Test point 1	Test point 3	Test point 3	Test point 4	
Outside Air Temperature	T_{amb}	-7	2	7		°C
Thermal Output Heating Heat Pump	$P_{WP,Heiz}$	6.38	8.00	8.43		kW
COP number Heating Heat Pump	COP_{Heiz}	2.44	2.82	2.97		-
Maximum available supply air temperature with Heat Pump only(*)		No supply air heating				°C

Hot water

		Test point 1	Test point 3	Test point 3	Test point 4	
Outside Air Temperature	T_{amb}	-7	2	7	20	°C
Thermal Output Heat Pump for heating up storage tank.	P_{DHW} heating up	3.13	3.19	3.83	6.30	kW
Thermal Output Heat Pump for reheating storage tank	P_{DHW} reheating	2.75	2.71	3.26	4.64	kW
COP Heat Pump for heating up storage tank	$COP_{DHW,}$ heating up	2.16	2.89	2.64	3.81	-
COP Heat Pump for reheating storage tank	COP_{DHW} reheating	1.68	2.19	2.33	2.61	-
Average storage tank temperature		34.8				°C
Specific storage heat losses		1.84				W/K
Exhaust air addition (if applicable)		360				m³/h

Measured values to be used in PHPP- recoCOMPACT 5kW VWL 59/5 230V (ID: 1325ch03) useful air flow rates 65 to 200 m³/h

Heating

		Test point 1	Test point 3	Test point 3	Test point 4	
Outside Air Temperature	T_{amb}	-7	2	7		°C
Thermal Output Heating Heat Pump	$P_{WP,Heiz}$	4.64	6.26	6.54		kW
COP number Heating Heat Pump	COP_{Heiz}	2.19	2.69	3.05		-
Maximum available supply air temperature with Heat Pump only(*)		No supply air heating				°C

Appendix to the certificate Vaillant GmbH, **recoCOMPACT**

Hot water

		Test point 1	Test point 3	Test point 3	Test point 4	
Outside Air Temperature	T_{amb}	**-7**	**2**	**7**	**20**	°C
Thermal Output Heat Pump for heating up storage tank.	P_{DHW} heating up	**0.96**	**1.95**	**2.47**	**4.38**	kW
Thermal Output Heat Pump for reheating storage tank	P_{DHW} reheating	**0.60**	**1.66**	**2.10**	**3.33**	kW
COP Heat Pump for heating up storage tank	$COP_{DHW,}$ heating up	**0.80**	**2.47**	**2.97**	**3.38**	-
COP Heat Pump for reheating storage tank	COP_{DHW} reheating	**0.46**	**2.22**	**2.51**	**2.42**	-
Average storage tank temperature		**34.8**				°C
Specific storage heat losses		**1.84**				W/K
Exhaust air addition (if applicable)		**260**				m³/h

Measured values to be used in PHPP- recoCOMPACT 3kW VWL 39/5 230V (ID: 1326ch03) useful air flow rates 65 to 200 m³/h

Heating

		Test point 1	Test point 3	Test point 3	Test point 4	
Outside Air Temperature	T_{amb}	**-7**	**2**	**7**		°C
Thermal Output Heating Heat Pump	$P_{WP,Heiz}$	**2.75**	**3.75**	**4.82**		kW
COP number Heating Heat Pump	COP_{Heiz}	**2.02**	**2.70**	**3.40**		-
Maximum available supply air temperature with Heat Pump only(*)		**No supply air heating**				°C

Hot water

		Test point 1	Test point 3	Test point 3	Test point 4	
Outside Air Temperature	T_{amb}	**-7**	**2**	**7**	**20**	°C
Thermal Output Heat Pump for heating up storage tank.	P_{DHW} heating up	**0.96**	**1.95**	**2.47**	**4.38**	kW
Thermal Output Heat Pump for reheating storage tank	P_{DHW} reheating	**0.60**	**1.66**	**2.10**	**3.33**	kW
COP Heat Pump for heating up storage tank	$COP_{DHW,}$ heating up	**0.80**	**2.47**	**2.97**	**3.38**	-
COP Heat Pump for reheating storage tank	COP_{DHW} reheating	**0.46**	**2.22**	**2.51**	**2.42**	-
Average storage tank temperature		**34.8**				°C
Specific storage heat losses		**1.84**				W/K
Exhaust air addition (if applicable)		**260**				m³/h

Appendix to the certificate Vaillant GmbH, recoCOMPACT

Passive House comfort criterion

A minimum supply air temperature of 16.5 °C is maintained at an outdoor air temperature of -10 °C.

Efficiency criterion (heat recovery rate)

The effective dry heat recovery rate is measured at the test facility using balanced mass flows on the outdoor air/extract air side. The boundary conditions for the measurement should be taken from the documents relating to the testing procedure.

$$\eta_{HR,eff} = \frac{(\vartheta_{ETA} - \vartheta_{EHA}) + \frac{P_{el}}{\dot{m} \cdot c_p}}{(\vartheta_{ETA} - \vartheta_{ODA})}$$

The (dry) ventilation heating load (the house is the system boundary) can be calculated using $\eta_{HR,eff}$ based on the formula $\dot{V}_{supply\_air}$ * (1- $\eta_{HR,eff}$) * 0.34 * $\Delta\vartheta$ (multiplied by the infiltration rate). The rates of heat recovery are usually greater if condensation occurs in the heat exchanger. Initially, this will not be taken into account on purpose.

For this device:

recoCOMPACT 7kW $\eta_{WRG,t,eff}$ = 83 %

recoCOMPACT 5kW $\eta_{WRG,t,eff}$ = 87 %

recoCOMPACT 3kW $\eta_{WRG,t,eff}$ = 87 %

Efficiency criterion (power consumption)

The overall electrical power consumption of the device including that for regulation, but without that for the frost protection heating, is tested at the test facility at an external pressure of 100Pa (50Pa for each of the pressure/intake sides).

For this device:

recoCOMPACT 7kW - 0.34 Wh/m³

recoCOMPACT 5kW - 0.33 Wh/m³

recoCOMPACT 3kW - 0.33 Wh/m³

Air tightness and insulation

Before starting the thermodynamic test, the air tightness test should be carried out for under pressure as well as for over pressure. The leakage air flows must not be greater than 3 % of the average air flow volume of the operating range of the ventilation device.

The following result was obtained for the device:

recoCOMPACT 7kW - Interne Leckagen: 2.46 %

recoCOMPACT 7kW - Externe Leckagen: 1.76 %

recoCOMPACT 5kW - Interne Leckagen: 2.48%

recoCOMPACT 5kW - Externe Leckagen: 1.81%

recoCOMPACT 3kW - Interne Leckagen: 2.48%

recoCOMPACT 3kW - Externe Leckagen: 1.81%

This ventilation unit meets the airtightness requirements.

Adjustability

It must be possible to adjust the balance between the exhaust air flow rate and the outdoor air flow rate for all units.

- This unit is certified for air flow rates of **110 - 280 m³/h (recoCOMPACT 7kW), 110 - 280 m³/h (recoCOMPACT 5kW/3kW)**
- Balancing the air flow rates of the unit is possible
- The users should have at least have following possibilities for adjustment:
  - ✓ Switching the system on and off
  - ✓ Synchronized adjustment of the supply air and extract air flow to basic ventilation (= 70 %), standard ventilation (= 100 %) and increased ventilation (= 120 %) with clear readability of the set status.
  - ✓ Depending on the demand, the user can choose between 3 operating levels that can be set manually at the control unit of the operating element.
- The device being tested here has no switch for shutting down or standby-Modul. The device must be equipped with an additional external switch to separate the device from the electric circuit if required.
- After a power failure the device automatically continues to operate in the mode that was set before the power failure.

Acoustical testing

In order to restrict the sound pressure level in the installation room, the sound power level should be restricted to 35 dB(A). With an equivalent room absorption area of 4 m² the amounts of sound power level and sound pressure level are nearly the same (the exact value of the sound pressure level in the specific installation room can be calculated with the help of the sound protection tool (download on www.passivehouse.com)).

Installation instructions must be provided which describe how the sound level can be kept below 25 dB(A) in living areas and below 30 dB(A) in functional areas. The following sound power levels have been determined :

recoCOMPACT 7kW (282 m³/h)

Geräteschall [dB(A)]	Kanalschall AU [dB(A)]	Kanalschall ZU [dB(A)]	Kanalschall AB [dB(A)]	Kanalschall FO [dB(A)]
58.2	47.6	66.1	44.1	65.9

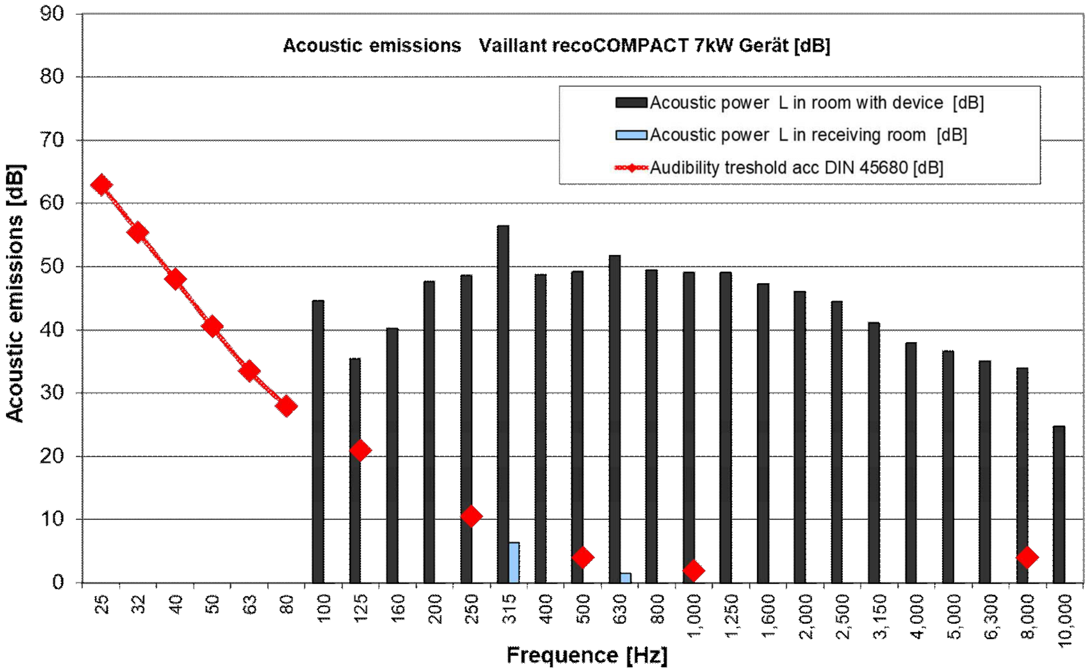


Figure 1: Acoustic emissions of unit body recoCOMPACT 7kW at air flow 280 m³/h

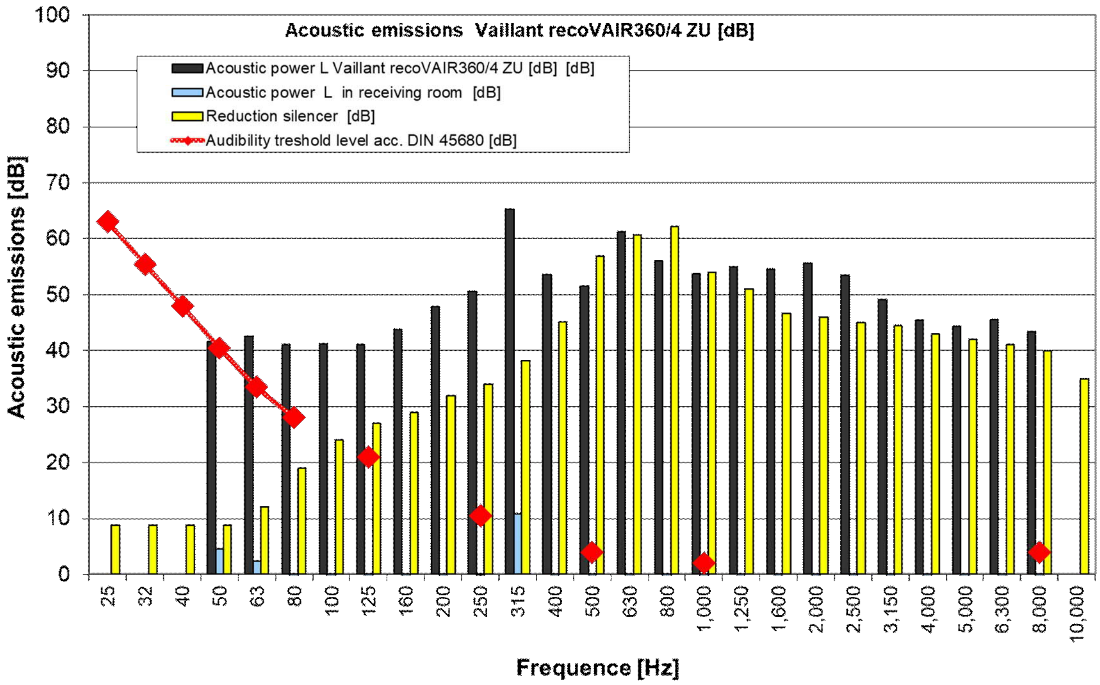


Figure 2: Acoustic emissions of supply duct recoCOMPACT 7kW at air flow 280 m³/h

Appendix to the certificate Vaillant GmbH, **recoCOMPACT**

recoCOMPACT 5kW (200 m³/h)

Geräteschall [dB(A)]	Kanalschall AU [dB(A)]	Kanalschall ZU [dB(A)]	Kanalschall AB [dB(A)]	Kanalschall FO [dB(A)]
51.6	40.8	59.4	38.7	59.3

recoCOMPACT 3kW (200 m³/h)

Geräteschall [dB(A)]	Kanalschall AU [dB(A)]	Kanalschall ZU [dB(A)]	Kanalschall AB [dB(A)]	Kanalschall FO [dB(A)]
51.6	40.8	59.4	38.7	59.3

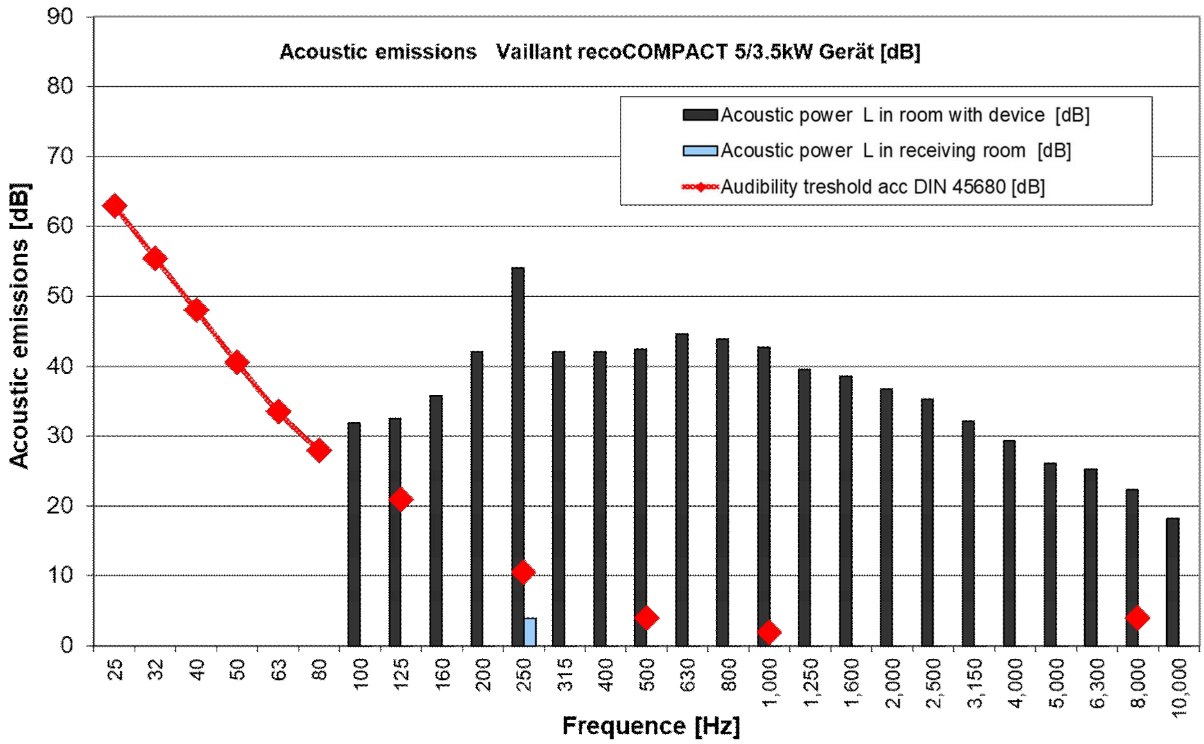


Figure 3: Acoustic emissions of unit body recoCOMPACT 5/3kW at air flow 200 m³/h

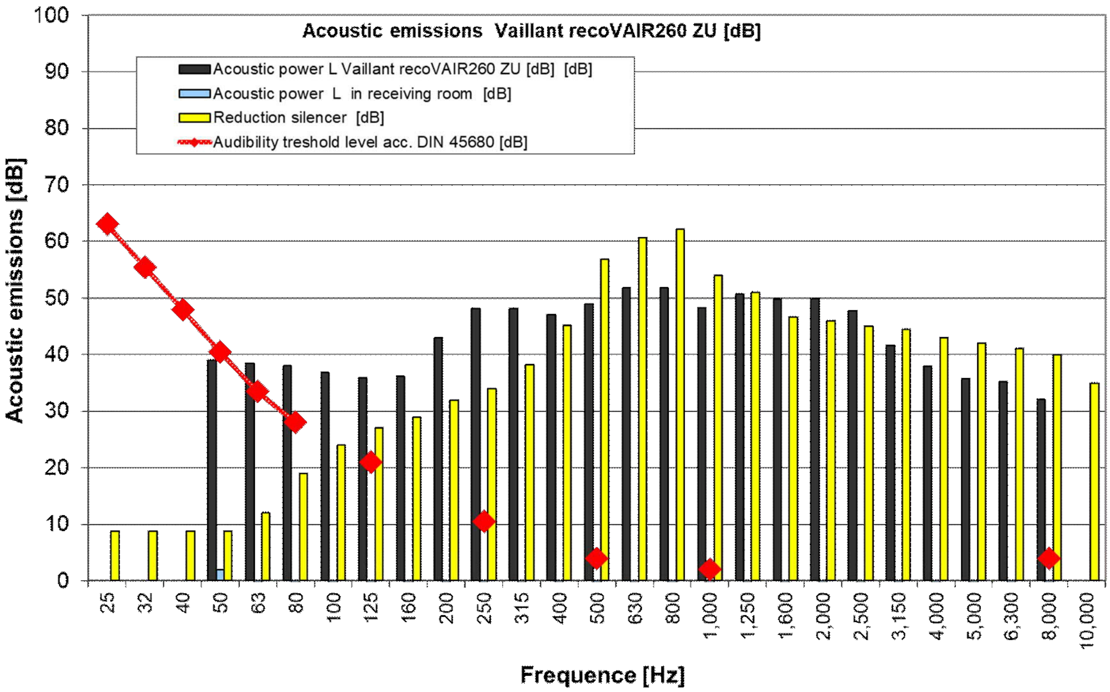


Figure 4: Acoustic emissions of supply duct recoCOMPACT 5/3kW at air flow 200 m³/h

- The sound level of the unit exceeds the limit value of 35 dB(A). Therefore the unit should be installed so that it is acoustically separated from living areas.
- Silencers are recommended by the manufacturer for complying with the required sound level in the supply air and extract air rooms. Detailed information about these can be found in the full report. Dimensioning of a suitable silencer is required for the specific project on the basis of the measured sound intensity level.

Indoor air hygiene

Inspection and cleaning of the central device including the heat exchanger is simple. The filter can be replaced by the user himself/herself (no specialist required). The unit is equipped with following filter qualities:

✓ Outdoor Air filter F7

✓ Extract Air filter G4

The Unit can be alternatively equipped with a filter of class F9 for the outdoor air.

If the device is not operated during the summer, the filter should be replaced before the next operation.

Filter replacement is recommended after an interval of 12 months.

Frost protection

Appropriate measures should be taken to ensure prevention of icing over of the heat exchanger and freezing up of hydraulic post-heater coils during extreme winter temperatures (-15°C). The regular functioning of the device should be permanently ensured during uninterrupted operation of the frost protection circuit (there is no interrupt circuit for outdoor air in the Passive House, as the heating loads caused by the forced infiltration would become too high). If heater coils for hot water are used, a suitable frost protection circuit should ensure prevention of frost damage to these heater coils. In the process, the possibility of failure of the pre-heating coils and extract air fans must also be taken into consideration.

- Frost protection circuit for the heat exchanger:
  - ✓ The built-in frost protection strategy of the device is suitable for passive houses.
  - ✓ The device can be optionally (as accessories) equipped with an electrical heater coil with a heating power of 1500 W (recoCOMPACT 7kW) respectively 1000 W (recoCOMPACT 5/3kW). During the investigation, the heating coil was installed. For use in Passive Houses, it is absolutely necessary to use it, in order to ensure continuous supply of fresh air. This strategy depends on the outdoor air and adjusts upon the temperature of -3°C behind the heating coil.
  - ✓ If the heating power of the heater coil is not enough at a very cold day, an additional frost protection strategy will work. This additional strategy depends on the temperature of the exhaust air. If the temperature of exhaust air is under 5 °C, the supply air ventilator will be shut down. After the temperature of exhaust air is over 8 °C, the supply air ventilator will be again turned on.
- Frost protection circuit for downstream hydraulic heater coils:
  - ✓ In order to protect a downstream hydraulic supply air heater, an undershooting of 5°C supply air temperature leads to a shutdown of the unit.

It should be noted that cold air can also lead to freezing up of stationary fans due to free circulation; this can only be ruled out if the air duct is closed (by means of a shut-off flap).

Assessment of the heat pump: The seasonal performance factor (SPF) of the system installed in the reference building and the primary energy consumption for the reference building without use of a ground heat exchanger are:

recoCOMPACT 7kW: SPF (without SHX) = 2.1, PE-value (without SHX)= 36.1 kWh/m²a. (Figure 5)

recoCOMPACT 5kW: SPF (without SHX) = 1.4, PE-value (without SHX)= 47.1 kWh/m²a. (Figure 6)

recoCOMPACT 3kW: SPF (without SHX) = 1.4, PE-value (without SHX)= 48.7 kWh/m²a. (Figure 7)

This unit recoCOMPACT 7kW can be used in Passive Houses with an air flow rate between 110 m³/h and 280 m³/h, based on an air flow rate of 30 m³/h/person and a heating load of 12 W/m². The characteristics of ventilation unit set the operational range of recoCOMPACT 7kW. The limit for PE-value was not exceeded.

The outdoor air intake temperatures are raised when a ground heat exchanger is used. Better performance values are obtained as a result.

recoCOMPACT 7kW: SPF (with SHX) = 2.7, PE-value (with SHX)= 34.6 kWh/m²a.

recoCOMPACT 5kW: SPF (with SHX) = 1.9, PE-value (with SHX)= 36.6 kWh/m²a.

recoCOMPACT 3kW: SPF (with SHX) = 1.9, PE-value (with SHX)= 34.6 kWh/m²a.

Appendix to the certificate Vaillant GmbH, **recoCOMPACT**

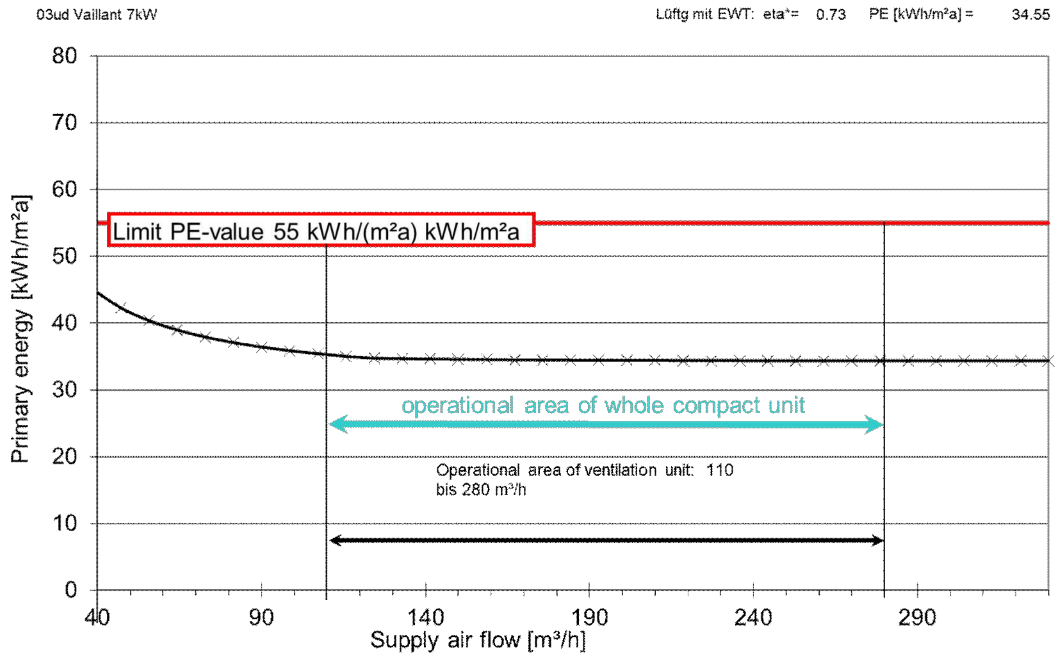


Figure 5: Operational range of recoCOMPACT 7kW (without SHX)

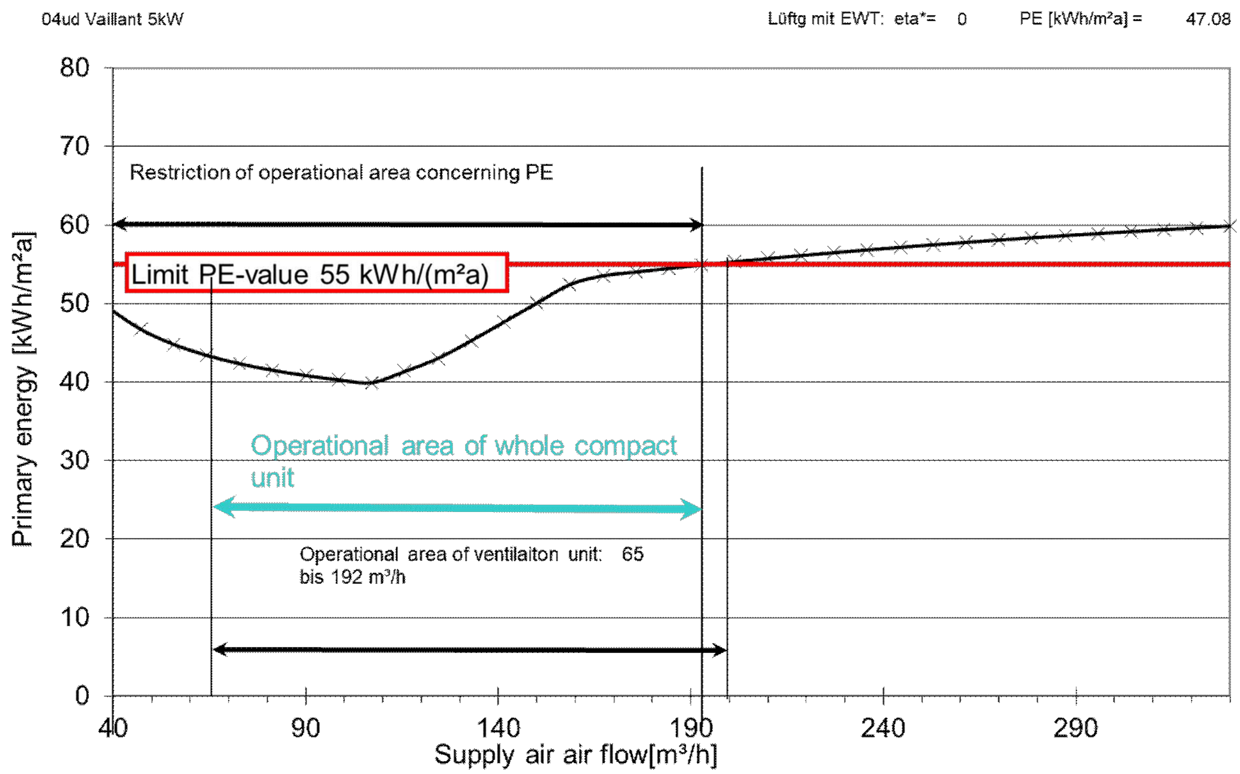


Figure 6: Operational range of recoCOMPACT 5kW (without SHX)

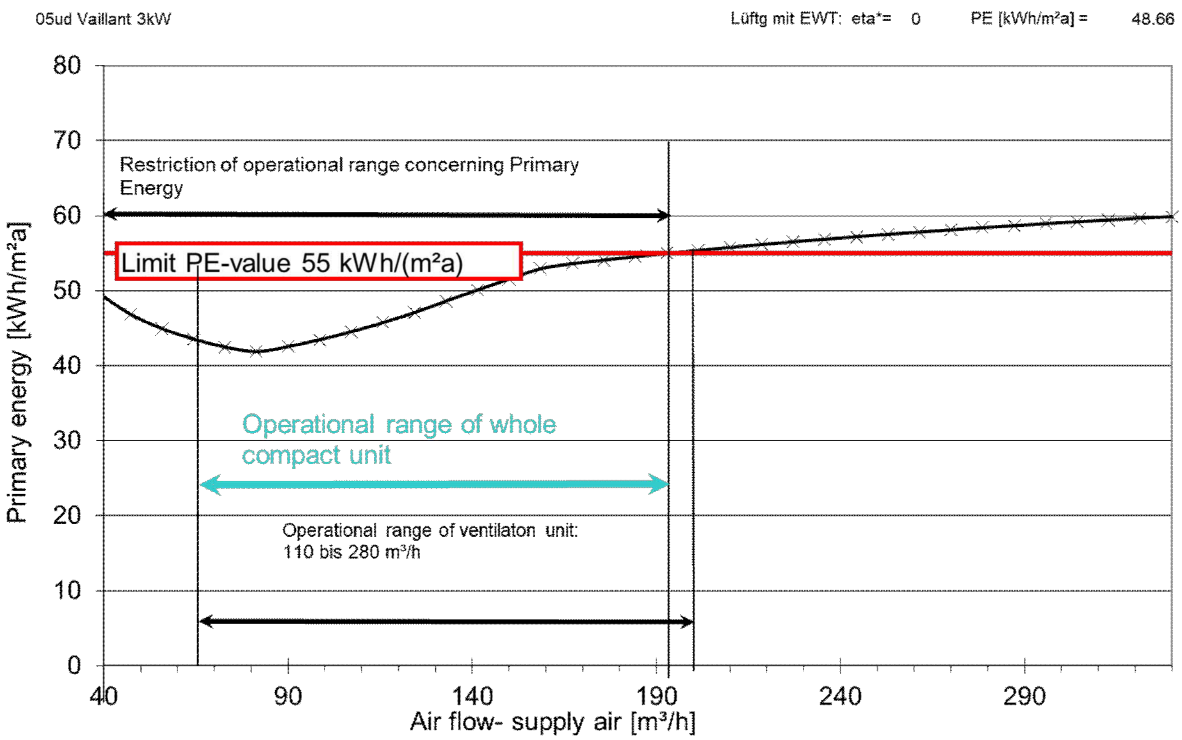


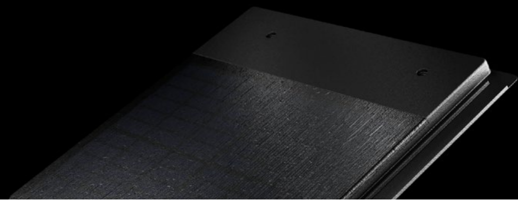
Figure 7: Operational range of recoCOMPACT 3kW (without SHX)

Abbreviations

- AU/ODA = Outdoor air
- FO/EHA = Exhaust air
- ZU/SUP = Supply air
- AB/ ETA = Extract air

6.3 PV System Proposed Specifications

XO SOLAR TILE
TECHNICAL SPECIFICATIONS /



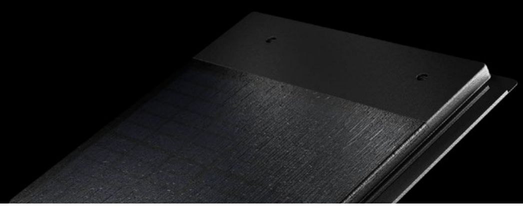
XO SOLAR TILE SPECIFICATIONS

XO/ST-I

XO SOLAR TILE	XO/ST-I
CELL TYPE	Monocrystalline Silicon
PEAK POWER (WP)	12Wp
CONVERSION EFFICIENCY (%)	18.60%
MAXIMUM POWER VOLTAGE (VMP)	10V
MAXIMUM POWER CURRENT (IMP)	1.2A
OPEN CIRCUIT VOLTAGE (VOC)	12.5V
SHORT CIRCUIT CURRENT (ISC)	1.25A
NOCT	44°C
POWER TEMPERATURE COEFFICIENT	-0.38%/°C
CURRENT TEMPERATURE COEFFICIENT	0.04%/°C
VOLTAGE TEMPERATURE COEFFICIENT	-0.30%/°C
MAXIMUM SYSTEM VOLTAGE (VDC)	600V
MAX VOLTAGE PER ELECTRICAL ROW	550V
OPERATING TEMPERATURE	- 40°C ~ +85°C
MAX. FUSE RATING (A)	15A
JUNCTION BOX RATING	IP67
CONNECTOR CABLE	4.0mm2
TERMINAL CONNECTORS	MC4

DOCUMENT VERSION 1.03

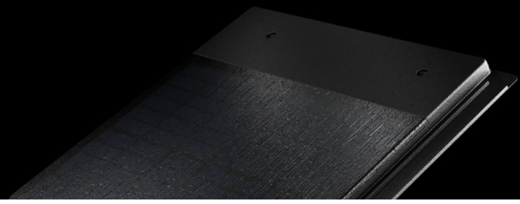
XO SOLAR TILE
TECHNICAL SPECIFICATIONS /



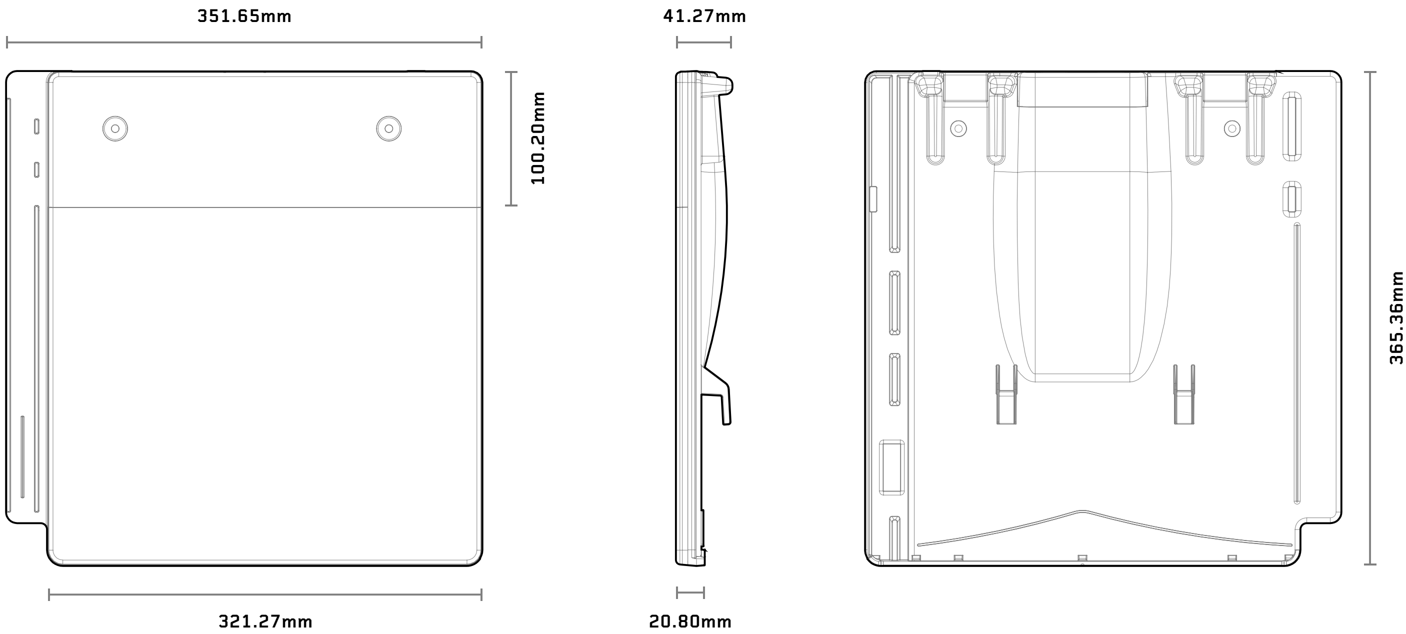
XO SOLAR TILE	XO/ST-I
MECHANICAL DATA	
EXTERNAL DIMENSIONS	351.65mm (W) x 365.36mm (H) x 41.27mm (D)
APERTURE AREA	300mm x 250mm
COVER WIDTH	315mm
HANGING LENGTH	260mm (@ 100mm headlap)
PROFILE DEPTH (LEADING EDGE)	21mm
WEIGHT PER SOLAR TILE	1.4kg
STATIC STRUCTURAL LOAD PER M2	17.5kg (@ 100mm headlap)
CHARACTERISTIC WIND RESISTANCE	2400 Pa or 244 Kg/mm2
ULTIMATE DESIGN LOAD	2400 Pa or 244 Kg/mm2
POSITIVE DESIGN LOAD	2400 Pa or 244 Kg/mm2
DESIGN CONSIDERATIONS	
SOLAR TILES PER KW	84
COVERAGE CAPACITY	12.5 per m2 (at 100mm headlap)
MAX SOLAR TILES PER ELECTRICAL ROW	55 (fifty five)
MAX ELECTRICAL ROWS PER STRING	16 (with an XO Inverter)
MINIMUM PITCH	15° (@ 110mm headlap)
MAXIMUM PITCH	90°
MINIMUM HEADLAP	75mm (22.5° and above)
	100mm (below 22.5°)
MINIMUM GAUGE	255mm
MAXIMUM GAUGE	285mm
RECOMMENDED GAUGE	260mm
BATTENS REQUIRED	2.9 lin.m/m² at 75mm headlap
	3.1 lin.m/m² at 100mm headlap
BATTEN SIZE RECCOMENDED	50 x 25mm for rafters/supports not exceeding 600mm centres
FIXING SPECIFICATION	Tile nails 50mm x 3.35mm or Countersunk screws 50mm x 3.35mm
COMPATIBLE ROOF COVERINGS	XO Mariana Tiles only
FIRE RATING	Class II (IEC 61730)
POWER WARRANTY	25 Years 80% Power Output
	12 Years 90% Power Output
	3 Years Material & Workmanship
SAFETY STANDARDS	IEC 61730 | UL | TUV | RETC
NOMINAL OPERATING CELL TEMPERATURE	Electrical specification measured under standard test conditions: Irradiation 1000W/m2 with light spectrum AM 1.5 and a cell temperature of 25°C.

DOCUMENT VERSION 1.03

XO SOLAR TILE
TECHNICAL SPECIFICATIONS /



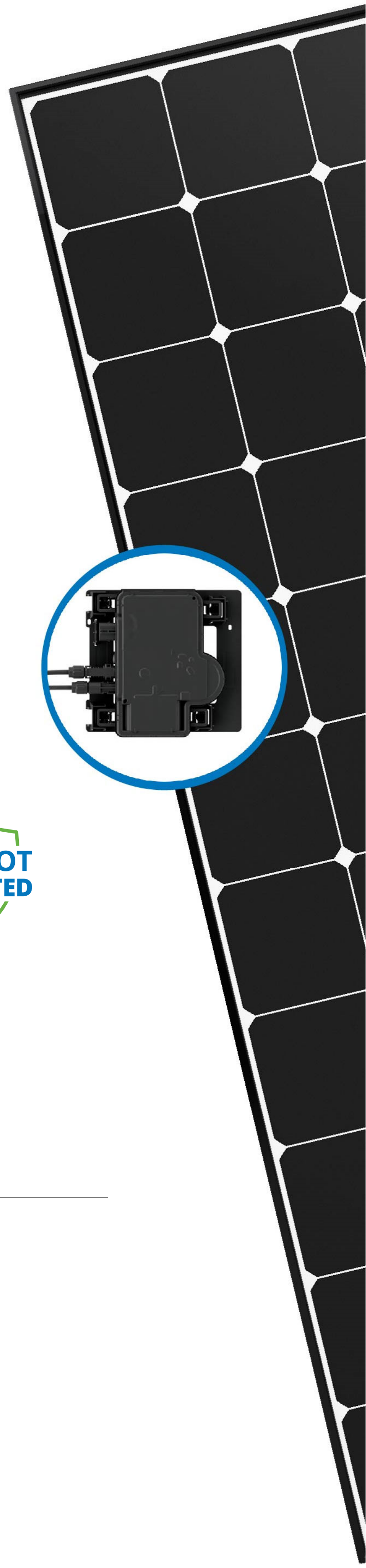
XO SOLAR TILE DIMENSIONS



XO SOLAR ROOF

DOCUMENT VERSION 1.03

SUNPOWER | FROM MAXEON SOLAR TECHNOLOGIES



MAXEON 6 AC SOLAR PANEL

420-445 W | Up to 23% Efficient

AC Factory-integrated microinverter

White backsheet, black frame

More Lifetime Energy

Designed to maximise energy generation through leading efficiency, enhanced performance in high temperatures, and higher energy conversion in low-light conditions like mornings, evenings and cloudy days.

Uncompromising Reliability

Engineered to power through all types of weather conditions with crack-resistant cells and reinforced connections that protect against fatigue and corrosion. Each panel's microinverter enables independent panel operation to mitigate the impact of shade while improving system performance.

HOT-SPOT PROTECTED

Superior Sustainability

Clean ingredients, responsible manufacturing, and lasting energy production for 40 years make SunPower Maxeon panels the most sustainable choice in solar.

40 YEAR WARRANTY
Power | Product | Service

The Industry's Longest Warranty

SunPower Maxeon panels are covered by a 40-year warranty[1] backed by extensive third-party testing and field data from more than 33 million panels deployed worldwide.

Product and power coverage	40 Years
Year 1 minimum warranted output	98.0%
Maximum annual degradation	0.25%
Microinverter limited product warranty covered by Enphase	25 Years

Learn more about the SPR-MAX6-XXX-E4-AC
sunpower.maxeon.com

MAXEON 6 AC POWER: 420-445 W | EFFICIENCY: Up to 23%

AC Electrical Data

Inverter Model: IQ 7A	@230 VAC
Peak Output Power	366 VA
Max. Continuous Output Power	349 VA
Nom. (L–N) Voltage/Range	219 – 264 V
Max. Continuous Output Current	1.52 A
Max. Units per 20 A (L–N) Branch Circuit	10
Weighted Efficiency[2]	96.5%
Nom. Frequency	50 Hz
Extended Frequency Range	45-55 Hz
AC Short Circuit Fault Current Over 3 Cycles	5.8 A rms
Overvoltage Class AC Port	III
Night-time Power Loss	50 mW
Power Factor Setting	1.0
Power Factor (adjustable)	0.8 lead. / 0.8 lag.

DC Power Data

	SPR-MAX6-445-E4-AC	SPR-MAX6-435-E4-AC	SPR-MAX6-425-E4-AC	SPR-MAX6-420-E4-AC
Nom. Power[3] (Pnom)	445 W	435 W	425 W	420 W
Power Tol.	+5/0%	+5/0%	+5/0%	+5/0%
Module Efficiency	23.0%	22.5%	22.0%	21.7%
Temp. Coef. (Power)	−0.29%/°C			
Shade Tol.	Integrated module-level max. power point tracking			

Mechanical Data

Solar Cells	66 Maxeon 6 Cells
Tempered glass	High-transmission tempered glass with anti-reflective coating
Environmental Rating	Microinverter Outdoor rated - IP67
Frame	Class 1 black anodized
Weight	21.8 kg

Packaging Configuration

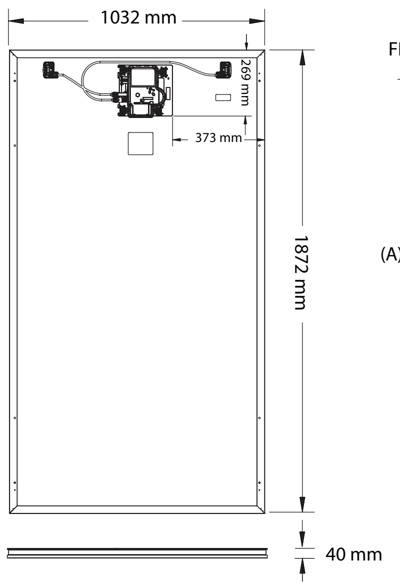
Number of modules per pallet	25
Number of pallets per 40ft HQ container	24
Number of modules per container	600

Tested Operating Conditions

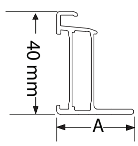
Operating Temp.	−40°C to +60°C
Max. Ambient Temp.	50°C
Relative Humidity	4% to 100% (Condensing)
Max. Altitude	2000 m
Max. Load[4]	Wind: 3600 Pa, 367 kg/m² back Snow: 5400 Pa, 551 kg/m² front
Impact Resistance	25 mm diameter hail at 23 m/s
Microinverter enclosure	Class II double-insulated, corrosion resistant polymeric enclosure

Warranties, Certifications and Compliance

Panel Warranties[1]	· 40-year limited power warranty · 40-year limited product warranty
Microinverter Warranty	· 25-year limited product warranty covered by Enphase warranty[5]
Certifications and Compliance	· IEC 61215, 61730[6] · IEC 62109-1, 62109-2 · IEC 61000-6-3 · AS4777.2, RCM · IEC/ EN 50549-1:2019, G98/G99 · VDE-AR-N-4105
Quality Management Certs	ISO 9001:2015, ISO 14001:2015
PID Test	1000 V: IEC 62804
LeTID Test	TUV 2fg 2689/04.19 (LeTID Detection)[7]
Available listing	TUV[6], EnTest
Green Building Certification contribution	Panels can contribute additional points towards LEED and BREEAM certifications
EHS Compliance	RoHS, ISO 45001:2018, REACH SVHC-201



FRAME PROFILE



(A) Long Side: 32 mm
Short Side: 24 mm

LEAD FREE RoHS COMPLIANT

1 40-year warranty is not available in all countries or all installations and requires registration, otherwise our 25-year warranty applies. Service availability varies by country and installation provider.
2 Tested per EN 50530 (EU).
3 Standard Test Conditions (1000 W/m² irradiance, AM 1.5, 25°C). NREL calibration standard: SOMS current, LACCS FF and voltage. All DC voltage is fully contained within the module.
4 As per IEC 61215-2016 tested and certified.
5 AC modules shall be connected to Enphase Monitoring hardware (IQ Gateway) to enable Enphase product warranty.
6 Refer to the DC module, Class C fire rating per IEC 61730.
7 Panels degraded 0% in extended LeTID testing conducted by PVEL. Test report R10124977G-1,2020.

Please read the safety and installation instructions.
Visit www.sunpower.maxeon.com/int/InstallGuideACModules
Paper version can be requested through
techsupport.ROW@maxeon.com

SUNPOWER
FROM MAXEON SOLAR TECHNOLOGIES

Made in Malaysia (Cells)
Assembled in Malaysia (Module)
Specifications included in this datasheet are subject to change without notice.

548942 REV A / A4_EN
Publication Date: February 2023

6.4 PHPP Summary Pages

Passive House-Verification

10.4a EN

Building:	79 Riddlesdown Road		
Street:	79 Riddlesdown Road		
Postcode/City:	CR8 1DH	Purley	
Province/Country:	London	GB-United Kingdom/ Britain	
Building type:	5-Multi-family house I Apartment building		
Climate data set:	GB0003a-London Gatwick, Altitude corrected, +5K summer correct		
Climate zone:	3: Cool-temperate	Altitude of location:	118.5 m
Home owner / Client:	Polaris Passivhaus Developments Limited		
Street:	Tepestede Court, Hazel Way		
Postcode/City:	CR5 3PJ	Chipstead	
Province/Country:	Surrey		

Architecture:	Polaris Passivhaus Consult + Construct Limited	
Street:	Tepestede Court, Hazel Way	
Postcode/City:	CR5 3PJ	Chipstead
Province/Country:	Surrey	GB-United Kingdom/ Britain
Energy consultancy:	Polaris Passivhaus Consult + Construct Limited	
Street:	Tepestede Court, Hazel Way	
Postcode/City:	CR5 3PJ	Chipstead
Province/Country:	Surrey	GB-United Kingdom/ Britain

Mechanical engineer:	None Applicable at Stage 2 Report	
Street:		
Postcode/City:		
Province/Country:		
Certification:	None Applicable at Stage 2 Report	
Street:		
Postcode/City:		
Province/Country:		

Year of construction:	2024	Interior temperature winter [°C]:	20.0	Interior temp. summer [°C]:	24.0
No. of dwelling units:	5	Internal heat gains (IHG) winter [W/m^2]:	2.7	IHG summer [W/m²]:	3.8
No. of occupants:	19.0	Specific heat capacity [Wh/K per m² TFA]:	60	Mechanical cooling:	

Specific building characteristics with reference to the treated floor area

		Unit	Value		Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	397.1				
Space heating	Heating demand	kWh/(m²a)	12	≤	15	-	Yes
	Heating load	W/m²	8	≤	-	10	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	-	≤			
	Frequency of overheating (> 24 °C)	%	3	≤			
	Frequency of excessively high humidity (> 12 g/kg)	%	0	≤	20		Yes
Airtightness	Pressurisation test result n_{50}	1/h	0.6	≤	0.6		Yes
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	68	≤	-		-
Primary Energy Renewable (PER)	PER demand	kWh/(m²a)	54	≤	45	54	Yes
	Renew. energy generation (in rel. to projected building footprint area)	kWh/(m²a)	81	≥	60	77	

I confirm that the values given here have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this verification.

Passive House Plus?

Task:	First name:	Surname:	Signature:

Certificate-ID	Issued on:	City:

POLARIS
PASSIVHAUS CONSULT + CONSTRUCT

Carbon postitive form

Biophilic designed

Passivhaus certified

We are creators of beautiful sustainable places that truly enhance our environment