The UK's progress towards a Passivhaus standard in new homes

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Debate

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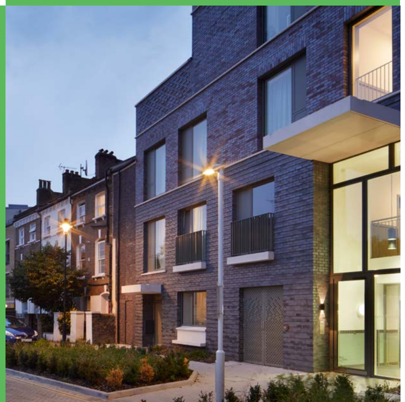

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The UK's progress towards a Passivhaus standard in new homes

NHBC Foundation
NHBC House
Davy Avenue
Knowlhill
Milton Keynes
MK5 8FP

Tel: **0344 633 1000**
Email: **nhbcfoundation@nhbc.co.uk**
Web: **nhbc.co.uk/foundation**

Prepared for
NHBC Foundation
by Sava

Sava

The NHBC Foundation

The NHBC Foundation, established in 2006, provides high quality research and practical guidance to support the house-building industry as it addresses the challenges of delivering 21st century new homes. To date we have published over 80 reports on a wide variety of topics, including the sustainability agenda, homeowner issues and risk management.

The NHBC Foundation is also involved in a programme of positive engagement with the government, academics and other key stakeholders, focusing on current and pressing issues relevant to house building.

To find out more about the NHBC Foundation, please visit **nhbc.co.uk/foundation**.
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NHBC is the standard-setting body and leading warranty and insurance provider for new homes in the UK, providing risk management services to the house-building and wider construction industry. All profits are reinvested in research and work to improve the construction standard of new homes for the benefit of homeowners. NHBC is independent of the government and builders. To find out more about NHBC, please visit **www.nhbc.co.uk**.

Agar Grove Estate, Hill Group

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Foreword

Housing supply in the United Kingdom continues to lag demand. In England alone, the annual target is for 300,000 new homes a year with new build expected to deliver the majority. However, it is not just a question of quantity. These new homes will need to be delivered with low energy demand, zero-carbon ready and to a high quality giving homeowners confidence in the construction sector. In order for the UK to meet its climate change objectives, consideration will have to be given to the embodied carbon of new buildings and how this can be reduced. And the in-use performance of new homes continues to be a concern with recent energy price increases making consumers more aware of running costs. In other words, the importance of ensuring that what is designed is actually built is greater than ever.

Just over ten years ago, the NHBC Foundation looked at whether Passivhaus could address most of these points - at the time in the context of the Government's commitment to deliver zero carbon homes from 2016. However full certification through the Passive House Planning Package has been limited. This report looks at the barriers and highlights where positive progress has been made. Delivery at scale is a considerable challenge for the housebuilding industry. The report discusses the cultural shift that would be required to construct homes to this standard, but also considers the end user and how they need to adapt to living in a dwelling designed to reduce energy consumption, whilst creating a more comfortable indoor environment.

The four nations of the UK are not standing still and changes to regulations in the early 2020s have heralded a step change in energy efficiency of new homes, with further changes due to phase out fossil fuel heating systems. The report questions whether apart from in Scotland (where the Government is committed to a PassivHaus equivalent standard being laid before Parliament by December 2024) government proposals are going far enough when it comes to building fabric.

We hope the report is a useful contribution to the ongoing debate in this crucial area.

Rt Hon. the Lord Barwell

Chairman, NHBC Foundation

Chapter 1 Introduction

In 2019, the UK made a significant commitment to the fight against climate change by officially adopting a target of achieving net-zero greenhouse gas emissions by 2050. This decision was made through the passage of "The Climate Change Act 2008 (2050 Target Amendment) Order 2019", a statutory instrument that established a legally binding target [1]. This was further accelerated at COP26 when the UK Government committed to achieving a 68% reduction in the UK's carbon emissions by 2030, compared to 1990 levels[1].

Achieving these ambitious goals requires strategic implementation of carbon reduction across all sectors in the coming decades.

One of the biggest contributors to the UK's greenhouse gas emissions is the built environment, accounting for up to 30% of all emissions according to RICS' report on decarbonising UK real estate [2]. To decarbonise this sector, multiple suggestions have been put forward - such as the electrification of space heating, and the tightening of Building Regulations to improve the fabric performance of dwellings. The Government has pledged to build 300,000 new low-energy homes per year in England, and along with the tightening of Building Regulations, could Passivhaus be a solution to decarbonising the built environment?

At the time of writing in the UK, there are over 2,900 fully certified Passivhaus buildings, with an additional 8,530 units reported to be under development [3]. This is a sharp rise from 10 years ago when there were just 165 that had been completed or were under construction [4].

1 Different standards apply in Scotland, Northern Ireland and Wales.

A decade after the NHBC Foundation's initial report on Passivhaus in the UK [5], there has been a notable increase in the adoption of Passivhaus principles in the country's construction industry. However, this progress has been slower than anticipated, primarily due to challenges related to education and costs. Our research underscores the mixed response within the construction sector to airtightness targets, with significant concerns raised by volume housebuilders regarding the feasibility of widespread adoption of Passivhaus standards.

As Scotland explores "Passivhaus equivalent" standards, it is crucial to grasp the objectives of such regulations and emphasise their alignment with Passivhaus principles, building upon existing standards, such as the Passivhaus Institut Low Energy Building Standard (PHILEB), which are somewhat less stringent.

If Passivhaus were to become the default standard in the UK, multiple matters need to be addressed. There is a clear need for increased education and funding. Passivhaus must also be seen as more than a building standard: it is also a premium comfort standard, offering not only environmental advantages but also significant societal benefits, including reduced utility bills and enhanced indoor air quality. Concerns with repairability need addressing and industry must ensure that Passivhaus is practical for everyone and that barriers to uptake are minimised.

Chapter 2 The Fundamentals of Passivhaus

2.1 What is Passivhaus?

Passivhaus is an energy-efficient building design and construction concept that originated in Germany in the late 1980s. The concept is owned by the Passivhaus Institut of Darmstadt, Germany, which strictly regulates the certification of buildings and ensures that high-quality standards are upheld.

The fundamental principle behind Passivhaus is to create structures that minimise the need for active heating or cooling systems. By utilising a combination of design strategies and high-quality building materials, Passivhaus buildings aim to maintain a comfortable indoor environment while significantly reducing energy consumption. By definition, they focus on design features that are passive in functionality such as insulation, airtightness, and solar orientation. However, they also include active elements in design to ensure comfort for residents most notably mechanical ventilation with heat recovery systems (MVHR). The overall aim of Passivhaus is to eliminate the need for traditional wet central heating systems. This is achieved by reducing the space heating load to a level where the required heat can be provided via the ventilation air alone.

2.2 The requirements of Passivhaus

Passivhaus requires a building to conform to strict requirements in order to be deemed Passivhaus compliant and achieve certification [6]. These requirements are as follows:

1. The space heating demand of the building is to not exceed 15kWh per square metre of net living space (treated floor area) per year or 10W per square metre peak demand. In climates where active cooling is needed, the space cooling energy demand requirement roughly matches the heat demand requirements above, with an additional allowance for dehumidification.
2. The Primary Energy Renewable demand (PER) for all domestic applications (heating, hot water, and domestic electricity) must not exceed 60kWh per square metre of treated floor area per year.[2]
3. The property must meet airtightness limits with a maximum of 0.6 air changes per hour at 50 Pascals pressure, as verified with several onsite pressure tests (in both pressurised and depressurised states).
4. Thermal comfort must be met for all living areas during winter as well as in summer, with the internal temperature not exceeding 25°C for a maximum of 10% of the hours in a year.
5. Requirement to record/photograph certain construction stages.

Passivhaus Plus and Premium

	Classic	Plus	Premium
Maximum Primary Energy Renewable (PER) demand (kWh/m²yr)	60	45	30
Maximum renewable energy generation (kWh/m²yr)	n/a	60	120

Table 1 Requirements of Passivhaus Plus and Premium

Passivhaus also offers a Passivhaus Plus and Passivhaus Premium standard, both of which incorporate the use of renewable energy generation in the certification assessment.
The PER demand focuses on the portion of primary energy use that is derived from renewable energy sources and is a subset of the total primary energy use.

2 Evidence for compliance with the non-renewable primary energy demand (PE) will still be accepted. In the PHPP software the Passivhaus Institut have country-specific PE limit values based on primary energy factors. If no value exists for a country, then the default is a maximum of 120 kWh/m²yr.

2.3 The Passivhaus principles

In order to meet the rigorous standards of Passivhaus, intelligent design is imperative to reduce air leakage in the building and also meet the space heating demand target. There are therefore five key basic principles that apply to the construction of a Passivhaus building:

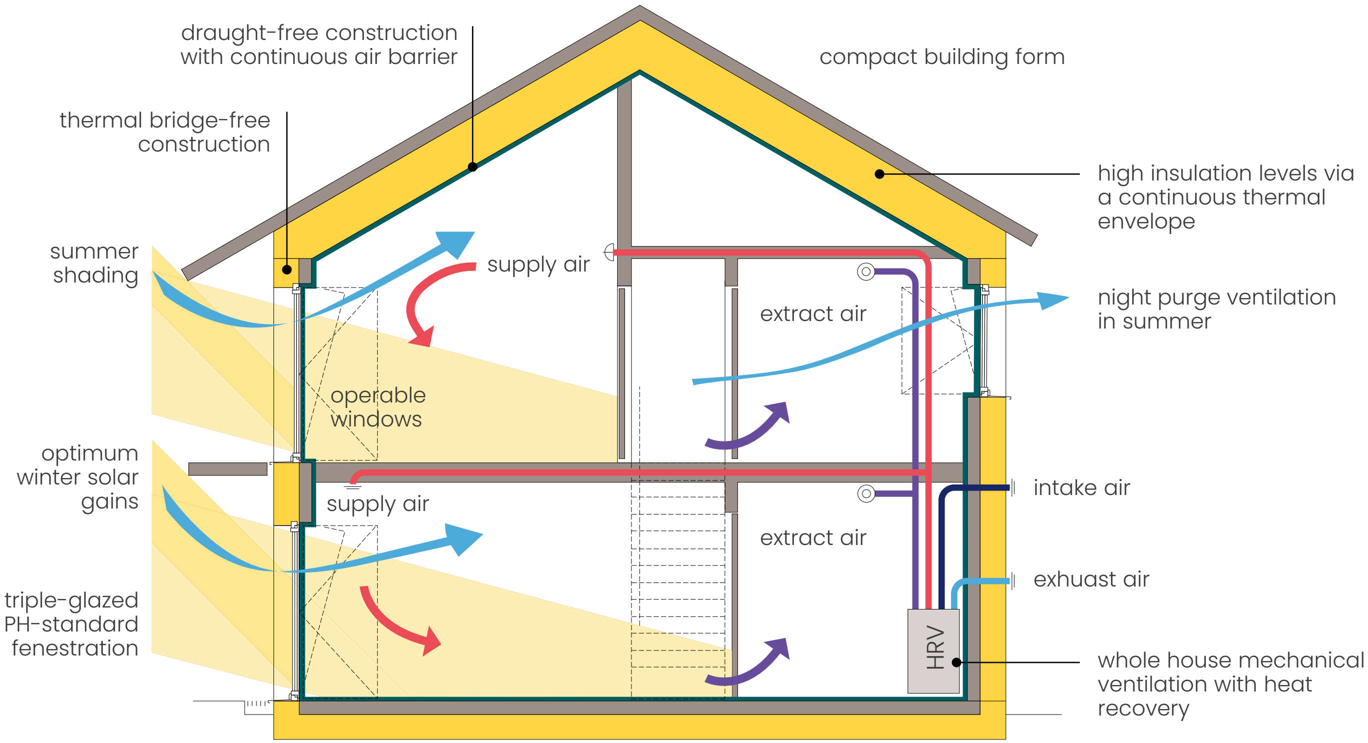

Figure 1 Passivhaus Principles

Thermal insulation

One of the basic principles of Passivhaus design is a well-insulated building envelope. Typically wall, roof and floor elements will achieve a U-value of between 0.10 W/m²K to 0.15 W/m²K [3]. They will also achieve minimal thermal bridging and, in some construction types, provide an internal service void so that services do not penetrate the airtight barrier of the building. This internal service void is important as it means that once the building has been constructed there should be no need to disturb the envelope of the building hence disrupting the airtight membrane that has been installed. This allows for easier repairs from within the internal service void.

Passivhaus walls are generally thicker, varying from 300mm to 500mm depending on the construction method and insulation chosen.

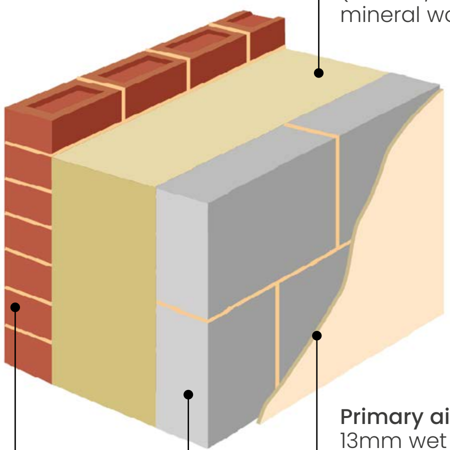

Figure 2a cavity wall build-up of a Passivhaus

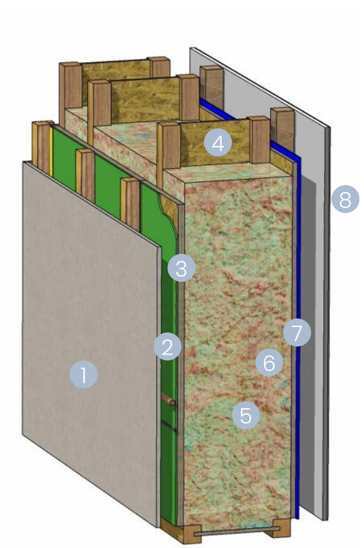

Figure 2b timber frame wall build-up of a Passivhaus

3 Heat loss is expressed as a measured or calculated U-value. U-values show how much heat in Watts is lost per square metre at a standard temperature difference of 1 degree Kelvin. To calculate the heat loss of an area such as a wall one therefore multiplies the U-value by the area and the temperature difference between inside and outside.

Floors are often constructed from insulated slabs which allow for a continuous insulated area with no thermal bridging and complete airtightness. There are instances where beam and block construction are used, although, this often requires adaptation and extra insulation to ensure it meets the U-values required for Passivhaus.

Well-insulated roof systems also play a crucial role in regulating indoor temperatures, helping to keep homes warm in the winter and cool in the summer.

Thermal bridge reduced design

Thermal bridging, also termed cold bridging, denotes localised regions within a building's envelope where the insulation barrier is compromised, permitting an easier flow of heat compared to the surrounding materials. Essentially, it represents a path of heightened heat conductivity that circumvents the insulation layer, resulting in an increased heat transfer zone between the building's interior and exterior.

Neglected thermal bridges can escalate heat loss from the building's structure by over 30%, primarily stemming from materials such as concrete or metal components, thereby impacting thermal comfort and potentially causing condensation.

Common instances of thermal bridges encompass structural components such as beams, columns, and studs in walls or floors, alongside areas surrounding openings like windows, doors, and vents. During cold weather, these zones may experience lower temperatures compared to the remainder of the building envelope, leading to heat dissipation, potential condensation, and occupant discomfort. In Passivhaus design, a strategic approach is adopted to eradicate thermal bridges through the incorporation of thermal breaks at vulnerable junctions, such as where steels connect to a concrete floor, ensuring optimal insulation continuity.

High-performance windows

Windows used in Passivhaus are designed to meet the strict energy efficiency and comfort standards of the Passivhaus standard. They achieve this by incorporating insulating frames with thermal breaks and triple glazing with low-emissivity coatings and gas filling.

Windows are sealed tightly to prevent uncontrolled air leakage. This involves using high-quality gaskets and sealing materials. They are also strategically sized and positioned to balance daylighting, solar gain, and thermal performance. Solar control is achieved by positioning windows to optimise solar heat gain during the winter and incorporating shading devices to minimise heat gain during the summer[4].

4 For more detail see 'Windows- making it clearer' (NF77), 2017 [25]

Airtight construction

Ensuring airtightness is crucial to the fundamental principles of Passivhaus. This is achieved through the use of a continuous air barrier that envelopes the entire structure, from walls and roofs to floors and openings.

The design process identifies all potential air leakage paths and emphasises the sealing of joints and connections. The use of high-quality building materials including tapes and membranes ensures the airtightness of the building.

A breather membrane is often added externally, along with an airtight barrier which can be plywood, OSB, plasterboard or a flexible membrane. The airtight barrier is then sealed with specialised tape[5]. In masonry construction, the required airtightness is sometimes achieved using plaster alone.

Blower door testing is conducted to measure the buildings' air changes per hour under pressure. Chemical smoke, thermographic cameras and anemometers may be used to search for leaks, which can then be plugged.

Airtightness- understanding the units

Passivhaus measures the outcome of a pressure test in terms of air changes per hour (ACH), representing how many times the entire house volume is replaced with air in an hour, at a pressure differential of 50 Pascals (Pa). Conversely, UK Building Regulations quantify airtightness by calculating the absolute volume of air replaced per hour divided by the total external envelope area under the same pressure differential of 50 Pa (for blower door tests). The units in this case are m^3/m^2h. Achieving an accurate conversion from one system to the other hinges on the building's size and the area-to-volume ratio. As a rough estimation, the 0.6 ACH of the Passivhaus standard is approximately equivalent to 1.0 m^3/m^2h in the UK terminology (at 50 Pascals in both cases).

Adequate ventilation strategy

With the building now sealed for airtightness and minimal air leakage, the focus shifts to ensuring proper ventilation to keep the indoor air fresh. Stale air is removed from the building and passed through a mechanical ventilation system with heat recovery (MVHR). Here the heat is recovered from the stale air and transferred to the incoming fresh air. Passivhaus MVHR systems have heat recovery efficiencies ranging from 75% to 95%, with 75% being the minimum to meet Passivhaus requirements. The incoming and outgoing airstreams mustn't be allowed to mix, to avoid contamination between the two.

5 For further information see NHBC Standards chapter 6.2 – External timber framed walls.

2.4 The Passivhaus Planning Package

In order to meet Passivhaus standards it is important to use a certified Passivhaus designer, architect, or consultant. In the UK such practitioners can be found on the Passivhaus Trust "members map" [7]. A Passivhaus designer will use the Passivhaus Planning Package software (PHPP) which will calculate the key parameters from the design plans and explore options for compliance and give recommendations for achieving the Passivhaus standard.

SAP or PHPP?

The Passivhaus Planning Package (PHPP) is an energy calculation tool based on an Excel spreadsheet developed by the Passivhaus Institut in Germany. The Institut exclusively authorises the simulation and certification of operational efficiency for proposed Passivhaus constructions. While PHPP shares energy calculation techniques common across Europe, like the UK's SAP, it also includes other factors such as household appliances. Moreover, it offers a deeper analysis of certain aspects of the computation, for example, thermal bridging. Research conducted by the Passivhaus Trust, the Association for Environment Conscious Building (AECB) and Elmhurst Energy into PHPP and SAP concluded that the core of both models was very similar. However, the models are used for very different purposes.

SAP is a more standardised calculation tool used as a method of compliance. Its primary focus is to establish consistent regulations across the UK, potentially at the expense of precise data. As a result, SAP employs average UK weather data, which could imply that dwellings in colder regions do not necessitate extra insulation for compliance. PHPP on the other hand, always uses local climate data and includes further details in certain sections such as the calculation of shading for individual windows.

The key difference between the two models is how they are employed, rather than the accuracy of the models themselves. In essence, the underlying physics of the two methodologies give very similar energy results, but PHPP uses more precise data which can reduce the performance gap.

At the time of writing the UK Government is consulting upon a replacement for SAP. This is currently referred to as the Home Energy Model (HEM) and is looking to make the calculations more accurate[6]. The core of the model will calculate the energy requirements of a dwelling in a similar fashion to SAP/PHPP: this will then be overlaid with 'wrappers', which will apply further steps in the calculation process to determine metrics associated with meeting the Future Homes Standard. Part of the validation process of this new model is comparing with outputs from the PHPP tool.

6 More detail on the Home Energy Model can be found at: gov.uk/government/consultations/home-energy-model-replacement-for-the-standard-assessment-procedure-sap

The performance gap

The performance gap refers to the disparity between the anticipated energy efficiency and performance of a building as initially predicted during the design and simulation stages, versus the actual energy performance observed during its operational phase [8].

This discrepancy can arise due to factors such as construction quality, occupancy behaviour, system operation, or inaccurate assumptions in modelling. Studies have conducted post-occupancy evaluations and found energy consumption can be many times higher than compliance calculations made during design.

This highlights the need for better alignment between design expectations and real-world outcomes to achieve intended sustainability and efficiency goals.

2.5 Passivhaus certification

The Passivhaus Institut has developed a quality assurance certification process to prevent false claims and abuse of the term 'Passivhaus'. The Passivhaus standard is based purely on building physics and the criteria for certification are performance-based, instead of relating to individual construction or technical details.

For certification to be granted, a building must first undergo modelling in the PHPP where checks are made to ensure the building complies with all criteria. This is the initial check, and if at any point it fails, recommendations are given to assist the designer in achieving compliance. Once an initial review has been done the design then goes through full PHPP verification. This is where designers will refine construction and select products to ensure compliance.

During the construction phase of a Passivhaus project, it is advised that Certified Passivhaus Tradespersons are used who are trained in the principles to ensure the correct implementation of the design[7]. Quality assurance measures are applied throughout construction, such as multiple pressure tests, detailed documentation of the MVHR commissioning, and photographic evidence of the as-built construction elements.

Upon completion, an as-built assessment is carried out and submitted to an independent certifier, who has not been involved in the design of the building[8]. The building is then deemed a Certified Passivhaus.

In addition to certifying complete buildings, the Passivhaus Institut also awards certification to proprietary products and individual components such as windows, wall systems and MVHR units. These products are held on a database making it easier for designers to conduct quick comparisons between products and help with design. The use of certified products is not a necessity; however, penalties may be applied in cases where they are not used. In the case of windows non-certified windows can be used if manufacturers supply data to EN 10077 so that the components worksheet in PHPP can be completed. Certifying products ensures quality and that materials will meet Passivhaus standards.

Figure 3 Passivhaus Certification

7 See passivehouse.com/03_certification/05_certified-tradesperson/05_certified-tradesperson.htm

8 See passivehouse.com/03_certification/02_certification_buildings/03_certifiers/01_accredited/01_accredited.html

Is certification necessary?

Certification is essentially a quality control process that ensures that the building will not only perform as designed but also will last. The PHPP software can be bought for £170 + VAT, and the cost per unit of certification for a Passivhaus is between £1,500 and £2,500[9]. Passivhaus Certifiers, Designers and Tradespersons will incur their own fees for training and registration.

Non-certified materials and systems may be used in Passivhaus designs provided one can provide the necessary parameters in PHPP for the calculation to be accurate.

It is possible to design and build using the fundamental principles of Passivhaus but not achieve the very strict targets required for certification. In situations where efforts have been made to achieve the Passivhaus standard, but they haven't quite achieved it, it is possible to seek the Passivhaus Institut Low Energy Building standard (PHILEB). This is discussed further in Chapter 5.

The importance of commissioning

Because a Passivhaus is exceptionally airtight, it relies heavily on the mechanical ventilation with heat recovery (MVHR) system to provide sufficient ventilation and prevent problems with indoor air quality and moisture. MVHR units are often installed in less accessible areas like the loft and usually operate quietly. Consequently, homeowners might not always know if the MVHR system is inactive, potentially leading to issues of condensation and mould.

It is crucial to conduct thorough commissioning of MVHR units. Additionally, a proper handover procedure post-commissioning is essential to educate homeowners about the system's functioning and correct usage, ensuring effective ventilation and optimal performance.

9 Costs are correct as at November 2023

Chapter 3
The Regulatory Drivers

3.1 Policies in place

3.1.1 England

In 2022 changes were made to Building Regulations parts L, F and O in England and Wales.

- Part L covers the 'Conservation of fuel and power' and new regulations require homes to produce 31% less carbon than what was previously acceptable. New U-Value standards were also brought in.
- Part F 'Ventilation' changes brought in the requirement for improved ventilation. All new dwellings now require air testing and if a dwelling achieves an airtightness rating of less than $5m^3/m^2h$ at 50pa then a continuous mechanical system may be required.
- Part O is a new Building Regulation document entitled 'Overheating'. Part O aims to protect the health and welfare of occupants by reducing the occurrence of high indoor temperatures. This is achieved by limiting unwanted solar gains in summer and providing an adequate means of removing excess heat from the building.

The Future Homes Standard (FHS) is the proposed 2025 energy-related Building Regulations for England[10]. The key purpose of the FHS is to ensure that the homes of the future have significantly lower carbon emissions and emit 75% less carbon than the Regulations set by Part L1A 2013. This is discussed further in section 3.2.

10 The FHS 2025 will only apply to England, with Scotland, Wales and Northern Ireland introducing their own changes.

3.1.2 Wales

The Welsh Government stated in their second carbon budget in 2021 that 'By 2025 all new affordable homes in Wales will be built to net zero carbon, and our ambition is that our net zero standards are adopted by developers of all new homes regardless of tenure by this date' [9]. Furthermore, a draft report states that all newly constructed social housing in Wales must achieve a minimum SAP of 92 (EPC A) and a minimum Environmental Impact Rating (EIR) of 92[11].

3.1.3 Scotland

Sections 6 and 3 of the Scottish Building Standards cover energy performance, overheating, and ventilation in residential and commercial buildings. These were updated in early 2023 and intend that new homes will achieve a 32% reduction in carbon emissions compared to 2015 standards. Section 6 also states a maximum air leakage figure of 7 m^3/m^2h at 50 Pa.

From April 2024 all new building warrants will require buildings to be fitted with heating systems with zero direct emissions; in essence this means dwellings will either be fitted with a heat pump or connected to a heat network.

Scotland has committed to make subordinate legislation by December 2024, to give effect to a 'Passivhaus equivalent' which is discussed further in section 5.1 [10].

3.1.4 Northern Ireland

In June 2022, Northern Ireland implemented an amendment to their 'Part F' building regulations, 'Conservation of Fuel and Power.' Notable provisions within this amendment include a 40% reduction in carbon emissions for new domestic buildings, heightened minimum fabric standards, and an increase in airtightness requirements to $10m^3/m^2h$ at 50 Pa. At the time of writing Northern Ireland's second phase consultation is under way[12].

3.1.5 Overview

Across the United Kingdom, there is a consistent trend towards enhancing building fabric standards, transitioning to electrified space heating systems, and reducing carbon emissions across the built environment. These comprehensive regulatory changes reflect a collective commitment to creating more sustainable, energy-efficient, and environmentally responsible housing.

11 Unless 'measures are not physically practical'

12 More information is available in: Consultation on a review of energy efficiency requirements and related areas of Building Regulations | Department of Finance (finance-ni.gov.uk)

3.2 The Future Homes Hub report

The Future Homes Hub is an organisation created to foster collaboration within and beyond the new homes sector, with the aim of addressing upcoming climate and environmental challenges. Over 100 organisations collaborated to help inform the Government's Future Homes Standard 2025 technical specifications, and as a result, came up with five "Contender Specifications" (CSs) [11]. Each specification was considered on a multitude of different aspects, ranging from affordability to how it could be delivered.

The five different Contender Specifications were formulated to analyse and discuss the different approaches to delivering the FHS. All five have different ways in which to achieve a 75% emissions reduction, each with its advantages and disadvantages. The overarching principle throughout each specification is that natural gas will no longer heat our homes. Instead, the Government expects that electric heat pumps will become the primary heating technology for new homes. Additionally, ventilation will be improved with tightening regulations ensuring that decentralised Mechanical Extract Ventilation units (dMEVs) are installed as a minimum requirement. Airtightness increases across the contender specifications, with CS 4 and 5 reaching a Passivhaus standard.

	Ref2021 Current new build home	CS1	CS2	CS2as	CS3	CS4	CS5
Fabric performance	Part L2021, to meet FEES		Part L2021, to meet FEES	Part L2021, to meet FEES	Similar to Ref2025 draft notional	Very low energy fabric levels	Very low energy fabric levels (absolute metric)
Windows	Double glazing	Double glazing	Double glazing	Double glazing	Double glazing	Triple glazing	Triple glazing
Ventilation strategy	dMEV Air permeability 4.5 – 5.0	dMEV Air permeability 5.0	dMEV[1] Air permeability 4.5 – 5.0	dMEV[1] Air permeability 5.0	MVHR Air permeability 3.0	MVHR Air permeability 1.0	MVHR Air permeability 0.5
Energy systems	Gas boiler (Combi, or with DHW tank for larger homes) [2]	ASHP[2] DHW tank	ASHP[2] DHW tank, WWHR		ASHP[2] DHW tank, WWHR	ASHP[2] DHW tank, WWHR	No heating system Integrated MVHR/ EAHP for DHW, WWHR
Renewable generation	PV	None, unless req. for 75% CO_2 reduction	PV + diverter for houses	PV + battery	PV + diverter for houses	PV + diverter for houses	PV
Home appearance	Similar form to Part L 2013 new build homes	Similar form to Ref2021 but typically no PV on roof	Similar form to Ref2021	Similar form to Ref2021, with max number of PV panels on roof	Similar form to Ref2021	Likely reduction in the number of dormer & bay windows; tendency for more efficient forms	Very few dormer & bay windows; much less complex forms
Housholder comfort	Similar to Part L 2013 homes	Similar to Ref2021			More consistent winter internal temperatures No draughts from window trickle vents	Stable winter internal temperatures No draughts from windows or trickle vents Very low external noise	
Healthy indoor environment	No better than the external environment	Similar to Ref2021			Better air quality than external environment		
EPC[3]	90B	84B	95A	92A	97A	99A	99A
CO_2 emissions reduction [4]	32%	78%	92%	74%	95%	98%	103%
Maintenance requirements	Boiler, cylinder – yearly service MEV – periodic cleaning of fans & ducts	Heat pump, cylinder – yearly service MEV – periodic cleaning of fans & ducts		MEV – periodic cleaning of fans & ducts	Heat pump, cylinder/DHW heat pump – yearly service MVHR – periodic cleaning of fans & ducts; 6 monthly filter change (by householder); 5-yearly service (+ circa £80/yr from Ref2021 for service & filters		
Future retrofit needs	Heat pump & hot water tank; Advanced controls for peak energy load shifting	Likely addition of PV; Advanced controls for peak energy load shifting	Advanced controls for peak energy lead shifting	None	Advanced controls for peak energy lead shifting		
Scale up complexity	–	Medium	Medium	Medium	Medium/High	High	High

Figure 4 Each Contender Specification as put forward by the Future Homes Hub

3.3 How Passivhaus could aid the Future Homes Standard

The Future Homes Hub contender specifications, CS4 and 5 are to Passivhaus standards. The Hub did however note that these two specifications have the highest complexity, potentially hindering the scaling up that will be necessary to meet the Government’s goal of 300,000 new homes per year in England.

One of the biggest advantages of adopting Passivhaus as an official UK Building Standard would be that the certification acts as a quality control process, ensuring standards are met and properly regulated. Passivhaus also surpasses the current Government standard for carbon reduction in new homes and accelerates the UK on the path to net zero buildings. As the end goal is to achieve net zero by 2050, Passivhaus seems to be a good solution with the data to back it up.

Passivhaus construction would require a significant upskilling programme in the current workforce, along with better building practices and more knowledge on how to achieve maximum airtightness standards. Passivhaus construction sites could also require the introduction of airtightness ‘champions’ on large sites on a permanent basis to monitor whether all units are meeting the airtightness requirements at each stage of construction. These additional costs would obviously impact house developers. However, with consistent monitoring throughout construction to achieve certification, Passivhaus offers a solution to the performance gap that is prevalent in new homes.

The fabric requirements of the FHS in relation to Passivhaus are discussed further in Chapter 5.

The comfort standard

Passivhaus presents an edge over conventional building design by prioritising occupant comfort. It provides heightened levels of thermal comfort and maintains superior indoor air quality. It has been argued by some practitioners that Passivhaus might thereby contribute to potential savings for the NHS by mitigating health conditions stemming from inadequate air quality and cold or damp homes.

3.4 Embodied carbon

Naturally, with the focus on reducing operational carbon, embodied carbon will represent a larger share of the carbon emissions found within the built environment. Therefore, a suggestion has been made by industry that the Government limit the impact through a new Building Regulation Part Z in England.

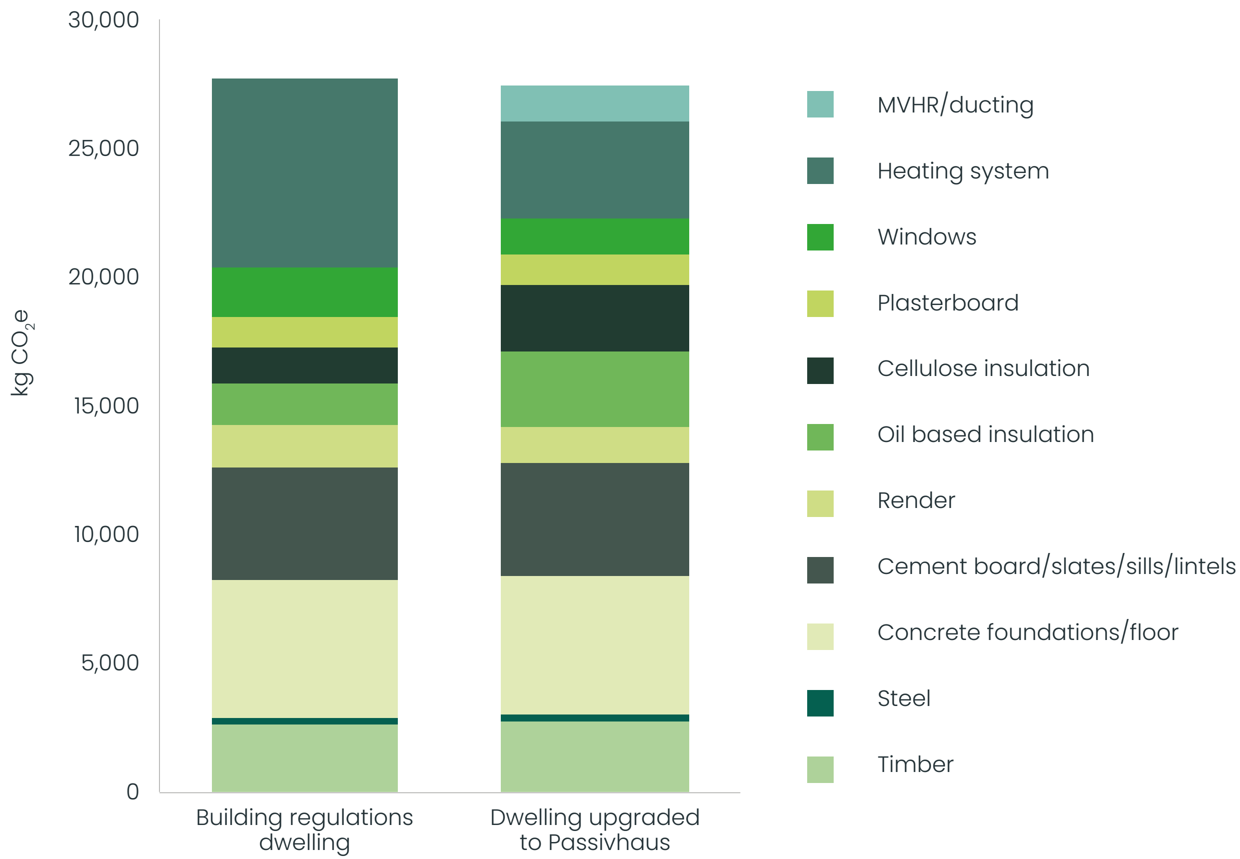

Figure 5 Embodied carbon of a dwelling built to Building regulations and the same dwelling upgraded to Passivhaus standards.

It has often been argued that designing a building to reduce operational carbon increases embodied carbon emissions based on the assumption that additional materials will be required, such as a third pane of glass for triple glazing or thicker walls with additional insulation. Research conducted by the Passivhaus Trust refutes this however, showing that compared to current Building Regulations Passivhaus dwellings have a very similar embodied carbon figure (see Figure 6) [12]. The research also concluded that even if the initial embodied carbon of materials may be higher at the installation stage when conducting whole-life embodied carbon assessments Passivhaus buildings and materials perform better (see Figure 5).

An analysis of the makeup of embodied carbon by materials was conducted by the Passivhaus Trust and showed that much of the embodied carbon comes from the concrete foundations of dwellings. The reduction in embodied carbon in the dwelling upgraded to Passivhaus was attributed to the reduced space heating load meaning that the building required a smaller heat pump and radiators than a non-Passivhaus.

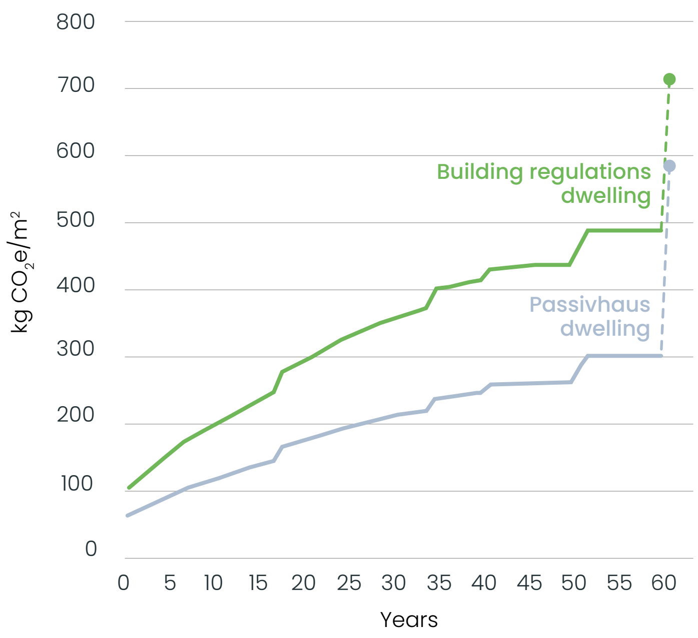

Figure 6 Whole life carbon emissions of a Building regulations dwelling, and the same building upgraded to the Passivhaus Standard.

Chapter 4 Passivhaus en masse

Certified Passivhaus buildings are usually built on a small scale. This is down to multiple factors; the two main ones being cost and education.

- Passivhaus standards are complex to meet and require a large amount of planning and expert advice. This can naturally increase costs.
- There is a lack of education and awareness surrounding Passivhaus as a building standard. Passivhaus is not widely known amongst consumers in the UK, and as a result, it is generally not considered by homeowners when purchasing their homes.

Small-scale developers building to the Passivhaus standard are able to maintain precise control over the development process, ensuring adherence to Passivhaus standards for energy efficiency and airtightness. Their skilled teams guide the project, guaranteeing airtight design integrity, crucial for performance and certification. Small errors during construction are easier to identify and rectify in smaller developments. Discussions with small developers highlighted small errors that can occur during construction such as the inadvertent cutting of airtight membranes when flooring is installed. On a small scale, these errors are easily identified and can be fixed quickly, however on larger scales errors such as this can be harder to identify and more costly to fix.

However, small-scale developers face notable challenges when confronted with rapid and frequent changes in building standards. Their ability to keep pace with evolving regulations is impeded by limited resources and operational scale. Compliance with new standards incurs financial burdens encompassing training expenses, re-education, and the acquisition of newly mandated materials. Additionally, small developers often have well-established product supply chains, with trade discounts accumulated over the years. The introduction of new systems, such as MVHR may necessitate establishing new supply lines from different wholesalers, adding further financial strain.

Overcoming the challenges in the context of small-scale developments necessitates strategic measures, including financial support to mitigate compliance costs, the provision of tailored training programs, and the promotion of industry collaboration to enhance small builders' access to essential resources and expertise. The challenges are somewhat different for larger builders, as follows.

4.1 Passivhaus at scale: navigating challenges and considerations

When contemplating the implementation of Passivhaus standards at a large scale within the housing development sector, several critical factors demand careful consideration. Large-scale housing developers typically operate within extended contracts, spanning multiple years, with contractors and suppliers. As a result, alterations in Building Regulations can significantly impact their ability to fulfil these commitments.

Many large-scale developers were actively engaged in the creation of the Future Home Hub's contender specifications. Discussions with a volume housebuilder revealed concerns regarding the practicality of achieving the stringent air permeability targets found in CS4 and CS5. Among the contender specifications, CS2 garnered the most confidence for large-scale adoption.

Should UK Building Regulations shift to contender specification 4 or 5, the industry would face a demanding transformation in a notably short period, potentially heightening the risk of quality issues and delays. The financial year ending in March 2023 saw the completion of 210,320 dwellings in the UK, with 174,600 in England alone [13]. With the UK Government's ambition to construct 300,000 homes annually in England, the industry may struggle to keep pace with the demands of CS4 or 5.

The transformation would also necessitate a cultural shift in residents' habits to ensure the correct use of these high-performance homes. For example, a malfunctioning MVHR system, unnoticed by residents, could lead to rapid condensation buildup, potentially compromising the property's structural integrity.

Our research also underscored supply chain concerns if CS4 or CS5 were to become UK Building Regulations, requiring the accelerated production of triple glazing and MVHR units from certified suppliers. Traditionally these more specialised materials have been imported, which raises the whole life carbon of the building process. However, in recent years there has been an acceleration in factories in the UK such as Zehnder opening a manufacturing plant in Kent. This should increase the supply in line with demand.

Furthermore, the certification market's capacity would require attention. Presently, there are only eight organisations accredited in the UK as Passivhaus certifiers by the Passivhaus Institut [14]. Scaling up Passivhaus adoption may necessitate a larger pool of certifiers in the UK.

Another issue that emerged from our research is the potential reduction in profitability for volume housebuilders due to the need for plot reconfiguration to meet changes in Building Regulations. Much of the land designated for development has already been acquired, with its value contingent on the expected number of plots. Notably, the introduction of standards like CS3, necessitates an increase in wall thickness, ranging from 50 to 100mm in comparison to the Part L 2021 standard, while CS4 suggests an increase of 80 to 130mm.

Another concern is the use of on-site substitutions where materials are interchanged due to cost or availability constraints. Large developers typically have robust quality control measures that minimise the impact substitutions have on overall build quality. However, smaller-scale developers may face challenges in adapting, potentially jeopardising their ability to attain certification upon project completion.

Moreover, navigating skills shortages and workforce availability is relatively easier for larger developers due to their size and resources. When faced with tight project deadlines, these developers can mobilise workers from other locations or outsource certain parts of projects. In contrast, smaller developers may encounter limitations in their capacity to employ this approach.

Is Passivhaus expensive?

The Passivhaus Trust undertook analysis to ascertain the difference between current Building Regulations and building to a certified Passivhaus standard. In 2015, Passivhaus was reported to incur an increase in build costs of 55%. By 2018 this was down to 8%, and the current figure is said to be just 4%. This is in comparison to current building standards and includes the cost of certification and the additional quality assurance that is required. [15]

The Trust argues that the 4% additional cost is worthwhile since it assures quality and negates the performance gap.

Case Study 1

Agar Grove Estate (The Hill Group)[13]

The Agar Grove Estate is a collaboration between Camden Council and the Hill Group and exemplifies sustainable urban redevelopment. Comprising 507 new homes, 359 of which will adhere to Passivhaus standards, it is set to be the UK's largest Passivhaus regeneration development[14].

Currently, 95 new homes are certified to Passivhaus standards. They include a communal MVHR system which incorporates automated filter replacement alerts to avoid the risk of poor maintenance. The development also addressed overheating, with a 35% window-to-wall ratio in its initial phase.

Key statistics

Air change rate: 0.5 ACH at 50pa.

Heating demand: 13 kWh/m^2.

Figure 7 Agar Grove Estate

13 For more details on the Agar Grove Estate please visit hill.co.uk/partnerships/contracting/agar-grove-estate

14 As at November 2023

Modular construction: A solution?

Modular construction involves constructing buildings or structures in a factory setting using pre-engineered components. The construction process is organised into modules, where each module represents a portion of the final building or structure. These modules are designed, manufactured, and assembled in a controlled factory environment before being transported and assembled at the building site.

Modular construction offers the ability to build quickly, with high levels of quality control. It can promote locally sourced materials and enable easier integration of energy-efficient design principles such as Passivhaus.

Modular construction is not without its challenges. Many modular construction companies have faced financial hurdles in setting up factories. Supply chain issues and regulatory obstacles, especially in the planning phase, can cause delays, with factory space occupied by units waiting to be assembled. The efficiency of modular systems depends on various factors working well together, and when they do not, it can affect the outcomes[15].

15 Further discussion is given in 'Modern methods of construction: building on experience'. NF 88, 2021.

Case study 2

Key statistics

Air change rate: 0.6 ACH at 50pa.

Wall & Floor U-values: 0.11 W/m²K.

Yr Hafan, Ferry Road (Beattie Passive)

In 2020, the City and County of Cardiff Council embarked on an award-winning project aimed at providing energy-efficient homes for homeless individuals in Cardiff. This temporary housing comprises 48 volumetric modular homes, offering 1, 2, and 3-bedroom apartments, along with 4 accessible bungalows. The site also incorporates two support blocks, housing training rooms and offices. Notably, the development of Ferry Road achieved a net-zero carbon rating, aligning with Cardiff Council's commitment to a carbon-neutral city by 2030.

The units achieved a level of airtightness, surpassing 0.6/ACH@50Pa, while walls and floors had U-values of 0.11W/m²K. Furthermore, the inclusion of photovoltaics enabled these units to achieve Passivhaus Plus standards.

Beattie Passive, the manufacturer of the modular homes, fabricated them offsite in their Norwich factory. Lifecycle analysis was carried out by Cercula, an independent analyst firm which reported that in comparison to a traditional masonry construction, the Beattie Passive system would save £17 million over a 60-year lifecycle and help save 5,189 tonnes of carbon. This works out at 78% less whole-life carbon compared to a traditional build.

Figure 8 Yr Hafan Modular Passivhaus. Photograph provided by Beattie Passive

Key Statistics

Air change rate of 0.22 at 50 Pa

Solar panels providing 24 kWp.

PER demand of 35 kWh/(m^{2}a)

Figure 9 Carrstone House

Carrstone House (Eco Design Consultants)

Carrstone House's living spaces are arranged in an open-plan format facing south to use maximum solar gain. The master bedroom and lounge are the most used rooms and so are located to the south maximising the views. A central utility spine separates private and public areas within the house, providing a clear design feature.

The house optimises high levels of natural light, reducing energy usage and improving wellbeing. Solar panels incorporated into the roof will provide enough energy to completely meet the power and heating needs of the home, with excess to run an electric car. This will make the house carbon-neutral and energy-positive. Efficient water fittings, water butts and sustainable drainage solutions will be included to reduce the usage of water.

Carrstone House achieved the Passivhaus Plus standard.

Case study 3

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4.2 Further challenges in scaling up Passivhaus

Culture shift

It seems clear that there is a cultural shift in building practices and in the way, consumers interact with their homes. The tightening of Building Regulations and the fabric of our homes will necessitate a transformation in consumer behaviour, particularly regarding airtightness and how space heating is delivered. To ensure consumer awareness of these impending changes, the use of home user guides could prove invaluable in educating residents on how to use their homes.

Many large housebuilders already offer digital home user guides which can provide new residents with the information needed to troubleshoot issues that may arise within their new home. Some offer after-sales services such as customer care teams to help residents solve any issues. Small developers may need support to provide similar services due to financial constraints. However, ensuring correct knowledge of how we use the homes of the future is vital in ensuring the minimisation of the misuse of such systems and the problems that could occur due to this. As discussed earlier, for example, not understanding the need to change filters on the MVHR system could lead to a system failure which then can lead to a multitude of issues. A further example is the importance of not puncturing the airtight barrier as discussed in section 4.5.

It is crucial that future homes are accessible to everyone. With the growing integration of smart technology in homes, it is essential to consider personal disabilities in the design process to ensure that the homes cater for all segments of the population. Passivhaus, utilising passive heating principles, should theoretically be more user-friendly than homes equipped with certain smart controls (etc) that may confuse some residents.

Moreover, it is important to acknowledge that different generations have distinct habits in utilising their living spaces. Traditionally, opening windows for fresh air and ventilation was the norm. Whilst openable windows are far from forbidden in Passivhaus, education becomes imperative to help users comprehend the intricacies of items such as the MVHR system installed to provide fresh air and ventilation optimally.

Fast-track planning for developments

In the United Kingdom, a perceived barrier to the development of Passivhaus is that they are more expensive and still require you to go through full planning applications. A notable trend within the construction and housing sector involves local authorities and councils providing incentives and expediting the planning process for developments that adhere to Passivhaus standards. These incentives may encompass reduced planning approval timelines, waived or discounted planning fees and additional support during the application process.

This approach would align with broader Government initiatives aimed at promoting energy efficiency, reducing carbon emissions, and improving the sustainability of buildings. Encouraging and facilitating Passivhaus developments enables local authorities to align construction practices with environmental goals. This not only enhances the reputation of the local authority as environmentally conscious but also encourages developers and architects to prioritise Passivhaus principles in their projects. It also provides councils with a key solution to fuel poverty within the social housing sector.

Examples of local authorities making it easier for Passivhaus

London Borough of Camden

Streamlined the planning process and provided financial incentives for projects aiming to meet high sustainability standards including Passivhaus. Notably helped to fund the construction of Agar Grove, the largest Passivhaus development in the United Kingdom to date.

London Borough of Sutton

Sutton has a 'Sustainable design and construction' supplementary planning document that encourages developments to meet high sustainability standards, including Passivhaus, by providing guidance and support during the planning process. Sutton most notably encouraged the construction of 'BEDZED' which comprises of 82 homes completed in 2002 with the aim of self-sufficiency and net zero energy.

Midlothian Council

Midlothian Council are currently considering an intent to set Passivhaus standards for all new council buildings, moving on to Passivhaus Plus and then Passivhaus Premium. The original intent was to streamline the planning process and provide user-friendly checklist tools to be adopted by all designers and architects delivering council projects. At the time of writing the policy is on hold pending consideration of the additional cost.

Hereford Council

Hereford Council set out a progressive plan in 2021 titled the 'Herefordshire Future Homes' policy. This aims to have all newly built council homes certified to Passivhaus Plus standard with predicted total energy use of less than 45 kWh/m^2y.

4.3 Consumer experience

Traditionally the energy performance of a home has not featured highly in the factors a consumer considers when purchasing a dwelling. Research conducted by NatWest showed that in 2021 only 29% of prospective homebuyers considered an EPC rating a 'very important' factor when selecting a property, although their latest figures show this increased to 40% in 2023 [16]. Factors such as location and interior design are still the most important.

Volatility in fuel prices has put more onus on the efficiency of homes and consumers are more aware than ever before about the efficiency of their homes[16], however until it becomes higher on homebuyers' needs developers will continue to focus on the issues at the top of these lists.

Price significantly influences homebuyers, and the 4%-19% higher construction costs of Passivhaus relative to current Part L usually leads to increased purchase prices. Conversations with the Passivhaus Trust revealed a 5-15% uplift in the valuation of certified properties, suggesting that consumers (albeit environmentally committed ones) are willing to pay more for certified homes, covering the additional construction costs. [17]

In summary, the key benefits to residents of certified Passivhaus are as follows:

- energy efficient homes with cheaper running costs
- enhanced comfort
- enhanced indoor air quality
  - high-quality construction assured
  - future-proof design.

16 Conflict in Ukraine has caused fuel prices to increase rapidly across Europe since 2022

4.4 EnerPHit- how does it PHit in?

The Passivhaus standard is primarily focused on new homes. However, it's important to note that a significant number of the UK's homes were built before 1900, with a peak in construction occurring between 1930 and 1982. Therefore, retrofitting existing buildings will be vital if the net-zero goal is to be met overall.

EnerPHit is a Passivhaus certification that is specifically aimed at retrofitting or renovating existing buildings. EnerPhit follows the core principles of Passivhaus, however has slightly relaxed targets to gain certification. It also varies the heating demand based on the location of the property; for example, the majority of the UK is categorised as being in the 'cool temperate' region, which means that its maximum allowed heating demand is 25 kWh/m^2yr.

The main differences between Passivhaus and EnerPHit are the relaxing of maximum space heating demand, primary energy demand, primary energy renewable and airtightness.

	Passivhaus criteria	ENERPHIT criteria
Maximum space heating demand [kWh/m^2yr]	15	20/25/30[17]
Maximum primary energy demand [kWh/m^2yr]	135	120 plus space heating demand
Maximum primary energy renewable	60	65.5/71[18]
Maximum airtightness pressurisation test result ACH@50Pa	0.6	1.0

Table 2 Criteria of ENERPHIT

Figure 10 EnerPHit Certification

17 Depending on climate zone within the UK: 'Warm' is 20, 'Cool' is 25 and 'Cold' is 30.

18 Depending on climate zone within the UK: 'Warm' is 65.5, 'Cool' is 71.

4.5 Repairability of Passivhaus

In addition to the construction challenges, implementation of Passivhaus at scale would necessitate a robust industry capable of addressing specific post-occupancy defects. For example, a resident hanging a new painting in their living room could lead to the puncturing of the airtight membrane which encapsulates the house, therefore compromising the performance. Repairing these instances of damage would require professionals to be able to identify the damaged areas and reapply airtight membranes or seal the points of damage. The same would apply when window frames are being replaced, where airtight taping would have to be reapplied.

Consideration might be given to re-testing the airtightness of the home after such repairs are carried out, however, this would incur increased costs.

Repairability could be enhanced if designers were to have the issue at the forefront of their minds when making design decisions. For example, designers using panelised construction could incorporate service voids into the wall construction which would allow easier access at times of repair.

Educating residents will play a part in avoiding other serious issues that could arise. For example, MVHR units require periodic cleaning every 6 months to change the filters and it is recommended they are serviced every 5 years. Ensuring a ready supply of engineers to maintain these units will be crucial in the implementation of Passivhaus at scale.

Chapter 5 'Passivhaus lite'

(Passivhaus equivalent / Passivhaus principles)

5.1 Passivhaus equivalent/principles

Inevitably, an equivalent to Passivhaus would need to adhere to the core principles of Passive design. Airtight membranes surrounding the fabric would need to be incorporated into the design, however, to address concerns relating to the practicality of achieving Passivhaus air permeability standards, the standard could be relaxed. The use of the airtightness criteria for the Passivhaus Institut Low Energy Building Standard (PHILEB) for example could be a guideline.

The PHILEB standard is a performance level standard which was introduced as a fallback recognition for constructions that did not quite comply with full Passivhaus requirements. This is not intended as a "target" in itself but could be a stopgap to provide a longer transitional period for builders to become more accustomed to the challenges of Passivhaus.

	Passivhaus criteria	PHILEB criteria
Maximum airtightness pressurisation test result ACH@50Pa	0.6	1.0
Maximum heating demand [kWh/(m^{2}yr)]	15	30
Maximum PER Demand [kWh/(m^{2}yr)]	60	75

Table 3 Criteria of the PHILEB

	Part L Regulations (2021)
Wall U-value	0.19
Roof U-value	0.11
Floor U-value	0.15

Table 4 2021 Part L regulations: indicative U-values

Any Passivhaus equivalent would need to meet U-value standards comparable to those outlined in Passivhaus guidelines. Typically, Passivhaus requires U-values ranging from 0.10 to 0.15 for roofs, walls, and floors. The existing Part L Building Regulations, as indicated in Table 4, closely align with these standards, except for walls, where meeting these standards might demand wider cavities to achieve the necessary lower U-values.

5.2 Scotland's proposals

In January 2023, the Scottish Government unveiled its intentions to tighten up the standards for newly constructed residential buildings. Scotland intends to have zero carbon emitting households and that 'Every building must be designed and constructed in such a way that the means by which space within the building is heated or cooled and by which hot water is made available in the building is not by means of a direct emission heating system'. The Scottish Government has also confirmed that they will make legislation by December 2024 to deliver "a Scottish equivalent to the Passivhaus standard" [18].

In a consultation report conducted for the proposed new Building Standards, 90% of respondents were supportive of the proposals to head towards Passivhaus [17]. However, concerns were raised on several issues such as the availability of qualified human resource available to implement Passivhaus, and the additional costs incurred due to Passivhaus adoption.

There was strong support for a 'Scottish equivalent to Passivhaus rather than Passivhaus itself'. Working groups are currently underway to formulate the details of these standards, and while Passivhaus certification is unlikely to be mandatory, a 'deemed to comply' option may be present within the new Scottish Building Regulations.

5.3 Are England, Northern Ireland and Wales going far enough?

The question of whether the rest of the UK is making sufficient progress in its Building Regulations is a complex one; some would suggest that even the Scottish approach isn't going far enough and only full PHPP certification is the answer. While there have been efforts to advance energy efficiency standards and align construction practices with environmental goals, more can clearly be done.

In the early 2000s energy standards evolved rapidly, and in 2006 the Government challenged industry to deliver zero carbon homes by 2016. However changing Government policies removed this target, and the pace of change in all four countries stalled. A requirement for airtightness testing was introduced into regulations for the first time in 2006 with industry needing to perform as-built testing; in June 2009 the NHBC Foundation published 'A practical guide to building airtight dwellings' [19], helping the industry understand how to build airtight homes. Initial progress was rapid, however overlaying requirements for ventilation has led to developers being cautious of building overly airtight dwellings.

The Future Homes Standard consultation published in December 2023 showed a very close resemblance to the fabric standards in the 2021 uplift to the Building Regulations with no clear improvements. The consultation states that the only 'cost-effective and practical improvement' was an improvement in airtightness which it states is matched by changes to Approved Document F, Volume 1: Dwellings. The assessment was that increasing fabric standards further offered no significant benefits and that they become less cost-effective in reducing carbon emissions as the grid decarbonises and shifts to electric forms of heating. The consultation therefore states that the transitioning of heat sources to efficient heat pumps and the integration of solar PV panels offer a much more cost-effective strategy for reducing carbon emissions.

It is likely that Wales and Northern Ireland will adopt a similar approach and align with the Future Homes Standard. The Welsh Development Quality Requirements set energy performance standards beyond regulations for social housing development. These include U-values akin to Passivhaus and a requirement for non-fossil fuel heating, but don't consider further reductions in air leakage nor a move to MVHR.

Considering the challenges faced by small-scale and large-scale developers, such as the impact of changes in building regulations and the potential consequences of on-site substitutions, it becomes clear that more support is needed.

Small developers, in particular, may require assistance in adapting to rapidly evolving standards, ensuring that construction meets these new requirements. The introduction of transitional arrangements, user guides, and targeted training programs could enhance their ability to achieve compliance and reduce the risk of costly errors.

For Passivhaus to have a high rate of voluntary adoption in the UK, developers need to feel incentivised to do so. The development of the Home Energy Model provides the opportunity to provide wrappers for different use cases. One of these could be a Passivhaus wrapper which would allow developers to undertake a concurrent assessment against building regulations and the Passivhaus standard, and avoid duplication of effort in certification of the building.

Some local authorities are already indicating a clear trajectory of providing financial or logistical aids to developers building to lower energy standards as discussed in section 4.2. These changes could boost Passivhaus developments in the years to come. There is also an unintended consequence: where Government regulation is not seen to go far enough, local planners may go further than the national standards, but at the time of writing a written ministerial statement [20] has an expectation that planners no longer set energy efficiency standards that go beyond current or planned regulations.

Chapter 6 Conclusions

A decade after the NHBC Foundation's previous report, the progress of Passivhaus development in the UK has been rather slow, with still only 2,900 fully certified buildings constructed in the UK (compared to 165 in 2013). Despite this, there's been a notable shift in how Building Regulations incorporate key Passivhaus principles to enhance existing standards.

Housebuilders are understandably cautious about the associated risks of adopting the Passivhaus approach, and there is a realisation that consumers might not be entirely ready for the lifestyle changes required to fully embrace Passivhaus standards.

If the long-term adoption of Passivhaus is to be used as a solution for the UK's growing demand for energy-efficient buildings and to aid the country in achieving its net-zero emissions goals, there is a clear need for increased education and funding. Passivhaus must also be seen as more than a building standard; it is also a premium comfort standard, offering not only environmental advantages but also significant societal benefits, including reduced utility bills and enhanced indoor air quality.

The UK building industry must adopt a cultural shift during the transition to net zero homes. The homes of the future will need to be more airtight and include new ventilation methods to accommodate this. It will be vital for developers and homeowners alike to be educated on the impending changes. Whether or not Passivhaus is inevitable, what is inevitable is that in order to ultimately reach net zero, UK homes will have to be constructed considerably closer to the Passivhaus principles than they are today in order to ensure dwellings of the future are built as designed, have low energy demand and provide a high quality living environment.

References

1 "The Climate Change Act 2008 (2050 Target Amendment) Order 2019".

2 "Decarbonising UK real estate report," RICS, 7th November 2022.

3 Passivhaus Trust, "Project Gallery," February 2024. **Click here**. [Accessed May 2024].

4 Passivhaus Trust, "Project Gallery," February 2024. **Click here**. [Accessed May 2024].

5 NHBC Foundation, "NF47: Lessons from Germany's Passivhaus experience," 2012.

6 Passive House Institute, "Criteria for Buildings Version 10c," Passive House Institute, Darmstadt, 2023.

7 Passivhaus Trust, Members directory. **Click here**. [Accessed May 2024].

8 NHBC Foundation, "NF41: Low and zero carbon homes: understanding the performance challenge," 2012.

9 Welsh Government, "Net Zero Wales Carbon Budget 2 (2021-2025)," 2021.

10 Scottish Government, "Building standards technical handbook 2022: domestic," 2022.

11 Future Homes Hub, "Ready for Zero: Evidence to inform the 2025 Future Homes Standard - Task Group Report.," 2023. **Click here**.

12 Passivhaus Trust, "Passivhaus and embodied carbon," 2022.

13 O. f. N. S. (ONS), "House building data, UK: January to March 2023," ONS website, 7 September 2023.

14 Passive House Institute, "Passive House certifier for buildings," **Click here**. [Accessed May 2024].

15 Passivhaus Trust, "Passivhaus Construction Costs," Passivhaus Trust, London, 2019.

16 Natwest, Consumer attitudes towards greener homes. **Click here**.

17 J. Bootland, Interviewee, Discussion regaring Passivhaus in the UK. [Interview]. 19 September 2023.

18 P. Harvie, "Written statement from Patrick Harvie under Rule 9.14.13," 2022. **Click here**.[Accessed May 2024].

19 NHBC Foundation, "NF16: A practical guide to building airtight dwellings," 2009.

20 B. Penn, "Written ministerial statement - Planning - Local Energy Efficiency Standards Update," 13 December 2023. **Click here**.

21 Environmental Audit Committee, "Building to net zero: costing carbon in construction," UK Parliament, London, 2022.

22 A. R. MSP, "Proposed Domestic Building Environmental," 2022.

23 Passive House Institute, "Become an accredited Passive House Certifier for Buildings," **Click here**. [Accessed May 2024].

24 Welsh Government, "Net Zero Strategic Plan," 2022.

25 NHBC Foundation, "NF77: Windows - making it clear," 2017.

The NHBC Foundation Expert Panel

The NHBC Foundation’s research programme is guided by the following panel of senior representatives from the industry:

Rt. Hon. Gavin Barwell
Chairman of the NHBC Foundation and Expert Panel

Tony Battle
Former Joint MD of Kind & Co

Jane Briginshaw
Director
Design England

Andrew Burke
Deputy Secretary
National Housing Maintenance Forum

Richard Cook
Group Director of Development
Clarion Housing Group

Hywel Davies
Independent Building Safety and Performance Adviser

Andrew Day
Sustainability Director
The Hill Group

Stuart Fairlie
Technical & Operations Director
Elmhurst Energy Services Ltd

Jemma Ison
Sustainability Manager
The Keystone Group

Monica Mateo-Garcia
Senior Lecturer in Sustainable Built Environment
Birmingham City University

Robin Nicholson CBE
Fellow
Cullinan Studio

Greg Roberts
Design Director
Croudace Homes

Gwyn Roberts
Energy Team Lead
BRE

Jules Robinson
Falls Engagement Lead
RoSPA

Rachel Smalley
Head of Inclusive Design
Jacobs

Karl Whiteman
Divisional Managing Director
Berkeley Homes (E. Thames)

Rhodri Williams
Technical & Sustainability Director
HBF

Diane Marshall
Operations Director
NHBC

Richard Smith
Head of Standards, Innovation & Research
NHBC

Steve Wood
Chief Executive
NHBC

NF95

NHBC Foundation
NHBC House, Davy Avenue, Knowlhill, Milton Keynes, MK5 8FP
Tel: **0344 633 1000** Email: **nhbcfoundation@nhbc.co.uk**
Web: **nhbc.co.uk/foundation**

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