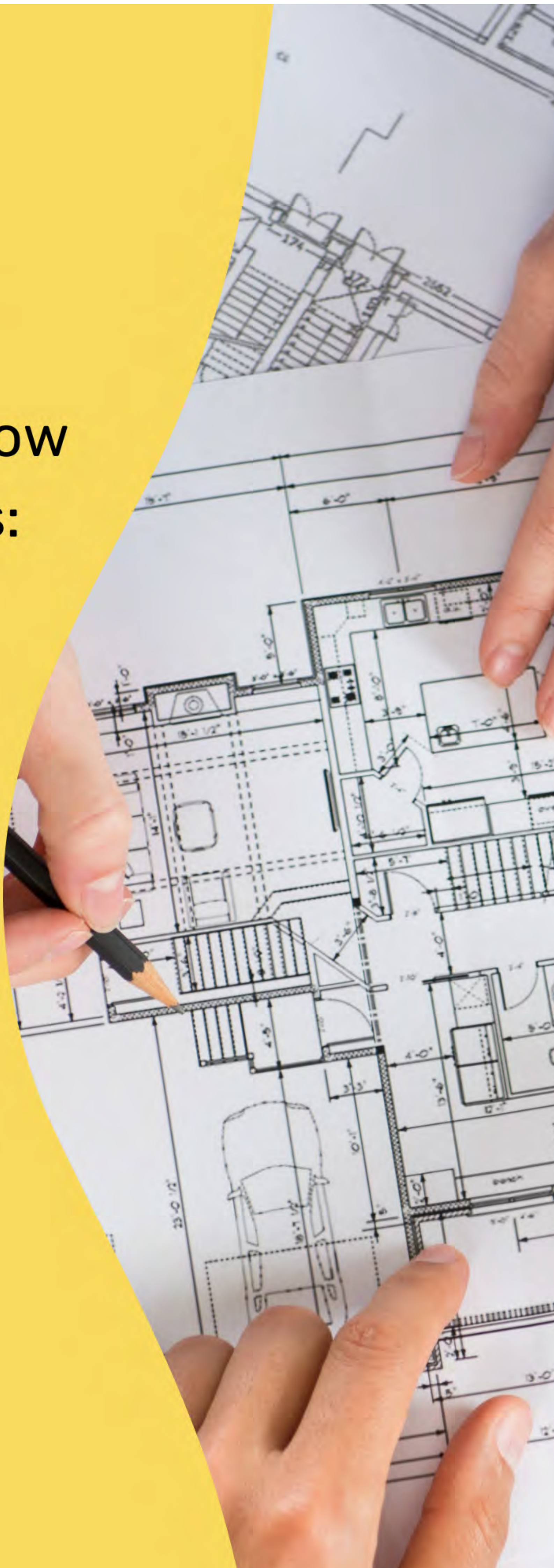
Research project: WI 1

Delivering very low energy buildings:

Energy Standards Report and Literature Review



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June 2023

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Acronyms

AECB – Association for Environment Conscious Builders

BPE – Building Performance Evaluation

BPIE – Buildings Performance Institute Europe

CABE – the Chartered Association of Building Engineers (CABE)

CEC – City of Edinburgh Council

CIAT – the Chartered Institute of Architectural Technologists

dMEV – decentralised Mechanical Extract Ventilation

EPBD – Energy Performance of Buildings Directive

EPC – Energy Performance Certificate

IAQ – Indoor Air Quality

FMB – Federation of Master Builders

HfS – Homes for Scotland

LTRS – Long-term Renovation Strategies

MEPS – Minimum Energy Performance Standards

MEV – Mechanical Extract Ventilation

MMC – Modern Methods of Construction

MVHR – Mechanical Ventilation with Heat Recovery

NECP - National Energy and Climate Plans

nZEB – nearly Zero Emissions Buildings

NZPB – Net Zero Public Buildings Standard

PER – Renewable Primary Energy Demand (according to PHI method): equivalent to the total energy to be used for all domestic applications (heating, hot water and domestic electricity).

PHI – Passivhaus Institut

PHPP – Passivhaus Planning Package

POE – Post Occupancy Evaluation

RIAS – the Royal Incorporation of Architects in Scotland

SAP – Standard Assessment Procedure

SBEM - Simplified Building Energy Model

SBF – Scottish Building Federation

SFT – Scottish Futures Trust

SPF – Scottish Property Federation

Executive Summary

EXECUTIVE SUMMARY

Built Environment Smarter Transformation (BE-ST), working collaboratively with the University of Strathclyde were commissioned to undertake research into energy standards to establish current and best practice, industry views on the route to net zero, and to identify challenges and opportunities along the way.

Background

Following consultation on proposals for a 2024 New Build Heat Standard[1], proposed changes to energy standards within building regulations from 2022, and publication of the Heat in Buildings Strategy[2] (covering the existing building stock), Scottish Government is engaging with the construction industry on a range of issues around delivery of a net zero emissions (entire) building stock by 2045.

The work acknowledges, that recent discussions on the proposed introduction of a Bill to introduce new minimum environmental design standards for all new-build housing with a view to meeting the Passivhaus standard or a Scottish equivalent, by Alex Rowley MSP, (the Proposed Domestic Building Environmental Standards (Scotland) Bill[3]), and a call for all new homes to be built to Passivhaus standards by Scotland's Climate Assembly, have prompted research exploring the most appropriate direction of travel and the feasibility of achieving Passivhaus (or a similar/ equivalent standard) within the regulatory framework. In addition, subsequent to the work being commissioned, in December 2022, the Scottish Government committed to passing legislation to deliver 'a Scottish Equivalent' to the leading international Passivhaus design standard by the end of 2024 [4].

Research Introduction

This research complements work already underway on similarly themed topics relating to construction quality, skills, implementation capacity and the wider drivers for a green economy; interaction with existing industry initiatives supporting a green recovery, including the proposed Construction Accord and the Construction Quality Assurance Initiative and awareness of the benefits from wider (UK) engagement on thematic work such as the Future Homes Delivery Hub. It builds on the Heat in Buildings Strategy, The Energy Efficiency Strategy, the 2024 New Build Heat Standard, the 2021 consultation on Section 6 of the Building Standards and ongoing work on building regulations compliance and Indoor Air Quality (IAQ).

Beyond the previously published policy work in the Programme for Government 2021-22 supporting the pathway to net zero by 2045 and as outlined above, a key aspect to be considered was the impact of the agreement between the Scottish Government and Scottish Green Party, and in particular the intent of 'explicit support

[1] https://consult.gov.scot/energy-and-climate-change-directorate/new-build-heat-standard-part-two/

[2] https://www.gov.scot/publications/heat-in-buildings-strategy-2022-update/#:~:text=This%20means%20that%20reducing%20emissions,work%20to%20tackle%20fuel%20poverty.

[3] https://www.parliament.scot/bills-and-laws/proposals-for-bills/proposed-domestic-building-environmental-standards-scotland-bill

[4] https://www.parliament.scot/-/media/files/legislation/proposed-members-bills/written-statement-from-patrick-harvie-under-rule-91413.pdf

for Passivhaus and equivalent standards' with laying of amended regulations by the end of 2024.

Considerations

In addition to the commitment from within Scottish Government on moving towards a Passivhaus standard or equivalent, the study takes into consideration wider commitments, such as the focus on a green recovery, just transitioning to net zero, a fabric first approach, and ongoing research into EPC reform for new and existing buildings. The work acknowledges the fact that flexibility in the regulations in recent times may have, to an extent, slowed progress by allowing technological trade-offs rather than improving energy efficiency.

This report explores the pros and cons of adopting a Passivhaus approach within the Scottish Energy Standards. One of the most significant challenges in reaching net zero emissions from buildings and energy systems will be the need to demonstrate and achieve compliance with any approach the Scottish Government moves forward with. While compliance is the responsibility of the applicant/ owner/ developer, verification is the responsibility of the local authority/ verifier. However, in order to demonstrate compliance, targets and systems against which to measure need to be in place or be developed and implemented. Either way this will impact the workload of building control staff in local authorities.

Workshop participation events

Focusing on issues that are within the remit of Building Standards, initial industry engagement comprised two focussed online workshops to establish a baseline. The aim was to collate evidence from industry to support Building Standards in developing a realistic, staged approach to improve the energy efficiency of new and existing buildings in line with Scotland's net zero ambitions. The objective was to establish industry readiness to deliver impactful low energy buildings focusing on fabric energy efficiency and wider low carbon building standards, (Appendix A). Following Workshop 1 a second workshop was held to map industry needs in respect of knowledge exchange, collaboration, mainstreaming best practice, funding mechanisms and procurement models. A third workshop was undertaken with Passivhaus experts, focused on what it would take to deliver a standard approaching Passivhaus within Scottish Building Standards (Appendix B). BE-ST hosted a Low Carbon Construction event, where University of Strathclyde, Passivhaus Trust, Morrison Construction and ECD Architect's presented learnings from low carbon construction, the event was attended by over 70 stakeholders.

Workshop observations

Some of the workshop participants (especially those who already advocate a Passivhaus approach) were of the view that without certification, there was no point in adopting Passivhaus standards. Others argued that even without certification, moving towards a Passivhaus approach in terms of fabric and energy system standards would be a significant step towards net zero in terms of statement of intent as well as the improved standards. However, there remained concerns that if we fail to impose certification and monitoring, we will not know whether or not the expected performance improvements have been achieved. This risks negatively affecting the final outcome in performance terms. As an alternative, it was suggested that we could go down the route of mandated post construction monitoring and POE but this would also have cost implications. Interestingly, very few of the identified Passivhaus case studies included monitoring or POE as this is not mandated within the Passivhaus approach – perhaps due to the rigour surrounding certification.

In summary, the development of a 'Passivhaus equivalent' standard specifically for Scotland must consider the technical aspects and the implementation throughout all stages of the construction industry and local authorities. This approach will ensure that everyone can keep up with the changes and confidently work towards achieving our net-zero goals.

Although some reservations were raised at the workshops (as outlined in the SWOT analysis on Page 43, and workshop outcomes reports), on the whole, the workshop participants expressed readiness and willingness to do whatever Scottish Government required to meet the Net Zero targets by 2045. The main concern was lack of certainty and understanding of how best to focus their upskilling efforts in order to meet the challenges ahead.

While the research indicates willingness and readiness to take the next step, we do not have a full picture across all authorities and housing providers. Similarly, Scottish Futures Trust has developed a Net Zero Public Buildings Standard (NZPB) but this is also voluntary and again local authorities are beginning to develop their own solutions – e.g. Edinburgh is aiming for Passivhaus Standard in all Schools – but is not insisting on certification. This reinforces a wider concern that no two organisations are doing this in the same way, all of which highlights a need for clear leadership and a single way forward.

Post workshop discussions

Following the workshops, wider discussions were held with the SFT, City of Edinburgh and RIAS who made some useful suggestions in this respect – particularly around roles and responsibilities:

SFT highlighted how through the Edinburgh Home Demonstrator project, using Offsite Manufacturing System demonstrator projects, and working with a number of housing providers and builders, they are exploring how to achieve building regulation compliance and beyond without certification by taking a fabric first, air tightness focussed approach to delivering ultra-low energy homes.

Edinburgh City argue that as Passivhaus/ PHPP is opensource, there is no reason why the Scottish Government/ BSD could not become the certifier as is the case in Mexico, Vancouver and Belgium, if there is concern about use of the private sector. Alternatively, this role could be undertaken by LA Building Control teams. As the standard evolves this could automatically be updated in our standards, with the research aspect of this sitting within the Passivhaus Institute rather than Building Standards.

Although work undertaken by Passivhaus Assessors has to be certified by the institute, CEC take the view that not certifying introduces risk of dilution and lack of clarity. They argue that the true value of PHPP is its prescriptive nature – it 'does what it says on the tin', no ambiguity. They also argue that it addresses comfort and fuel poverty proportionately, through a fabric first approach.

Other advantages of being part of a recognised, existing scheme include access to a wider network of designers and delivery teams that can provide support and access to buildings where challenges had been met and overcome.

The RIAS has a similar view. They see no issue in adopting PHPP, as like SAP and SBEM it meets the requirements of BS ISO EN 13790. Like these it is complicated, but not complex. It is not simulation, like SAP, PHPP is a steady state calculation.

The RIAS has discussed with BSD their view that the Passivhaus Standard comprises 4 building blocks. Three of these effectively already exist in the Scottish system and can be built up. The fourth runs counter to existing legislation. Their views assumed that the use of SAP and SBEM would continue to produce EPCs – whether this would remain the case is a key point in the discussion and arrival at a solution.

As BSD has no influence over the PHPP methodology and how it may develop in future and PHPP does not have the capability to produce EPCs. Thus, adoption of PHPP could be done as a parallel activity. BSD does have the capability to set thresholds of compliance relative to SAP and SBEM outputs and the nature of the calculation methodologies is that it should be possible to identify the key criteria that would deliver equivalence.

While BSD has no influence over the quality assurance environment created by the Passivhaus Institute and the Passivhaus Institute is not subject to audit by BSD, Scottish legislation does allow for the creation and operation of Certification of Design Schemes. The SG Certification of Design (Section 6 – Energy) scheme demonstrates that a precedent already exists for certification scheme that sits alongside Building Standards if required. The existing schemes could be adapted to include Passivhaus certification and already have in place the quality assurance environment required of Approved Certifiers of Design. This might ease the passage of Passivhaus certification.

Regardless of the merits of the design approach, which Passivhaus Certification requires, Passivhaus is adopts a prescriptive approach to design, this runs counter to current Scottish legislation, which is performance based. Adoption of Passivhaus Certification would therefore require, they believe, a change to legislation, rather than simply being adopted into the current Technical Standards. Moreover, Passivhaus Certification, like other guidance, can already be used as the basis for demonstrating compliance, although such projects will still require an SAP or SBEM compliance calculation as well as an EPC on completion.

Routes to adopting a Passivhaus equivalent approach

In summary there are several options available to the Scottish Government should it choose to build-in a Passivhaus approach to the Scottish energy standards.

Passivhaus calculation and certification methods could be built into existing schemes, such as the Certifier of Design.

PHPP does not negate the need for EPCs produced via SAP and SBEM, and so there is no need to create a ned system altogether – there remains an option to run the two approaches in parallel in the first instance – or to build in PHPP as an alternative route to compliance (as already exists).

Perhaps most intriguing is the notion of separating the Scottish Government from setting the standard – leaving this to an external body – with the government retaining responsibility for verification (in discussion with the Passivhaus Institute).

Beyond the scope of this research are legislative, and logistical issues such as garnering industry support. These would be for the Scottish Government to resolve as implementation of some required actions will be immediately or imminently achievable, whereas others would require a complete revision of the system or would need legislation to support delivery.

A clear message from the research discussions was the need for a robust and verifiable approach to quality assurance of design and construction in order to provide assurance that the standards set are achieved in practice.

Case Studies

Information from the case studies (Chapter 4) was gathered via desktop research and stakeholder outreach, in order to identify relevant best practices on energy efficiency standards and technologies. We had no difficulty in finding organisations willing to share their experiences and gathered a significant number of examples.

The analysis of the presented cases highlights:

- The Passivhaus approach requires a whole house ventilation system typically delivered via MVHR. MVHR maintenance and operation are critical to success of Passivhaus targets. If the Scottish Government adopts a Passivhaus approach wholesale – such systems will be automatically built in to new buildings, so there is a need for better understanding of the systems. Particularly in social housing and public non-domestic buildings where users are not involved in system selection, there remain associated concerns about achieving and maintaining high standards of indoor air quality in relation to all building types. It could be argued that an alternative Passivhaus equivalent could exclude whole house ventilation, however, this will potentially have a significant impact on performance.

- The question of whether or not to certify arose a number of times. Passivhaus proponents were generally of the view that if a 'passive house' design is not certified, and if Passivhaus approved components are substituted by 'equal and approved' alternatives this could result in unacceptable sacrifices in environmental and energy performance. Others felt that we should not allow 'perfect' to be the enemy of 'good' and that even an uncertified building to Passivhaus equivalent standards would be a huge step forward for Scottish regulations.

- In terms of adoption, the public sector and some private sector clients, designers and contractors are ready, willing and able to deliver to the standards required for full certification. There are already a number of tier 1 contractors upskilling to meet the challenges, both in terms of site practices and inhouse expertise.

- An overriding message was certainty, Passivhaus is a single clear approach, complex but not overly complicated – this gives contractors clarity and only one new skillset to learn rather than the current approaches which vary from Local Authority to Local Authority.

01.

Introduction: Research Objectives and Methodology

Chapter 1. Introduction

Research Objectives and Methodology

The literature review, combined with the outcomes of three online industry workshops held by BE-ST in conjunction with the University of Strathclyde, supports the development of a strategy to further engage with the construction industry.

The research covers the following:

- A **desktop study** and **literature review** to establish best practice in Scotland and elsewhere to identify existing guidance and good practice used in the design and delivery of new (2015 onward) buildings including potentially transferrable solutions to stumbling blocks.
- A series of themed online workshops held with key delivery partners such as include Homes for Scotland (HfS), Scottish Property Federation, Federation of Master Builders (FMB), Scottish Building Federation, the Royal Incorporation of Architects in Scotland (RIAS), The Chartered Institute of Architectural Technologists (CIAT), the Chartered Association of Building Engineers (CABE), Section 6 certifiers of design and others:
    - An online **workshop** to discuss current good practice, successful case studies illustrating exemplars of current good practices and quality assurance issues.
    - A follow up **workshop** to identify of the issues and experiences faced by professionals in response to the proposed changes to legislation.
    - A follow up (online) **roundtable** including stakeholder roundtables, comprising industry and academic experts in Passivhaus.
    - A seminar outlining lessons learned and sharing information from recent successful delivery of Passivhaus and very low energy building projects.

  This includes soliciting views on how good practice may need to respond to the proposed changes to legislation, the role of regulations, the Heat in Buildings Strategy and the 2024 New Build Heat Standard in delivering very low energy new buildings that meet the Scottish Government's Climate Change targets.
- Building on these initial workshops: **identification of examples of the measures taken to improve the energy performance of new buildings**, exploring 'what good looks like' and seeking to identify innovative ways of minimising risk, and cost to deliver.
- An examination on a sectoral/sub-sector basis – new homes, new commercial, new public sector, specific and more specialised building types. Understand the 'hierarchy of need' – sectors most 'at risk' and those well placed to move forward.

Methodology

The approach taken builds on the research team's combined experience, in-house knowledge and track record relating to the energy and environmental performance of buildings and expertise in industry and wider stakeholder engagement drawing on a wide range of domestic and non-domestic research projects.

The aim is to make best use of existing knowledge and data while building a multi-scale approach to gather additional data necessary for this project.

Work commenced with a cross industry survey to gather information on how professionals view and use the current available guidance and supporting literature in order to establish a clear starting point for broader discussions. In addition, it was hoped that this would allow us to identify key themes and potential sticking points. Following this, a range of methods were employed to identify current and leading-edge practice and wider perceptions regarding the direction of travel as follows:

1. a focused literature review to identify and reference existing guidance and good practice used in the design and delivery of new (2015 onward) buildings;
2. a summary of the state of the art in terms of current initiatives and activities – through desktop literature review and identification of case studies.

The report covers the potential to adopt Passivhaus or equivalent standards in the context of Scotland's energy standards. This includes industry views on implementation options and an interrogation of the benefits of enabling such an approach on a regulatory basis, including:

- recognition of any need to examine action to support very low energy construction on a sectoral/sub-sector basis where appropriate – new homes, new commercial, new public sector, specific and more specialised building types;
- understanding any 'hierarchy of need' – sectors most 'at risk' and those well placed to move forward based upon current perceived levels or risk and action needed or which is already being undertaken;
- objective assessment of the benefits of a Passivhaus – or equivalent approach to the delivery of new buildings, both energy demand reduction and delivered energy reduction and of the viability of delivering similar levels of energy performance at a national level by other means;
- recommendations for industry to mitigate key risks, making reference to potential current sources of information to support alleviation of risk and filling of knowledge gaps;
- unintended consequences of decarbonisation of heating energy; and ideas on associated research stimulus.

02.

Desktop Study and Literature Review

Chapter 2. Desktop Study and Literature Review

Scottish and UK Perspectives

Anticipating changes to Building Regulations and acknowledging a certain direction of travel, a number of local authorities and social housing providers have developed their own standards, but the approach is inconsistent. Some of these follow the Passivhaus[5] approach of setting targets for annual kWh/m^2 rather than defining fabric U-Values. This makes it difficult to make direct comparisons with Section 6 of the Building Standards which places the emphasis on fabric energy performance and airtightness.

Passivhaus now offers a number of options consisting of three classes:

- The **Passivhaus Classic**, which is the traditional Passivhaus
- The **Passivhaus Plus**, in which additional energy is generated, such as from photovoltaics. In the case of single family and buildings with few stories, such buildings produce about as much energy as residents consume, at least in an – admittedly somewhat misleading – annual net-zero energy balance.
- In a **Passivhaus Premium** house, typically far more energy is produced than needed. It is therefore a goal for the particularly ambitious: those who want to go beyond what economic and ecological considerations already propose.

Passivhaus Classic: Space Heating energy ≤15 kWh/m2/annum, and Renewable Primary Energy Demand (PER)[6] 60 kWh/m2/annum.

Passivhaus Plus: Space Heating energy ≤15 kWh/m2/annum, and requires a total Primary Energy demand (PER) reduction from 60 kWh/m2/annum to 45 kWh/m2/annum with an onsite renewable energy contribution of 60 kWh/m2/annum.

Passivhaus Premium: Space Heating energy ≤15 kWh/m2/annum, and requires a total Renewable Primary Energy Demand (PER) reduction from 60 kWh/m2/annum to 30 kWh/m2/annum with an onsite renewable energy contribution of 120 kWh/m2/annum.\

Passivhaus Classic, Plus and Premium all have the option of space heating demand of ≤15 kWh/m2/annum or a peak heat load of ≤10W/m2. As a measure of energy efficiency, Passivhaus offers a choice from two alternative criteria for heating – peak heating load in W/m² or space heating demand in kWh/m².a. By reducing heating and cooling load to a very low level to achieve comfort, simplified building services and very low energy use

Buildings which do not comply with one or more of the Passivhaus criteria may still satisfy the **Passivhaus Institut (PHI) Low Energy Building Standard:** Space Heating energy ≤30 kWh/m2/annum, Renewable Primary Energy Demand (PER) 75

[5] https://www.passivhaustrust.org.uk/what_is_passivhaus.php#

[6] PER, the **Renewable Primary Energy Demand (according to the PHI method),** is the total energy to be used for all domestic applications (heating, hot water and domestic electricity).

kWh/m2/annum. All classes allow for ±15 kWh/m². A deviation from the PER criteria, with compensation through additional generation.

PER is the total energy to be used for all domestic applications (heating, hot water and domestic electricity) plus the energy required to generate, transport and store that energy. On-site renewable energy generation is assessed in terms of m² of building footprint, so multi-storey buildings which have less roof space in relation to internal floor area are not excluded from the Plus and Premium standards.

These criteria are summarized below in Table 1.

	Passivhaus Classic	Passivhaus Plus	Passivhaus Premium	Passivhaus Institut (PHI) Low Energy Building (LEB) Standard
Space Heating or peak heat load'	≤15 $kWh/m^2/yr$ or ≤10W/m2	≤15 $kWh/m^2/yr$ or ≤10W/m2	≤15 $kWh/m^2/yr$ or ≤10W/m2	≤30 $kWh/m^2/yr$ or ≤10W/m2
PER	≤60 $kWh/m^2/yr$	≤45 $kWh/m^2/yr$	≤30 $kWh/m^2/yr$	≤75 $kWh/m^2/yr$
Renewables	N/A	60 $kWh/m^2/yr$	120 $kWh/m^2/yr$	N/A
Infiltration	$0.6m^3/h/m^2$@50 Pa	$0.6m^3/h/m^2$@50 Pa	$0.6m^3/h/m^2$@50 Pa	$1.0m^3/h/m^2$@50 Pa

- Summer overheating Max 10% at > 25°C*
- Surface temperature > 17°C**
- Ventilation > 20m³/hr.person***

*Overheating is limited to no more than 10% of the year at over 25°C for certification. However, best practice is <2% of the year, and additional risk assessments and stress testing to take into account future climate and occupant behaviour are recommended, following the guidance in Avoiding summer overheating (PHT, 2021).

**The surface temperature criterion not only addresses indoor comfort – eliminating the sensation of cold from chilly spots – but also protects the building fabric from the dangers of condensation and mould, with their detrimental impact on occupants' health.

**Passivhaus Trust recommend supply air is set at 30 m³/h.person. The 20 m³/h.person basic criterion is a minimum, but it is not expected to be sufficient for UK homes because of our mild and damp climate.

Table 1.Passivhaus criteria are described in more detail in Appendix C.

AECB

The Association of Environment Conscious Builders (AECB)[7] sets its own standards which make reference to Passivhaus but are less stringent, (AECB standards also include a range of options).

The AECB building standard follows Passivhaus principles and criteria, with a target space heating demand of ≤40 kWh/m^2/annum. While evidence is required to support a certification claim, this is a self-certified scheme which is reliant on the project's energy consultant to provide a formal declaration. This is likely to provide much better-quality assurance than a typical project, but it is not likely to achieve full compliance in all cases as would be expected from an independently assessed scheme.

Calculations in AECB standard are undertaken using the Passivhaus Planning Tool (PHPP). Details are summarised in Table 2 below.

Parameter	Target	Notes
Delivered Heat and Cooling	≤ 40 kWh/m^2/yr	According to the methodology described in the PHPP* handbook.
Primary Energy	Varies kWh/m^2/yr****	As per PHPP for each country
Primary Energy Renewable	≤75 kWh/m^2/yr	As per PHPP for each country
Air Tightness	≤ 1.5 h-1 (≤ 3 h-1)	With MVHR (with MEV) **
Thermal Bridges***	<0.01 W/mK	Calculated if > 0.01 W/mK
Summer Overheating	<10%	<5% recommended

Table 2: Summary of AECB Standard Performance Requirements

* Passivhaus Planning Package.

** it may not be possible to meet the heat demand target without MVHR for some buildings.

*** Standard Passivhaus methodology is used. If no calculation is submitted, then the decision as to whether a detail is thermal bridge free may be queried at the discretion of the AECB.

**** PE demand varies by country according to each nations PE ratio. The Passivhaus Institute reviews and updates the PE ratio at intervals.

In 2020, the Good Homes Alliance[8] undertook a study to look at the performance gap between Passivhaus certified and other standards, based on the proposition that the performance gap for Passivhaus as a certified standard in monitored homes can be reduced to zero, and comparing with theoretical vs monitored results in other dwellings. However, with the declaration of the climate emergency, new regulations coming in and the energy crisis, even data from 2020 will not be accurate.

[7] https://www.aecb.net/wp-content/uploads/2019/09/AECB-Standard-Further-Information.pdf

[8] https://kb.goodhomes.org.uk/wp-content/uploads/2020/09/Building-Standards-Comparison-October-2020-v1.2.pdf

AECB have recently introduced a certification scheme (https://aecb.net/become-an-aecb-carbonlite-standards-certifier/)

Beyond Regulations

Energy Standards and schemes currently adopted or under consideration by clients include:

- Passivhaus/ EnerPHit;
- AECB;
- Future Homes Standard (2025 Regulations in England);
- 'Homes of 2030' (RIBA competition winners);
- The Glasgow Standard;
- Edinburgh's Net Zero Standard for Newbuild Housing;
- Midlothian Council: Net Zero Housing Design Guide;
- Renfrewshire: RenZEB (own standard – close to Passivhaus);
- Perth and Kinross Housing Guide;
- North Ayrshire;
- The Highland Council;
- The LETI Net Zero Operational Carbon Standard;
- Homes of 2030 (RIBA)
- The Future Homes Standard

The descriptions and tables below compare some of the standards being adopted by local authorities with a few of the recognised standards – AECB and Passivhaus.

How is this being delivered?

The next step involved identification of organisations that are already going beyond the regulations, those that were resistant and an analysis of how the additional costs were being addressed.

Who is going beyond the regulations?

Local Authorities:

The following section outlines the approaches taken by a number of local authorities. These vary considerably with regard to what is/ is not included. It is therefore difficult to make direct comparisons. In an attempt to introduce some consistency each is summarised in a table below the description comparing each standard with the current (February 2023) Section 6 (energy) standards within the Scottish building regulations[9]. During consultation on the new standard[10], two options were reviewed, an 'Improved' and an 'Advanced' Standard. The Advanced fabric standard approached Passivhaus fabric efficiency standards and has therefore been included within the comparisons below together with the Passivhaus Classic Standard on the understanding that it signified a proposed/ possible direction of travel. Anything not common to all standards is listed separately below the tables.

Edinburgh

City of Edinburgh Council (CEC): has adopted a standard that is 'towards' Passivhaus for its Future Schools programme[11]. The Council has also announced plans to "carry out a targeted energy efficient retrofit of the Council's operational buildings and commit to its own Net Zero Standard for newbuild housing (developed by Anderson Bell + Christie Architects (ABC)), which approaches but does not achieve full Passivhaus Standard as the default standard for all Council newbuilds across the operational estate". They are adopting a similar standard for retrofit but not achieving EnerPhit.

CEC's energy targets sit in the context of the Scottish Government plan to transition to low or zero carbon sources of heat by 2025. The approach is designed to deliver most benefit to customers, while mitigating capital cost uplift and maintenance implications.

The energy performance specifications briefed below ensure that all dwellings will achieve a percentage improvement that exceeds Building Standards Section 7[12] - Gold Aspect 1 but is not expected to achieve Platinum Aspect 1 in SAP2012. Gold Aspect 1 is not set as a minimum target, the strategy disregards Section 7 targets for a more holistic approach to net zero carbon. This strategy will optimise the building performance, minimise the cost for the occupant and achieve the best value from capital expenditure. The remaining carbon emissions are calculated and then offset.

The offset can be delivered through several routes. CEC are currently developing a Community Carbon approach. This approach will assign quantitative carbon values to urban design measures, looking at carbon offset from a range of measures

[9] https://www.gov.scot/publications/building-standards-technical-handbook-2020-domestic/6-energy/6-0-introduction/
[10] https://www.gov.scot/publications/scottish-building-regulations-proposed-changes-energy-standards-etc-consultation-analysis-report/
[11] https://democracy.edinburgh.gov.uk/documents/s9896/Item%204.1%20 - %20Achieving%20Net%20Zero%20in%20the%20City%20of%20Edinburgh.pdf
[12] https://www.gov.scot/publications/building-standards-2017-domestic/7-sustainability/70-introduction/

throughout the development e.g. sustainable transport, active travel, reduced parking, SUDs, community gardens, local food production, tree planting, etc.

The design approach follows fabric first principles. These principles are supplemented by the provision of renewable heat. On site electricity generation is included to an appropriate level, with the balance calculated to quantify the level of offset required. Orientation should be taken into consideration while adopting efficient dwelling layouts.

Beyond fabric and emissions standards, there is a requirement to consider: communal heating with heat pumps, heat storage in properties, communal PV systems (total kW output sized to match total annual hot water demand of properties served by the communal heating system (taking cognisance of Coefficient of Performance (CoP))), electrical storage (e.g. provision of space and connections to allow future installation of an electrical battery in the common close area that will provide time shifted energy to the communal heat pump system should sufficient surplus electrical energy be generated by the photovoltaic array).

Table 3. below compares the Edinburgh standards with Scottish Section 6 (2023) and the Passivhaus Classic Standard.

Table 3. The Edinburgh standard.

Specification	Scottish 2023	Scottish Adv.	Edinburgh	Passivhaus Classic
Wall U-Value	0.15 W/m²°C	0.13	0.13	Not specified
Roof U-Value	0.09 W/m²°C	0.09	0.10	Not specified
Floor U-Value	0.12 W/m²°C	0.10	0.10	Not specified
Opening U-Value	1.2 W/m²°C	0.8/1.0	0.70 Win/ 1.2Drs	≤ 0.8
Junctions ψ-Value	0.06 W/m°C	0.04	Accredited construction details 2015	Aim thermal bridge free ***
Infiltration	5m³/h/m²@50Pa	3m³/h/m²@50Pa	4m³/h/m²@50Pa	ACH@50Pa
Ventilation	If infiltration <3m³/h/m²@50Pa use MEV/ dMEV	MVHR	dMEV	MVHR – 30m³/person/hr
Lighting*	100% low energy	100% low energy	100% low energy	100% low energy
Total energy space heating	Not specified	Not specified		≤15kWh/m2/yr or ≤10W/m2

* Daylighting covered under Section 7, Aspect 7, Gold

**Passivhaus Institut (PHI) Low Energy Building (LEB) Standard

- Summer overheating Max 10% at > 25°C
- Surface temperature > 17°C
- Ventilation > 20m³/hr.person

*** The critical aim to be thermal bridge free, accounting for any remaining thermal bridges and make sure surface temperatures remain > 17°C.

Sustainable Urban Drainage to be considered.

With regard to selection of materials, the standard refers to the BRE Green Guide[13] to specification and use of local and recycled materials where possible.

[13] https://tools.bregroup.com/greenguide/podpage.jsp?id=2126

Glasgow

Glasgow City Council: has set 'The Glasgow Standard'[14] as a minimum standard for housing in Glasgow funded through the affordable housing supply programme. Passivhaus certification is deemed an acceptable route towards achieving the 'Gold' level within the standard (Option 2). Gold level compliance has been required for new developments from 1 September 2018 onwards. Numerous social housing schemes within Glasgow have achieved Passivhaus certification, including Newfield Square and Cunningham House.

The Standard includes all aspects of design including accessibility, space standards and secure by design in addition to sustainability, renewable energy and setting carbon targets, embodied carbon in materials, but stops short of specifying U-Values beyond those stated in the current Section 6 and Section 7 standards.

The Council considered adopting Section 7, Gold Level, Aspects 1-8 inclusive however, following discussion with representatives from the development sector, it was decided that this was not currently viable in its entirety and raised fundamental issues for the development industry.

In response to this context, and to continue to fulfil our statutory requirement whilst achieving the essential outcome of delivering lower carbon development, the Council has developed alternative options for compliance with the policy at Gold level. A key element of these alternative options has been that they will still achieve the statutory and corporate objectives to lower carbon and increase sustainability but will also reduce the technical and financial viability obstacles currently presented.

A key element of these alternative options has been that they will still achieve the statutory and corporate objectives to lower carbon and increase sustainability, affordably. Nevertheless, it is a mandatory planning requirement (from September 2018) that all new-build developments will meet the three options set out for Glasgow's Sustainability Levels.

Three options are available:

Option 1: Gold Hybrid

Building Standards (Technical Handbook 2017: Domestic), Section 7 Sustainability Gold Level (aspect 1 only), Silver Level (Aspects 2-8 Inclusive).

Option 2: Nearly Zero Emissions

This level is a mix of the Passivhaus (Classic) requirements and the Technical Standard, Domestic, 2017, Section 7 Sustainability Gold Level (aspect 1 only) Silver Level (Aspects 4-8

Option 3: Net – Zero carbon

This level is a mix of the Passivhaus (Classic) requirements and the Technical Standard, Domestic, 2017, Section 7 Sustainability Platinum Level (aspect 1 only) Silver Level (Aspects 2-8 Inclusive).

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[14] Glasgow Standard - https://www.glasgow.gov.uk/CHttpHandler.ashx?id=45371&p=0

In addition: All will be required to include a minimum 20% carbon dioxide emission abatement through the use of low and zero carbon generating technologies, except certified Passivhaus developments which are exempt.

Developers are required to demonstrate compliance with one of the 3 options: Options 1 and 3 will require an Independent Assessor to be appointed for each project while Option 2 will require a Passivhaus Certifier to be appointed for each project, to verify compliance with the requirements that are set out in these options. The costs associated with their appointment will be grant eligible.

Table 4. below compares the Glasgow Standard with Scottish Section 6 (2022) and the Passivhaus Classic Standard.

Table 4. The Glasgow Standard

Specification	Scottish 2022	Scottish Adv.	Glasgow	Passivhaus Classic
Wall U-Value	0.15 W/m²ºC	0.13	(See Note **)	Not specified
Roof U-Value	0.09 W/m²ºC	0.09	(See Note **)	Not specified
Floor U-Value	0.12 W/m²ºC	0.10	(See Note **)	Not specified
Opening U-Value	1.2 W/m²ºC	0.8/1.0	(See Note **)	≤ 0.8
Junctions ψ-Value	0.06 W/mºC	0.04	(See Note **)	Aim thermal bridge free ****
Infiltration	$5m^3/h/m^2$@50Pa	$3m^3/h/m^2$@50Pa	(See Note **)	ACH@50Pa
Ventilation	If infiltration <$3m^3/h/m^2$@50Pa use MEV/ dMEV	MVHR	**Option 1** (See Note **) **Option 2** ≤ 0.6ach/h@ 50Pa (See Note **) **Option 3**	MVHR – $30m^3$/person/hr
Lighting*	100% low energy	100% low energy	100% low energy	100% low energy
Total energy space heating	Not specified	Not specified	**Option 1** $30kWh/m^2/yr$ (Flat/ Maisonette) $40kWh/m^2/yr$ (Hse) **Option 2** Passivhaus Classic <$15kWh/m^2/yr$ **Option 3** DER 100% lower than TER $30kWh/m^2/yr$ (Flat/ Maisonette) $40kWh/m^2/yr$ (Hse)	≤15kWh/m2/yr or ≤10W/m2

* Daylighting covered under Section 7, Aspect 7, Gold

**Passivhaus Institut (PHI) Low Energy Building (LEB) Standard

- Summer overheating Max 10% at > 25°C
- Surface temperature > 17°C
- Ventilation > $20m^3$/hr.person

*** Assume Options 1 and 3 fabric and infiltration to Section 6/7 standards; Option 2 to Passivhaus Standard

Technical Standard, Domestic, 2017, Section 7 Sustainability Platinum Level (aspect 1 only) Silver Level (Aspects 2-8 Inclusive). Option 3 requires at least 5% of the annual demand for water heating to be met by renewables or heat recovery.

All homes to have Quick Start Guides and resource use monitors.

Under the guidance of Standard 6.1, the carbon dioxide emission (Dwelling Emission Rate) is to be 27% lower than the Target Emission Rate set by the 2015 Standards.

The standard will require to be updated now that the 2022 Section 6 Standards have come into force.

**** The critical aim to be thermal bridge free, accounting for any remaining thermal bridges and make sure surface temperatures remain > 17°C.

Midlothian

Midlothian Council: The Council's newly-published (March 2022) Net Zero Housing Design Guide[15] seeks to address operational energy and the performance gap in new build housing projects, aiming for Passivhaus Classic from 2022; Passivhaus Plus from 2024 and Passivhaus Premium from 2028 – aiming for Net Zero by 2030. In all new housing as part of the council's ambitious aspiration to become net zero by 2030. Each level comes with additional requirements related to Section 7 Silver and Gold, plus RICS Whole Life Carbon Assessment, Post Occupancy Evaluation and Circular Economy and more. However, they have ruled out EnerPhit for retrofit. The Council has also set out an ambition to achieve the Passivhaus Classic 'standard' for new council buildings from 2022, with an aim of Passivhaus Plus being adopted in 2024 and Passivhaus Premium in 2028. The design guide is a briefing document for all council new build residential projects and is a reference base.

Table 5 below compares the Midlothian standard with Scottish Section 6 (2022) and the Passivhaus Classic Standard.

Table 5.

Specification	Scottish 2022	Scottish Adv.	Midlothian – Passivhaus Classic	Passivhaus Classic
Wall U-Value	0.15 $W/m^{2o}C$	0.13	@ 0.1	Not specified
Roof U-Value	0.09 $W/m^{2o}C$	0.09	@ 0.1	Not specified
Floor U-Value	0.12 $W/m^{2o}C$	0.10	@ 0.1	Not specified
Opening U-Value	1.2 $W/m^{2o}C$	0.8/1.0	< 0.8	≤ 0.8
Junctions ψ-Value	0.06 $W/m^{o}C$	0.04	Aim thermal bridge free ***	Aim thermal bridge free ***
Infiltration	$5m^3/h/m^2$@50 Pa	$3m^3/h/m^2$@50Pa	ACH@50Pa	ACH@50Pa
Ventilation	If infiltration <$3m^3/h/m^2$@50Pa use MEV/ dMEV	MVHR	MVHR – 30m3/person/hr	MVHR – $30m^3$/person/hr
Lighting*	100% low energy	100% low energy	100% low energy	100% low energy
Total energy space heating	Not Specified	Not Specified	≤15kWh/m2/yr or ≤10W/m2	≤15kWh/m2/yr or ≤10W/m2

** Daylighting covered under Section 7, Aspect 7, Gold*

**Passivhaus Institut (PHI) Low Energy Building (LEB) Standard

- Summer overheating Max 10% at > 25°C
- Surface temperature > 17°C
- Ventilation > $20m^3$/hr.person

*** The critical aim to be thermal bridge free, accounting for any remaining thermal bridges and make sure surface temperatures remain > 17°C.

[15] https://www.smith-scott-mullan.co.uk/2022/03/22/midlothian-council-net-zero-housing-design-guide/

Renfrewshire

Renfrewshire Council: developing their own standard (RenZEB) with John Gilbert Architects (JGA) and University of Strathclyde (UoS).

In 2019 Renfrewshire Council (RC) declared a Climate Emergency and as part of a range of proposals, the Council initiated this project to create a 'zero carbon' social housing model that can be delivered as standard and at scale over the next decade for all social housing within Renfrewshire. This is to be done by identifying best practice and good design principles from across the construction industry and should take account of the following:

- Embodied and operational carbon
- Energy demand and gain
- Health and environment
- Post completion house performance monitoring
- Risk and value management analysis
- Demographics of social housing
- Construction viability
- Capital and operational costs

Recognising that delivering zero carbon homes will need to take into account a wide range of aspects, the brief required that the proposals must also be practical to achieve and cost effective as far as possible. The work has been undertaken by the University of Strathclyde in collaboration with John Gilbert Architects (JGA) and NBM Cost Consultants (NBM).

The Council has already made some steps to move beyond its own 2018 specification but it was decided to use this as a base because it is the last time that compliant tenders were received and so can act as a useful baseline against which to calibrate likely costs for this and subsequent versions.

Thus a '2018' baseline has been established and assessed for operational energy and embodied carbon, along with a range of other considerations. This option is simply to set the scene and establish our own methodology for then assessing the subsequent proposals which have been called '2022', '2025' and '2030' respectively, with '2022' having two options (with either gas boiler or heat pump).

Table 6 below compares the Renfrewshire standard with Scottish Section 6 (2022) and the Passivhaus Classic Standard.

Table 6.

Specification	Scottish 2022	Scottish Adv.	Renfrewshire 2025	Passivhaus Classic
Wall U-Value	0.15 W/m²°C	0.13	0.10	Not specified
Roof U-Value	0.09 W/m²°C	0.09	0.09	Not specified
Floor U-Value	0.12 W/m²°C	0.10	0.09	Not specified
Opening U-Value	1.2 W/m²°C	0.8/1.0	0.80 (PH)	≤0.8
Junctions ψ-Value	0.06 W/m°C	0.04	Thermal bridge free required	Aim thermal bridge free ***
Infiltration	$5m^3/h/m^2$@50 Pa	$3m^3/h/m^2$@50Pa	$1m^3/h/m^2$@50Pa	ACH@50Pa
Ventilation	If infiltration <$3m^3/h/m^2$@50 Pa use MEV/ dMEV	MVHR	MVHR	MVHR – $30m^3$/person/hr
Lighting*	100% low energy	100% low energy	100% low energy	100% low energy
Total energy space heating	Not Specified	Not Specified	<30 kWh/m²/yr	≤15kWh/m2/yr or ≤10W/m2

** Daylighting covered under Section 7, Aspect 7, Gold*

Plus - Under the guidance of Standard 6.1, the carbon dioxide emission (Dwelling Emission Rate) is to be 27% lower than the Target Emission Rate set by the 2015 Standards.

**Passivhaus Institut (PHI) Low Energy Building (LEB) Standard

- Summer overheating Max 10% at > 25°C
- Surface temperature > 17°C
- Ventilation > $20m^3$/hr.person

*** The critical aim to be thermal bridge free, accounting for any remaining thermal bridges and make sure surface temperatures remain > 17°C.

Wider UK Perspective

Future Homes Standard (England): The UK government hosted a public consultation from 1 October 2019 to 7 February 2020 on proposed changes to the Building Regulations for new homes – The Future Homes Standard[16]. The Future Homes Standard will require new build homes to be future-proofed with low carbon heating and world-leading levels of energy efficiency; it will be introduced by 2025.

This was the first stage of a 2-part consultation which proposed an ambitious uplift in the energy efficiency of new homes through changes to Part L (Conservation of fuel and power) of the Building Regulations. The second stage has now been published as the Future Buildings Standard[17].

The Future Homes Standard proposed that:

- From 2025, new homes built to the Future Homes Standard will have carbon dioxide emissions at least 75% lower than those built to current Building Regulations standards (2019).
- Introducing the Future Homes Standard will ensure that the homes this country needs will be fit for the future, better for the environment and affordable for consumers to heat, with low carbon heating and very high fabric standards.
- All homes will be 'zero carbon ready', becoming zero carbon homes over time as the electricity grid decarbonises, without the need for further costly retrofitting work.

New energy efficiency measures through changes to Part L - conservation of fuel and power in the building of new homes - of the Building Regs in England have been implemented since June 2022, and covered the wider impacts of these changes for new homes, including changes to Part F. This uplift is the first step in achieving the Future Homes Standard and should achieve carbon emissions reductions between 30% to 40%.

There are also proposals to mitigate against overheating in new homes, which was been addressed via a new requirement in Part O.

Table 7 overleaf compares the Future Homes standard with the Current Part L and the Passivhaus Classic Standard.

[16] https://www.gov.uk/government/consultations/the-future-homes-standard-changes-to-part-l-and-part-f-of-the-building-regulations-for-new-dwellings
[17] https://www.gov.uk/government/consultations/the-future-buildings-standard

Table 7.

Specification	Current 2013 Part L	Standard 2021 Part L	Standard Indicative Future Homes Standard	Passivhaus Classic
External wall U-value	0.18 W/m^{2o}C	0.18	0.15	Not specified
Roof U-value	0.13 W/m^{2o}C	0.11	0.11	Not specified
Floor U-value	0.13 W/m^{2o}C	0.13	0.11	Not specified
Openings	Win 1.4 W/m^{2o}C Door 1.0 – 1.2	Win 1.2 Door 1.0	Win 0.8 Door 1.0	≤ 0.8
Junctions ψ-Value	0.05 W/m^{o}C	0.05 W/m^{o}C	0.05 W/m^{o}C	Aim thermal bridge free **
Infiltration	5.0 m^3/h/m^2 @ 50Pa	5.0 m^3/h/m^2 @ 50Pa	5.0 m^3/h/m^2 @ 50Pa	ACH@50Pa
Ventilation	Natural (with extract fans)	Natural (with extract fans)	Natural (with extract fans)	MVHR – 30m^3/person/hr
Lighting*	Not specified	TBC	100% low energy	100% low energy
Total energy space heating	Not specified	Not specified	Not specified	≤15kWh/m2/yr or ≤10W/m2
Energy Systems				
Heating	Gas boiler	Gas boiler	Low-carbon heating (e.g. Heat pump)	Not specified
Heating Emitters	Regular radiators	Low temperature heating	Low temperature heating	Not specified
Wastewater heat recovery	No	Yes	No	Not specified
PV	No	Yes – 40% ground floor area	None	Depends on options
On-site carbon target: typical semi-detached home	16.0 kgCO_2/m^2 /yr	11.0	3.6	Depends on options

*Passivhaus Institut (PHI) Low Energy Building (LEB) Standard

- Summer overheating Max 10% at > 25°C
- Surface temperature > 17°C
- Ventilation > 20m^3/hr.person

** The critical aim to be thermal bridge free, accounting for any remaining thermal bridges and make sure surface temperatures remain > 17°C.

LETI Net Zero Standard

The **LETI Net Zero Standard**[18] for residential dwellings sets an **overall delivered energy target of 35 kWh/m²/annum** with a space heating demand limit of **15 kWh/m²/annum.** This means that the standard takes into account the efficiency of delivered energy. Whilst this can be achieved in several ways, the final energy performance is very similar to the Passivhaus Classic standard. There is no formal quality assurance process, it is a voluntary standard and adoptees are encouraged to monitor performance and make this information public.
Table 8 below compares the LETI standard with Scottish Section 6 (2022) and the Passivhaus Classic Standard

Table 8.

Specification	Scottish 2022	Scottish Adv.	LETI	Passivhaus Classic
Wall U-Value	0.15 W/m^2°C	0.13	0.13 – 0.15	Not specified
Roof U-Value	0.09 W/m^2°C	0.09	0.10 – 0.12	Not specified
Floor U-Value	0.12 W/m^2°C	0.10	0.08 – 0.10	Not specified
Opening U-Value	1.2 W/m^2°C	0.8/1.0	0.8 (W)/ 1.0 (D)	≤ 0.8
Junctions ψ-Value	0.06 W/m°C	0.04	0.04	Aim thermal bridge free **
Infiltration	5m^3/h/m^2@50Pa	3m^3/h/m^2@50Pa	<1m^3/h/m^2@50Pa	ACH@50Pa
Ventilation	If infiltration <3m^3/h/m^2@50 Pa use MEV/ dMEV	MVHR	MVHR	MVHR – 30m^3/person/hr
Lighting*	100% low energy	100% low energy	Not specified	100% low energy
Total energy spac heating	Not specified	Not specified	<15kWh/m^2/yr	≤15kWh/m2/yr or ≤10W/m2

*Passivhaus Institut (PHI) Low Energy Building (LEB) Standard

- Summer overheating Max 10% at > 25°C
- Surface temperature > 17°C
- Ventilation > 20m³/hr.person

** The critical aim to be thermal bridge free, accounting for any remaining thermal bridges and make sure surface temperatures remain > 17°C.

Table 9 below shows the most prevalent standards and systems in use in Scotland and the UK collated into a single matrix to allow comparison. This indicates that the Renfrewshire 2025 standard and the Glasgow Nearly Zero Emissions standard are very close to AECB and Passivhaus, and a marginal improvement upon the Scottish Building Standards Advanced level (as consulted on last time around).

[18] https://www.leti.uk/_files/ugd/252d09_c1ae6c7277c7467ebd4810a02423802e.pdf

	Table 9	Element	Wall (W/m^2K)	Roof (W/m^2K)	Floor (W/m^2K)	Openings (W/m^2K)	Party Wall (W/m^2K)	Junctions (W/m^2K)	Infiltration ($m^3/h/m^2$ @ 50Pa)	Ventilation	Passive solar	Lighting ($kWh/m^2/yr$)	Total energy space heating ($kWh/m^2/yr$)
	Passivhaus Clasic		0.1	0.1	0.1	0.8		Thermal bridge free required	0.6	MVHR – 30m3/person/hr	Key design factor	100% low energy	<15 OR <30 (LEB)
	Scottish building regulations - current (2015)	**Newbuild**	0.17	0.11	0.15	1.4	0	0.08	7				
		Back stop (New)	0.22	0.15	0.18	1.6	0.2	n/a	n/a				
		Back stop (Shell)	29	36	20	14	n/a	n/a	n/a				
	Scottish building regulations - 2023	**Newbuild**	0.15	0.09	0.12	1.2		0.06	5	If infiltration <3 - Use of MEV / dMEV		100% low energy	
		Back stop	0.17	0.12	0.15	1.4		n/a	n/a				
		% var	20	33	25	17		n/a	n/a				
	Scottish building regulations - (consultation) Advanced	**Newbuild**	0.13	0.09	0.1	0.8 / 1.0		0.04	3	If infiltration <3 - Use of MEV / dMEV		100% low energy	
		Back stop	0.16	0.11	0.13	1.2		n/a	n/a				
		% var	23	11	30	20		n/a	n/a				
	Edinburgh		0.13	0.1	0.1	0.70 / 1.2		Accredited construction details 2015	4	dMEV		100% low energy	
	Glasgow	**Gold hybrid Option 1**	0.22	0.15	0.18	1.6	0.2	0.01 -1.00	5 - 7			100% low energy	≤ 40 (houses) ≤ 30 (flats / maisonettes)
		Nearly Zero Emissions Option 2	0.1	0.1	0.1	0.8	1.2	0.01 -1.01	0.6			100% low energy	≤ 15
		Net-zero carbon Option 3	0.22	0.15	0.18	1.6	0.2	0.01 -1.00	5 - 7			100% low energy	≤ 40 (houses) ≤ 30 (flats / maisonettes)
	Midlothian		0.1	0.1	0.1	0.8		Thermal bridge free required	0.6	MVHR – 30m3/person/hr	Key design factor	100% low energy	<15 OR <30 (LEB)
	Renfrewshire 2025		0.1	0.09	0.09	0.80 (PH)		Thermal bridge free required	1	MVHR		100% low energy	≤30
	Future Homes	**2025?**	0.15	0.11	0.11	0.8 (W)/ 1.0 (D)		0.05	5	Natural plus Extract		100% low energy	
	LETI		0.13 – 0.15	0.10 – 0.12	0.08 – 0.10	0.8 (W)/ 1.0 (D)		0.04	<1	MVHR			<15
Additional identified	**Perth & Kinross**		0.22	0.15	0.18	1.6	0.2	0.01 -1.00	5 - 7			100% low energy	≤ 40 (houses) ≤ 30 (flats / maisonettes)
	North Ayrshire		0.22	0.15	0.18	1.6	0.2	0.01 -1.00	5 - 7			100% low energy	≤ 40 (houses) ≤ 30 (flats / maisonettes
	The Highland Council		0.22	0.15	0.18	1.6	0.2	0.01 -1.00	5 - 7			100% low energy	≤ 40 (homes) OR ≤ 30 (Maisonettes)
	Part L - England (2021)		0.18	0.11	0.13	1.2 (W) / 1.0 (D)		0.05	5	Natural plus Extract		100% low energy	

Alternative Approaches

Other organisations adopting a similar stance: Public bodies and the social housing sector are not the only organisations going beyond the minimum as a matter of course. Based on the desktop research, feedback from workshop attendees (see Section 7.0), and the case study evidence (see Section 6.0), a number of architects, contractors and developers are also providing a 'beyond regulations' approach as standard supported by a growing number of clients seeking this service. This again demonstrates a range of approaches from a 'very low energy buildings' approach, to AECB, Passivhaus or Passivhaus equivalent standards as standard, to a range of approaches to embedding sustainability (mainly building on the higher standards within Section 7 of the Building Standards). These are outlined in more detail in Appendix D.

There is evidence of a growing demand for higher standards of design, construction, thermal performance and guaranteed outcomes from within local authorities which are demanding higher performance targets, in support of the net zero agenda. This is an approach also being adopted by clients and while these are currently mainly public sector bodies such as social housing providers, the fact that contractors are also developing ready-made solutions to deliver against these demands, indicates that they too are making ready to respond as soon as this is required. In the interim, they have had an opportunity to build skills and develop ideas – e.g., around offsite construction, energy systems, guaranteed airtightness and ventilation for health and wellbeing.

Passivhaus adopts an ultra-low infiltration rate of 0.6$m^3/h/m^2$@50Pa combined with whole house ventilation with heat recovery, whereas most other standards examined opted for infiltration within the range of 4-7$m^3/h/m^2$@50Pa. Most did not specify MVHR/ MEV unless infiltration rates were found to be lower than 3 $m^3/h/m^2$@50Pa.

Those specifying MVHR/ MEV included:

- Scottish 'Advanced' (consultation) standard (Infiltration 3$m^3/h/m^2$@50Pa.),
- Edinburgh (Infiltration 4$m^3/h/m^2$@50Pa.),
- Glasgow Option 2 (Nearly Zero Emissions) standard (Infiltration 0.6$m^3/h/m^2$@50Pa.),
- Midlothian (Infiltration 0.6$m^3/h/m^2$@50Pa.),
- Renfrew (Infiltration 1.0$m^3/h/m^2$@50Pa.), and
- LETI (Infiltration <1.0$m^3/h/m^2$@50Pa.).

Passivhaus also specifies a ventilation rate of 30m^3/person/hour. Of those examined, only Midlothian adopts this principle.

In terms of Primary Energy Renewable at Passivhaus Classic specifies <60kWh/m2/year.

Targets for heating energy use are summarised below:

- Scottish 'Advanced' (consultation) standard no target,
- Edinburgh no target,

- Glasgow Option 1- Gold hybrid - ≤ 40 kWh/m^2/year (houses) ≤ 30 (flats / maisonettes)
- Glasgow Option 2- Nearly Zero Emissions - ≤ 15 kWh/m^2/year (Passivhaus)
- Glasgow Option 3- Net Zero Carbon - ≤ 40 kWh/m^2/year (houses) ≤ 30 (flats / maisonettes)
- Midlothian - ≤ 15 kWh/m^2/year (Passivhaus)
- Renfrew - ≤30 kWh/m^2/year and
- LETI - 15 kWh/m^2/year (Passivhaus)
- Perth and Kinross - ≤ 40 kWh/m^2/year (houses) ≤ 30 (flats / maisonettes).

It is difficult to make direct comparisons between the various approaches to delivering very low energy buildings as not all of the systems and approaches researched record information in the same way. The Scottish and wider UK Building Standards for energy focus on heating energy, using a fabric performance-based approach, backed up by compliance testing. Other, non-mandatory approaches such as AECB and Passivhaus are building energy performance focussed and rely on monitoring in-use to guarantee targets are met. In order to address net zero targets holistically, the EU is targeting all building energy use – not It is just heating – and as such has set targets for renewable energy contribution to wider energy needs.

European Union Perspective

New Buildings
Since 1st January 2021, all new buildings across the EU, whether residential or non-residential, publicly, or privately owned, must be constructed to the national nZEB standard. This standard addresses all energy use and not just that required for heating and cooling. The date for compliance for publicly owned and occupied building was two years earlier 1st January 2019).[19]

This requirement was met in all countries except:

- Bulgaria: Ordinance 7 (2004) is awaiting amendments from the Ministry of Regional Development.

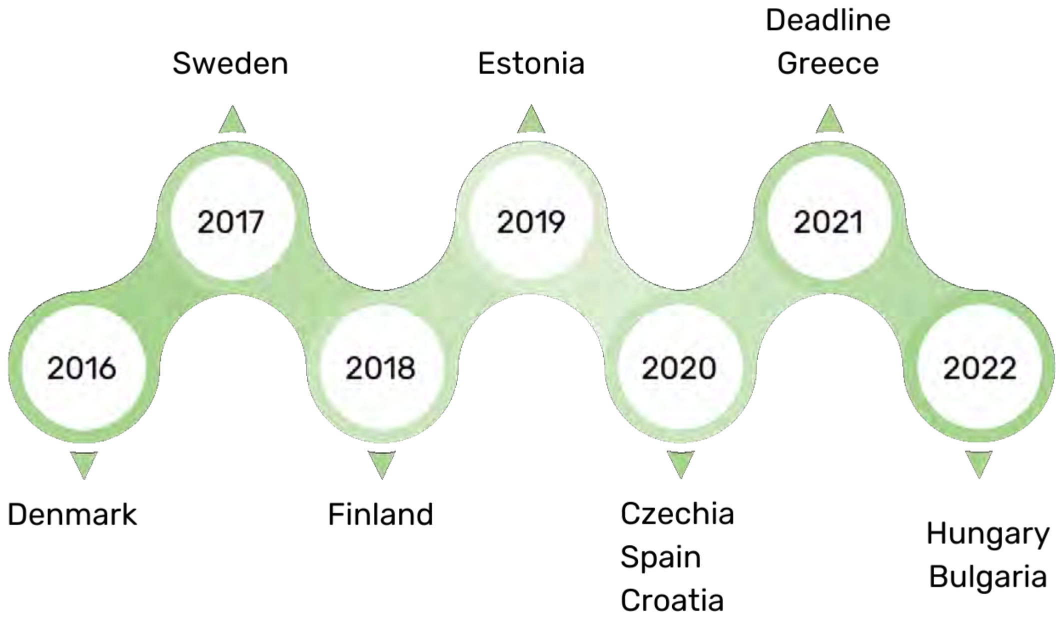
- Greece: The requirement and the entry into force date of 1st January 2021 was introduced in the legislation in February 2013, but an amendment made in May 2020 postponed it to 1st June 2021.

- Hungary: As for public buildings, Hungary postponed the introduction from 1st January 2018 to 30th June 2022.

[19] 'Nearly Zero: A review of EU member state implementation of new build requirements' (2021) - https://www.bpie.eu/wp-content/uploads/2021/06/Nearly-zero_EU-Member-State-Review-062021_Final.pdf.pdf

Member States introducing the requirement before the 2021 deadline include:

- 2016 Denmark
- 2017 Sweden
- 2018 Finland
- 2019 Estonia
- 2020 Czechia, Spain, Croatia



EU countries must also meet a related renewable energy target. Details of progress across the EU are outlined in a table in Appendix E. By 2021 only 8 member states had complied with all 4 of the requirements: Croatia, Denmark, France, Ireland, Lithuania, Netherlands, Romania and Slovenia. The rest failed to meet or at least adequately address at least one of the provisions.

However, all Member States have now defined their nearly zero-emission building (nZEB) requirements, including those which have yet to be formally introduced. To determine how ambitious these requirements are, we considered two main parameters:

• the energy performance of the building, expressed in primary energy consumed and

• the share of energy requirements supplied from renewable sources produced on-site or nearby.

Countries with milder climates are expected to have both the lowest net primary energy requirements (Column B above) and the highest share of renewables (Column E). However, when considering the primary energy requirement of the building irrespective of whether it is supplied from renewable sources or not (i.e., Column D), the range across the 4 climatic zones is much narrower:

• for single family houses, the range is 50-90 kWh/m^2/a

• for offices, the range is 80-100 kWh/m^2/a

Several Member States and one Belgian region do not specify kWh/m^2/a values or ranges for energy performance for new buildings as part of their nZEB requirements. Instead, they are based on minimum performance levels or achievable performance ranges calculated in comparison to reference buildings and considering building typology, U-values, geometry, climatic region, and a range of other factors. This approach is used notably in: Austria, Flanders (Belgium), Germany, Italy, Luxembourg, and Portugal. Given these variations, these Member States and Flanders are excluded from the comparisons shown in Table 11 below[20].

A	B	C	D	E
	Net Primary Energy kWh/m^2/a	**Energy from renewable energy resources** kWh/m^2/a	**Primary energy threshold including renewable sources** kWh/m^2/a	**Renewables as % of total primary energy (based on midpoint)**
SINGLE FAMILY HOMES				
Mediterranean	0 - 15	50	50 - 65	87%
Oceanic	15 - 30	35	50 - 65	61%
Continental	20 - 40	30	50 - 70	50%
Nordic	40 - 65	25	65 - 90	32%
OFFICES				
Mediterranean	20 - 30	60	80 - 90	71%
Oceanic	40 - 55	45	85-100	49%
Continental	40 - 55	45	85-100	49%
Nordic	55 - 70	30	85-100	32%

Table 11: Comparison of EU Member States

Scotland falls into the 'Oceanic' climate region of Europe, (Table 12) which aligns with European energy standards of:

[20] Figure and Text Source: https://www.bpie.eu/wp-content/uploads/2021/06/Nearly-zero_EU-Member-State-Review-062021_Final.pdf.pdf see also page 16 - https://www.bpie.eu/wp-content/uploads/2021/12/BPIE_Assessing-NZEB-ambition-levels-across-the-EU_HD.pdf

	Primary Energy *kWh/m²/annum*	Renewables *kWh/m²/annum*	Primary Energy Threshold Including Renewables *kWh/m²/annum*	% Renewable Energy Contribution (Primary Energy)
Domestic	15 – 30	35	50 – 65	61%
Non-Domestic	40 – 55	45	85 – 100	49%

Table 12.

Long-term renovation strategies (LTRS) for existing buildings

The requirement to produce national renovation strategies was first introduced in 2012 in the EED. It was moved from the EED to the EPBD in 2018 in order to ensure greater alignment with other aspects of the energy performance of buildings.

Each Member State is required to establish a national long-term strategy to support the cost-effective transformation of the national stock of residential and non-residential buildings, both public and private, into a highly energy efficient and decarbonised existing building stock by 2050. [21,22]

Retrofit does not form part of this study, however as the EU strategies for newbuild and retrofit are linked, wider discussion on retrofit and renovation are included as Appendix F.

Standards Summary

The previous section highlights that there is a significant number of local authorities that are not waiting for regulation change. These authorities are mainly (but not exclusively) larger urban authorities and the range of approaches being taken varies from a straightforward improvement on the current fabric-based approach to a combination of Section 6 and Section 7 of the regulations in terms of sustainability to incorporation of other safety, space and accessibility standards to adoption of more stringent standards such as Passivhaus and AECB. From the evidence gathered during the course of the research, there appears to be a growing trend of local authorities going down this route.

This activity demonstrates both appetite for change and a risk of the development of a range of standards across the country which could lead to disruption as and when current mandatory standards are updated. This approach could also lead to contractors and developers being required to respond to a range of approaches across the country, and while the setting of a new minimum regulatory requirement

[21] A GUIDEBOOK TO EUROPEAN BUILDING POLICY (2020) https://www.bpie.eu/wp-content/uploads/2020/08/BPIE_Guide-on-Building-Policy_Final.pdf

[22] ‘Ready for Carbon Neutral by 2050’ (2022) - https://www.bpie.eu/wp-content/uploads/2021/12/BPIE_Assessing-NZEB-ambition-levels-across-the-EU_HD.pdf

would not eliminate this risk altogether, it might dissuade others from going down the route of generating yet more standards.

From Table 7 it can be seen that the current Scottish and English regulations are less stringent than the Passivhaus Classic standard in terms of fabric performance, but the recently consulted on ‘Advanced’ Scottish Standard and the proposed Future Homes Standard for 2025 do approach the Passivhaus standard in terms of fabric. Where they differ significantly is in terms of aspects such as ventilation and infiltration and the specification of targets for total energy use and space heating energy use.

Key points:

- The Scottish, English, Welsh, Northern Irish and EU building regulations are moving towards specifying energy performance-based targets (kWh/m^2/year) in buildings for heating energy demands, rather than setting U-Values and solutions for building elements. However, there is an appetite to achieve/develop a holistic standard that goes beyond operational carbon.
- Based on the research, the most commonly demanded heating target, as set by Scottish local authorities for domestic properties is 30 kWh/m^2/year (flats and maisonettes) / 40 kWh/m^2/year (houses), although lower figures (15 kWh/m^2/year) have been targeted by some and in some circumstances.
- The number of organisations, clients, contractors and housing providers that seek building beyond the current building standards is growing. Demand in the social housing in particular seems to be growing.
- In line with the Passivhaus approach, Europe is also setting primary energy targets (total energy) to deliver nZEB. The Scottish equivalent to this standard would be 50-65 kWh/m^2/year for homes and 85-100 kWh/m^2/year for offices.
- Based on the total energy approach adopted by the EU, and the intention to move to a Passivhaus equivalent standard in order to remain on target to deliver its commitment to net zero carbon emissions by 2045, the Scottish Government should consider defining and setting mandatory total primary energy performance targets, i.e., beyond heating energy consumption.

03.

Workshops

Chapter 3. Workshops

Workshop Introduction

Work commenced with two workshops for invited construction industry experts, policy makers, researchers and delivery bodies to try to establish the current state of play.

The workshops were facilitated by BE-ST to explore the industry's readiness and appetite for change in Scotland. The first two workshops took place during the first quarter of 2022. Engagement included key delivery partners such as include Homes for Scotland, Scottish Property Federation, Federation of Master Builders, Scottish Building, The Royal incorporation of Architects in Scotland (RIAS), the Chartered Institute of Architectural Technologists (CIAT), the Chartered Association of Buildings Engineers (CABE), Section 6 certifiers of design and others.

Given evidence of wider interest in adopting a standard that approaches Passivhaus, this section explores the current state of play based on existing initiatives relevant to the delivery of very low energy buildings or a high-quality agenda in Scotland and elsewhere. This was undertaken by engagement across the construction sector and drawing on the experiences of and evidence from those successfully delivering very low energy buildings.

In addition, the workshops investigated the concerns (and the reasoning behind these) of those taking a 'minimum standards' approach at present. The objective is to identify and address as many of the 'blockers' raised by the sector as is practicable, by sharing solutions and tried and tested approaches to demonstrate how perceived risks can be mitigated and how change can be led by industry.

The work also considers how adopting such an approach can help to define a level of energy efficiency and performance in new buildings which is deliverable - combining pragmatism with aspiration. It includes exploration of the role of monitoring and building performance evaluation in delivering better outcomes and the impact of related changes such as the proposed move away from fossil fuel and other combustion solutions in 2024 on ensuring delivery of a 'just' transition.

Workshop Aims

The aim of the first two workshops was to understand the current industry position and attitudes towards the rate of change of regulation and standards and to explore the perceived challenges and opportunities associated with the adoption of low carbon construction beyond the current standards.

Workshop objectives, to:

- gather views on the viability of reaching net zero;
- establish lessons from experiences and share information from successful delivery of recently completed very low energy buildings including objective assessment of the benefits of a Passivhaus – or equivalent approach to the delivery of new buildings;
- map current good practice, successful case studies illustrating exemplars of current good practices and quality assurance (who is doing what, how and why?);
- map current activity within the Scottish construction sector in support of the green recovery, skills development needs and supply chain capacity;
- understand how good practice may need to respond to the proposed changes to legislation and solicit views on the role of regulations, the Heat in Buildings Strategy and the 2024 Heat Standards in delivering very low energy new buildings and new building work;
- identify gaps in availability of information and other barriers that might adversely affect how prepared industry is to deliver to proposed standards;

- identify and understand challenges, barriers and opportunities and measures that could mitigate perceived risks to facilitate progress including blockers of adoption and potential remedial solutions;
- examine, on a sectoral/sub-sector basis – new homes, new commercial, new public sector, specific and more specialised building types. Understand the 'hierarchy of need' – sectors most 'at risk' and those well placed to move forward;

Following this the aim was to draw conclusions, identify gaps in knowledge and information and make recommendations to inform the next steps for Scottish Energy Performance standards, including recommendations for industry action to mitigate key risks, ideas on associated research stimulus, making reference to potential current sources of information.

Workshop 1&2 outcomes are included in the full report in Appendix A, but topics covered included:

- policy and procurement;
- enabling infrastructure;
- skills and supply chain;
- achievability of various standards (e.g., Passivhaus);
- the role of Modern Methods of Construction (MMC), Offsite Construction and standardisation;
- knowledge sharing and exchange;
- unlocking value, funding and
- cost vs benefits.

Workshop 1

The aim of the first workshop was to try to understand construction industry concerns and the perceived challenges and barriers associated with the adoption of low carbon construction techniques and methods generally. It considered a variety of perspectives relating to design, specification, construction and occupancy stages, as well as issues relating to workforce, policy, and supply chain development.

Workshop 2

As we prepare for the next review of Section 6 - Energy of the Scottish Building Standards, the aim of Workshop 2 was to explore the following:

- What can we do now to support effective knowledge exchange that prepares businesses to respond to the anticipated changes?
- How can we support better collaboration between key stakeholders to adopt and mainstream future standards more effectively?
- How can funding mechanisms and approaches be better aligned with policy aspirations?
- How do we ensure procurement models are incentivising best practice?
- Are there good examples we can learn from?

The outputs from these workshops allowed consideration of the application of a standard such as Passivhaus in the context of broader heat decarbonisation policy as set out in the Heat in Buildings Strategy, including the proposals for the 2024 New Build Heat Standard.

The next step was to continue discussion with industry experts and stakeholders on what capacity there is for further improvement to energy standards in the short term and what alternatives to current consultation proposals and approach may be viable considerations.

Workshop 3

The third workshop explored issues around how a Passivhaus-type approach might be implemented without adding additional financial burdens on projects. The general view was that there is no point in adopting a stringent standard like Passivhaus without certification as insulation integrity and ventilation standards plus system commissioning are necessary to ensure that the standard is achieved. Some however argued that moving to a Passivhaus equivalent in terms of fabric performance or adopting Passivhaus without certification would still represent a significant step forward. More details are included in Appendix B. This was subsequently followed up in interviews with Scottish Futures Trust (SFT) and the City of Edinburgh Council (CEC) and the Royal Incorporation of Architects in Scotland (RIAS) (as reported in Chapter 5: Follow on Research).

The group highlighted three nations/ regions that have adopted a Passivhaus or equivalent approach, supported by their respective governments and developed in conjunction with the Passivhaus Institute. This could offer a way forward. The countries identified were Mexico, the Brussels region of Belgium and Vancouver, Canada. Details are provided within the main text, but worthy of note is that the Brussels government pump-primed the initiative in Belgium, and it has over time become enshrined in law. Over time, there have been attempts to water down the implementation of the initiative depending on the views of the government of the day, but it has become the way that the industry does business, and so these attempts do not overly impact on practice. For example, attempts to be less stringent with ventilation standards have made little impact as, a) the industry builds to a high standard now anyway, and b) it is almost impossible to achieve the minimum energy performance standard without meeting the airtightness standards.

Further investigation on how the standards were developed and the roles of governments and the Passivhaus Institute in developing the standards is ongoing. It was suggested that the Scottish Government considers an approach of this type as many public sector organisations are already demanding similar standards from the industry. Adopting such an approach within Building Standards would streamline and simplify what is becoming a complex landscape whereby as a result of a perceived need to do better, the industry is on the verge of having to respond to different standards in different parts of the country. The most important aspect of this is the issue of certification and compliance. The workshop view on this was that this could be rolled into the current Building Warrant process – which is currently being modified anyway with the introduction of the Compliance Plan Manager role – thus presenting an opportunity. The issue of certification appears to have been resolved in Belgium through dialogue with the Passivhaus Institute – the mechanism for this is being clarified.

WORKSHOP 'SWOT' ANALYSIS

Views on current and future practice in Scotland: Workshops 1 and 2: SWOT Analysis

Strength/Advantages

- There is interest/appetite from the building industry to drive the change in building standards.
- Willingness to adopt new ideas and ways of working with contractors.
- Resilient supply chain.
- There is evidence of a growth in and increased interest from qualified professionals in the use of certifications.
- Willingness to change direction for regulations and improve design principles for green construction – demonstrated by increase in self-imposed local authority standards for example.
- Current focus is on fabric performance focused approach – this supports future proofing.
- Successful pilot projects delivered.

Weakness/Risks

- Lack of access to training at all levels – from operatives & supervisors to managers & designers.
- Language – lack of clear definition of measurable targets that are easy to compare across all sectors and policies.
- Lack of infrastructure to provide construction waste and cradle to cradle solutions.
- Existing reporting mechanisms are poor and ill defined, including lack of clarity on methodologies to minimise the performance gap, and compliance checks.
- Current focus on fabric performance focused approach needs to link with technologies.
- Technologies not all market ready and continually evolving.
- Lack of available funding for delivery for net zero and support for testing/monitoring (i.e., BPE, POE).
- Reliance on local supply chains

Opportunities

- Support to develop a net zero strategy within the building regulations and net zero strategies.
- Use of MMC to improve quality assurance (off-site manufacturing).
- Create a knowledge bank and skills-sharing repository – BE-ST identified as potential central knowledge hub.
- Knowledge and learning exchange opportunities and signposting for innovative design solutions, training opportunities and upskilling of delivery assessment teams.
- Public engagement and education programmes for net zero solutions and methods.
- Involvement of FE & HE institutions (active learning & research) with contributions from industry.
- Need to develop skills for better compliance testing, monitoring of outcomes, and BPE/POE to reduce the performance gap.
- Develop CPDs/training opportunities for upskilling at all levels, particularly on 'building tight', BPE and monitoring of outcomes.
- Development of local supply chains.

Threats

- There is no willingness from some sectors of the industry to go beyond the regulation requirements.
- Lack of adequate funding to explore the cost-value perception.
- Lack of a clear path for the future (hence LAs going down the route of developing their own approaches and standards).
- Lack of path for transdisciplinary collaborations.
- Lack of alignment between policy (i.e., building standards) and government targets.
- Lack of standardisation of methods for measurement (SAP/EPC/energy targets, heating demand, u-values, blower door)

Good practice in the delivery of very low-energy new buildings Workshop 3: SWOT Analysis

Strength/Advantages

- Several net zero standards have already been developed, adopted and fully integrated into the construction industry.
- Taking a robust approach to workflow provides better protection against extended liability.
- Collation of design and construction evidence, efficient, compliant design, and extended liability for building professionals.
- The methodology is the same with 50kWh or 15kWh targets, the key is the building warrant inspection workflow.

Weakness/Risks

- The need to find and use the right tool (e.g., PHPP)
- High reliance on local authorities and councils.
- Existing performance gap between design and built.
- Current U-value testing methodology is not sufficiently embedded in the construction industry, particularly for non-domestic buildings.
- Oversizing building systems (i.e., heat pumps and MVHR systems)

Opportunities

- Building warrant inspection could accommodate testing, POE.
- Scotland can develop its own certification based on performance requirements; there is no need to mention the Passivhaus.
- Creation of a transition agency to establish frameworks within the existing building warrant so that the checks are seamlessly built in. This agency could also oversee the adoption of the standard within the building control over the time.
- Integration of building control officers trained on the standard of the building control system within each council team.
- Sector-by-sector basis adoption.
- Countering the Threat that Certification would be required to deliver the standard – if we do not allow to be 'Perfect' be the enemy of '(very) Good', building to a higher fabric standard with a few checks and balances on the certification front (e.g. air tightness and thermal imaging) should automatically make a significant difference – rather than (say) aiming for perfect in 5 years and not achieving this.
- The direction of travel across Europe is on Minimum Energy Performance Standards (MEPS) based on annual energy consumption figures in kWh/m2/annum. Should Scotland follow this direction? If so, what are the alternatives? Passivhoos, Carbon Lite, AECB, other Local Authority or independent standard (e.g. Scottish Building Energy Standard).

Threats

- Certification might be required to help to enforce the change.
- Without proper monitoring or testing, there is a high risk of not meeting the standard. But should we allow perfect to be the enemy of good?
- There are no established routes for POE/BPE.
- All ties in with the building safety bill, all these changes are coming whether people like it or not.
- The development of a standard specifically for Scotland, should take into consideration not only the technical side, but also its implementation through all the stages in the construction industry and local authorities and ensure that everyone can keep up with the changes.

Workshop Conclusions

The issues identified as being required to facilitate progress included mechanisms for the dissemination of knowledge; opportunities for collaboration between those charged with delivery and supporting organisations; the role of educators in further and higher education in ensuring that those delivering have the right skills; the role of the energy sector; the need for roadmaps for domestic, non-domestic and retrofitting of buildings; early adopters as champions; partnership working; the role of those developing standards from e.g. SFT, PHT and AECB to LAs and RSLs setting higher standards; the need for an understanding of what is happening elsewhere in Europe; engagement with funders and RICS to explore 'value' and how all of this fits with the SG's route map to net zero by 2045.

- It was recognised that the Scottish Government might perceive committing to being tied-in to a commercial solution such as Passivhaus as problematic but that the spirit of Passivhaus might be something to aspire to. We are aware that the University of Strathclyde is working with John Gilbert Architects on a Knowledge Transfer Partnership (KTP) project exploring a Scottish (non-certified) version of Passivhaus, currently branded as 'Passivhoos'. A solution like this might offer a way forward, however if there is no need to demonstrate achieving 'performance' over and above 'compliance' with a theoretical standard, the question remains as to whether or not the intention is realised.
- Workshop attendees and a wider network of organisations (see Appendices A & B) known to be delivering buildings that go beyond regulation standards as a matter of routine, were consulted to establish the detail of what is achievable and affordable, and how this compares with Passivhaus.
- It was highlighted that many saw a move to full/ certified Passivhaus as 'a step too far'. It is not always appropriate in free-flowing accommodation like nurseries, for example, when it is possible to achieve net zero and significant energy reductions for less capital expenditure. The cost of achieving full Passivhaus in schools is enormously expensive.
- In residential property, other than cost, the main problem in social tenures is seen as maintenance and access for maintenance. Edinburgh Council is already reporting problems with properties with MVHR, so natural ventilation is preferred. For local authorities with large housing portfolios they need robust and easy to manage strategies.

04.

Best Practice Case Studies

Chapter 4. Best Practice Case Studies

Domestic Newbuild Passivhaus and 'Towards Passivhaus' developments

These case studies were provided by organisations regularly delivering to Passivhaus (certified) and Passivhaus 'standard' (non-certified). Sources SFHA and PHT).

Tigh-Na-Cladach – Gokay Deveci for Fyne Homes, Dunoon

Client: Fyne Homes
Architect: Gokay Deveci
Contractor: CCG
Location: Dunoon
Project design objective: Passivhaus
Units: 14 Terraced
Completed: 2010

Outcome

Achieved energy performance – 120 kWh/m2/ year.

MVHR installed – Yes

Energy performance monitored? Yes

Other ventilation system? Not available

IAQ monitored? Not available

Information on construction materials
The construction is prefabricated super insulated I-beam roof and walls, externally finished with Sto-render on blockwork.

Lessons learned

The heating requirement for one of the houses is 1,600 kWh/year. A solar thermal system further reduces the energy bill for hot water by over 50%.

Key features:

The Passive House has a solar thermal collector on its south-facing roof, feeding the domestic hot water tank.

A 1kW heater pre-heats the air that the MVHR system brings into the house. A small 1kW air-to-air heat pump with its outlet in the hall and a heated towel rail in the bathroom upstairs generate an additional amount of heat in the house for the MVHR to circulate.

Fyne Initiatives regretted not being more on top of the workings of the MVHR system by the time the house was occupied. They felt that they would have been better able to judge the nature of the problems when the system appeared not to be operating correctly, resolve it sooner and give more support to the owner of the property.

Springfield Terrace, Newtown St Boswells – Eildon Housing

Client: Eildon Housing Association
Architect: John Gilbert Architects with Highland Passive
Contractor: Stewart and Shields
Location: Borders
Project design objective: Passivhaus

Outcome

Target heating energy performance – Passivhaus Classic - 15 kWh/m2/year
MVHR installed – Yes
Energy performance monitored? Yes
Other ventilation system? Not available
AQ monitored? Not available

Shortlisted for National RIBA MacEwen Award - Architecture for the Common Good

Green Homes Standard (Silver Aspects 1&2)

The council will assess how energy efficient the properties are and will also seek the views of residents living in the homes.

Information on construction materials
The construction methodology included research into efficient airtightness robustness at the intermediate floor edge, resulting in the use of I-section timber studs for balloon frame construction, including reduced embodied carbon and thermal bridging.

Lessons learned

Eildon Housing's first Passivhaus development of 3 homes in Newtown St Boswells, designed by John Gilbert Architects and delivered by Stewart and Shields has been successful, with customers experiencing lower fuel bills in Eildon's fight to eradicate fuel poverty.

Key features:

The homes are fitted with an MVHR that both supplies fresh air and extracts stale air throughout the property and recycles the heat generated within it.
Triple Glazing installed – Aluclad low maintenance window systems. MVHR Heat recovery – 94% heat recovery.

Stewart & Shields built full-scale prototypes of the houses in its factory, enabling the contractor to train site staff and 20 apprentices in Passivhaus techniques.

Balgove Road, Gauldry – Kingdom Housing Association

Client: Kingdom Housing Association
Architect: Oliver and Robb Architects
Contractor: Campion Homes
Location: Fife
Project design objective: Passivhaus Certification
Units: 30 Mixed
Completion by: Sept 2023

Outcome

Target heating energy performance – Passivhaus classic <15kWh/m2/year

MVHR installed – Yes

Energy performance monitored? Yes

Other ventilation system? Not available

IAQ monitored? Not available

Information on construction materials

The Passivhaus Standard is internationally recognised and focuses on five key principles: high quality insulation, heat control and high performing windows, airtight construction, heat recovery ventilation, and thermal bridge free design.

Lessons learned

The project is scheduled to complete in September 2023.

The properties will all be built to Passivhaus and net zero carbon standards making it Kingdom's largest green development to date.

The homes will also achieve the Gold Secured by Design Standard and the Building Regulations Scotland Silver with Gold Level 2 and Platinum Level 1 for carbon dioxide emissions.

The total project cost is £6.9 million with funding of £3.9 million provided by the Scottish

Government and a contribution of £74,726 provided by Scottish Water.

More information can be read here.

Newfield Square, Nitshill, Glasgow – Sanctuary Homes

Client: Sanctuary Homes
Architect: MAST
Contractor: CCG
Location: Glasgow
Project design objective: Passivhaus Certification
Units: 2 x Semi Detached
Completed: 2020

Outcome

Achieved energy performance – 120 kWh/m²/year

MVHR installed – Yes

Energy performance monitored? Yes

Other ventilation system? Not available

IAQ monitored? Not available

Information on construction materials

Design modelling using the Passive House Planning Package (PHPP). Very high levels of insulation in floors, walls and roof. Extremely high-performance windows and doors with insulated frames

Lessons learned

Ten of a 178 total dwellings, at Sanctuary's £19.6 million Newfield Square development in the Nitshill area of Glasgow, have been built to the Passivhaus standard, but only two of these were certified as part of a pilot project. A further 8 meet Glasgow Sustainability Gold, Silver & Bronze. Local apprenticeships are helping to train and upskill people in the area.

Key features:

Airtight building fabric 'Thermal bridge free construction. A mechanical ventilation system with highly efficient heat recovery (MVHR).
The main development is designed to achieve Bronze Active for sustainability under Section 7 of the Scottish Building Regulations by using solar photovoltaic panels (PV). Part of the project is also designed to achieve Silver Level Aspect 1 & 2 under Section 7 of the regulations.

Type A1 – "The Benchmark House" (Silver Aspects 1 – 8)
Type A2 – "The Simple House" (Gold Aspect 1/Silver Aspects 2 – 8)
Type A3 – "The Renewable House" (Gold Aspects 1 – 8)
Type A4 – "The Platinum House" (Platinum Aspect 1/Silver Aspects 2 – 8)
Type A5 – "The Passive House" (Certified Passivhaus Standard).

Cunningham House, Carntyne – Shettleston Housing Association

Client: Shettleston Housing Association
Architect: Page\Park
Passivhaus expert: John Gilbert Architects
Contractor: Stewart and Shields
Location: Glasgow
Project design objective: Passivhaus
Units: 5 x Two & Three Bedroom
Completed: 2019

Outcome

Target heating energy performance – Passivhaus classic <15kWh/m2/year

MVHR installed – Yes

Energy performance monitored? Yes

Other ventilation system? Not available

IAQ monitored? Not available

Information on construction materials

Materials Used: A broad mix of materials have been used allowing us to showcase traditional crafts and skills, with modern solutions. Materials included stone, zinc, timber, lead, facing brick, concrete, Kingspan insulation, Marmox blocks, farrat boards, natural slate, single Ply roofing membrane.

Lessons learned

Nineteen new homes for older people have been provided in this innovative project that combines the construction of a modern five storey Passivhaus tower with the sensitive restoration and conversion of the 19th century Carntyne Old Parish Church on Shettleston Road.

Each of the thirteen flats constructed within the old Church building has an individual, bespoke design that reflects its relationship with the existing stone structure. Every home has a very individual aspect, whether through the restored lancet windows or through the new high-performance glazing into the residents' courtyard.

All five flats in the new tower have been designed and constructed to Passivhaus standard and benefit from high levels of thermal insulation, triple glazing and Mechanical Ventilation and Heat Recovery.

Dormont Park Passivhaus Development –Dormont Estate – Dumfries

Client: James Dormant, Dormont Estate
Architect: White Hill Studio
Contractor: CCG
Location: Dumfrieshire
Project design objective: Passivhaus
Units: 8 x Two & Three Bedroom
Completed: 2011

Outcome

Achieved energy performance – 120kWh/m²/year

MVHR installed – Yes

Energy performance monitored? Yes

Other ventilation system? No

IAQ monitored? Not known

Information on construction materials

All of the homes are delivered to an enhanced standard as a result of CCG's offsite manufacturing capabilities and the use of the 'iQ' Closed Panel Timber System with a bespoke wall solution achieving a U-value of 0.095W/m²K.

Lessons learned

The homes are built to certified Passivhaus standard, with :

- Large, south facing, high spec triple glazed windows for maximum solar gain, super insulation and extremely high levels of airtightness which allows heat generated within the house by daily activity to be retained
- To ensure continuous, healthy air throughout each property, airtightness was matched with the use of an MHVR System, a system that delivers a heat recovery rate of 90%. This draws moist warm air from the kitchens and bathrooms and passes it through a heat exchanger which warms fresh air from outside and delivers it to the living rooms and bedrooms.
- Hot water is entirely from renewable energy sources via roof mounted solar thermal panels and small log burning stoves using timber from the estate.

Had these houses been built to the building regulation standard of the time, it is estimated that each house would emit 63 tonnes of CO2 every year. By building to certified Passivhaus standards and utilising solar and biomass renewable energy, it is estimated that each house will emit around 3 tonnes of CO2 a year – a saving of 60 tonnes of CO2 per house every year for the estimated 60-year lifespan of these houses. See Passivhaus Trust

Drymen Passivhaus, Drymen – Hanover (Scotland) HA

Client: Hanover (Scotland) HA
Architect: ECD
Contractor: Cruden
Location: Drymen, Scotland
Project design objective: Passivhaus
Project type: Housing
Units: 15 Properties
Completed: Dec 2022

Outcome

Target heating energy performance – Passivhaus classic <15kWh/m2/year
MVHR installed – Yes
Other ventilation system? No
IAQ monitored? Not known
Other information/ Awards, etc. Shortlisted: Scottish Home Awards

The project aim was primarily to fight fuel poverty by providing high quality, sustainable, energy efficient, comfortable homes.
A key feature of the homes is optimal solar orientation to maximise solar gain potential to living rooms.

Information on construction materials

Heating is provided to the super-insulated homes by air source heat pumps and the MVHR systems ensure a constant supply of fresh, clean air to homes which have outstanding levels of airtightness.

Lessons learned

Key features:

1. Construction system - Original warrant package was based on SIPs panel system, however the project was novated to the contractor to produce the construction package, and the contractor could not obtain specified system at a competitive price. The change of specification increased space heating demand increase by 2kWh/m²a (above the target of 15kWh/m²a). This resulted in a change of insulation product to a rigid EPS.

2. Air tightness – It is important to select an airtightness membrane that allows the PH standard to be met but practical consideration such as location of wall studs is also important. Increased costs in materials can save time and improve accuracy. So 'equivalence' in terms of materials may be a false economy.

3. Responsibility – Everyone needs to understand the objective and know what is important and why. For example if working with new materials follow instructions and understand why it is important.

Teamwork is important - We have a lot to think about when we specify materials/details when designing and pricing projects:

1. Really think about the install process
2. The simpler the better
3. Cheaper is not always cheaper!

MMC - The Home Group Project Gateshead

Client: The Home Group
Architect: ID Partnership
Contractor: Engie Regeneration Ltd.
Location: Gateshead
Project design objective: Energy efficient homes
Units: 41 x Mixed
Completed: 2021

Outcome

MVHR installed – Not available

Achieved energy performance – Not available

Energy performance monitored? Yes

Other ventilation system? Not available

IAQ monitored? Not available

Information on construction materials

Steel-based modular, timber-frame modular, light-gauge steel frame, panelised light-gauge steel frame and an aerated concrete panelised system

Lessons learned

An approach to sustainable energy solutions has been adopted, testing different MMC / Offsite solutions alongside traditional building methods. The installation of ground source heat pumps, thermal stores, air source heat pumps and infra-red electric heaters enables a comparison between heat source and house types to determine the most energy efficient and cost-effective combinations.

Sixteen volumetric and nineteen modular houses were constructed, alongside six traditional, to compare performance.

Initial results claim to show the 2025 Future Homes standard has already been achieved with regard to CO2 emissions on this gas-free development.

Non Domestic Passivhaus and very low energy buildings

These case studies were provided by participants in a workshop on Passivhaus organised by BE-ST, Scottish Futures Trust (SFT) and City of Edinburgh Council.

Scottish Futures Trust - Net Zero Public Sector Buildings Standard

SFT has developed the Net Zero Public Sector Buildings standard for public non-domestic buildings. This guide supports organisations participating in publicly funded new build and major refurbishment projects to develop and improve buildings to achieve a step change improvement in Net Zero Operational Energy, taking action on embodied carbon, whole life emissions and other aspects such as whole life costing and indoor environmental quality.

SFT is a delivery partner on the first phase of the £2bn Learning Estate Investment Programme (LEIP). This work is linked with the Edinburgh (Passivhaus) Schools Programme and the Passivhaus Delivery Forum which involves 8 local authorities. The first phase comprised of 12 projects, with a second phase announced in December 2020, comprising of 25 projects.

SFT is also a partner on the Edinburgh Home Demonstrator (EHD) project, focussed on Offsite Manufacturing System demonstrator projects, and exploring how to achieve building regulation compliance and beyond without certification. Working with a number of housing providers and house builders, they are taking a fabric first, air tightness focussed approach to delivering ultra-low energy homes.

Edinburgh City Council – Edinburgh Passivhaus Schools Programme

The City of Edinburgh took the decision to adopt a certified Passivhaus standard in 2017 following the identification of construction, and environmental and indoor air quality issues in its PFI and Edinburgh Schools Partnership delivery programmes around 2015-2016. They had also identified energy performance gaps in both their newbuild and refurbishment programmes.

Justification for adopting a certified Passivhaus approach was linked to the fact that poor energy performance issues was linked to mechanical services engineers expressing concern about having to service poorly designed and constructed buildings – leading to inefficient system operation and energy profligacy.

Edinburgh was not the first council to do this as Fife and Perth and Kinross had already gone down this route.

EHD Pilot 1, Granton Regeneration Site D1 – The City of Edinburgh Council

Client: The City of Edinburgh Council
Architect: Anderson Bell + Christie
Contractor: CCG (Scotland) Ltd
Location: Edinburgh
Project design objective: Net Zero Ready
Project type: Residential

Outcome

Predicted energy performance
– average 19.5kWh.m2/year

Communal energy centre Post Occupancy Evaluation (POE) to be undertaken covering:
-U-values
-Air Tightness
-Electricity Usage
-Temperature
-Co2
-Humidity
-Occupant Surveys

dMEV and cMEV ventilation systems

75 flats (48 social rent and 27 mid- market rent)

3 commercial spaces

Information on construction materials

Constructed using CCG IQ system
Brick clad

Lessons learned

Key features:

The driver is to reduce the energy demand by taking a fabric first approach which will in turn assist with tackling fuel poverty for the tenants. The project is also future proofed in terms of net zero carbon by eliminating direct emissions heating systems.

The project has two blocks of flats that are all supplied with heating and hot water from a communal energy centre. The energy centre contains two large air source heat pumps, two water-water heat pumps and thermal storage. This is powered from the electricity grid and the solar PV.

It is projected that the PV will produce 82,000 kWh/year of electricity.

The project's average DER is 73% less than the TER.

Evaluated to meet the EHD Net Zero Ready Standard as part of the EHD Net Zero Route Map.

Blackridge Early Years Centre,– Blackridge, West Lothian Council

Client: West Lothian Council
Architect: Scott Brownrigg
Contractor: Morrison Construction
Location: Blackridge, West Lothian
Project design objective: Passivhaus Classic Certified
Project type: Early Years Centre
Floor area: 275 m2
Completed: January 2021

Outcome

Target heating energy performance – Passivhaus classic <15kWh/m2/year
Air-tightness <1 m3/hr m2 @50 Pa
Air source heat pump
MVHR installed – Yes
Energy performance monitored? - Yes
IAQ monitored? - Yes

Other information – currently being compared with St Mary's an (almost) identical building built to Building Regulations standard.
•Air-tightness 4.5 m3/hr m2@50Pa
•'Standard' U-values
- Air source heat pump
- Naturally ventilated

Information on construction materials
Passivhaus compliant components Ultra low U-values:
Roof: 0.10 W/m^2K
Wall: 0.10 W/m^2K
Floor: 0.095 W/m^2K
Windows: 0.6 W/m^2K

Lessons learned

Key features:

In 2018, West Lothian Council assessed their response to Scottish Government's policy of 1140 hours of early learning care for all children over the age of 3 and 4 and qualifying 2 year olds.

The Blackridge Early Years Centre is the first early years learning building in Scotland to be built to Passivhaus Certification standards. Part of a pilot scheme with West Lothian Council and Hub South East Scotland, the nursery has successfully proved the concept.

The nursery was developed alongside another early years centre, St Mary's (completed Nov 2020) which is spatially identical but built without adherence to the Passivhaus standards. This allowed for a direct comparison on process, construction method, programme, capital and operational costs. This is coupled with enhanced data logging when now in use, has helped inform not only how we can fine tune the existing facilities but also how we directly influence next generation design proposals.

Undergoing monitoring – early results promising – expecting:
Up to 75% reduction in space heating requirements compared with 'standard' build
Lower carbon emissions Increased comfort levels for building users Improved CO2 levels.

Maybury PS, Maybury, Edinburgh – City of Edinburgh Council

Client: CEC
Architect: Architype Ltd
Contractor: Morrisons
Location: Maybury, Edinburgh
Project design objective: Passivhaus
Project type: Education
Floor area: 5,975m2
Completed: 2025

Outcome

Designed heating energy performance – Passivhaus Classic (Certified) 14.5kWh/m2/year (limit 15)

MVHR installed – Yes

Energy performance monitored? Yes

IAQ monitored? Yes

Information on construction materials

Timber frame construction; brick cladding at ground floor level with metal cladding at upper levels; mineral wool insulation; high performance triple glazing

Lessons learned

Building has a form factor of 2.3 which is a good ratio between internal floor area and the thermal envelope.

250m2 of PV's required in order to meet the target PH Primary Energy targets.

South facing aspect of classrooms help minimise glare and overheating risk (BB101).

Use of timber frame on a building of this scale a challenge with CEC insurers and obtaining relevant fire certification proved problematic, highlighting an industry wide issue with up to date certification.

Key features:

2 storey primary school and early years centre with GP surgery and Health Centre.

Creates a community school building as part of a wider masterplan to the west of Edinburgh

Designed to achieve Passivhaus Classic (Certified) standard as well as the embodied carbon objectives of the new Scottish Government's Net Zero Carbon Public Sector Building Standard (NZPSBS)

Currie High School, Currie, Edinburgh – City of Edinburgh Council

Client: CEC
Architect: Architype Ltd
Contractor: Kier Construction
Location: Currie, Edinburgh
Project design objective: Passivhaus
Project type: Education
Floor area: 12,749m2
Completed: 2025

Outcome

Designed heating energy performance – Passivhaus classic 12kWh/m2/year (limit 15)

MVHR installed – Yes

Energy performance monitored? Yes

Other ventilation system? Specific MVHRs for swimming pool and fitness suites

IAQ monitored? Yes

Information on construction materials

Steel frame construction; brick cladding at ground floor level with metal/terracotta cladding at upper levels; mineral wool insulation; high performance triple glazing

Lessons learned

Use of steel frame added complexity to detailing related to airtightness to achieve Passivhaus compliance

PHPP modelling split into 5 models due to varying internal temperature requirements and different usage of the building including a PH certified pool.

Pool PH requirements required bespoke criteria to be provided by the PassivHaus Trust.

Key features:

3 storey high school serving 1,000 pupils with Scotland's first Passivhaus swimming pool.

Designed in line with CEC Zero Carbon aspirations

Primary heating energy source utilises fossil fuel free sources (i.e. Air Source Heat Pumps (ASHP's).

Community access to library, swimming pool and fitness suites.

Wester Hailes High School, Edinburgh – The City of Edinburgh Council

Client: The City of Edinburgh Council
Architect: CEC Sustainable Construction Delivery
Contractor: TBC
Location: Edinburgh
Project design objective: Passivhaus Classic
Project type: Education

Outcome

Achieved heating energy performance – Passivhaus classic <15kWh/m2/year
MVHR installed – Yes
Energy performance monitored? Yes

Information on construction materials

•Concrete in situ frame with pile foundations.
•SFS wall infill and in situ concrete shear walls.
•Airtightness layer is primarily airtight OSB sealed to concrete fram with localised areas of an external airtightness barrier.
•External insulation system with render or brickslip finish.
•Ventilated rainscreen systems to staircores and feature areas of building.
•Bitumous waterproofing roofing system on insulation.

Lessons learned

Avoids use of steel frame based on lessons from previous scheme.

Form of building design for simplicity of detailing.

Key features:

A new 800 pupil high school building with a strategy for further 400 pupil expansion. Project to rationalises all educational function on the site into one PH Certified building, while allowing for community use within the retaining shared facilities building. The gross internal floor area of the building is 7,894m2. The external areas of the campus will also be redeveloped to enhance outdoor learning and improve connectivity.

The new building will be designed to Passivhaus Classic standard incorporating high levels of thermal insulation, triple glazing and Mechanical Ventilation and Heat Recovery. Photovoltaic panels mounted on the roof will provide an annual yield of approximately 75,000 kWh/a. The building's heating system will be provided by air source heat pumps. To aid overheating control and minimise the impact of noise from the adjacent roads attenuated wall ventilators units has been provided to the buildings fenestration.

Newcraighall PS, Newcraighall, Edinburgh – City of Edinburgh Council

Client: CEC
Architect: Architype Ltd
Contractor: TBC
Location: Newcraighall, Edinburgh
Project design objective: Passivhaus
Project type: Education
Floor area: 5,075m2
Completed: 2025

Outcome

Designed heating energy performance – Passivhaus Classic (Certified) 14.5kWh/m2/year (limit 15)

MVHR installed – Yes

Energy performance monitored? Yes

IAQ monitored? Yes

Information on construction materials

Timber post and beam glulam structure with timber infill; full fill cellulose insulation; brick cladding at ground floor level with metal/terracotta cladding at upper level; high performance triple glazing

Lessons learned

Restrictive nature of site meant form factor for Passivhaus is not optimal.

Non optimal orientation made it harder to achieve daylight and overheating requirements.

Key features:

2 storey primary school and early years centre set within new housing development in SE Edinburgh

Designed to achieve Passivhaus Classic (Certified) standard as well as the embodied carbon objectives of the new Scottish Government's Net Zero Carbon Public Sector Building Standard (NZPSBS)

Photovoltaics proposed with an approximate annual yield of 63,000kWh

Primary heating energy source is 4no Air Source Heat Pumps (ASHP) with an additional ASHP providing domestic hot water for the kitchen. Circulation pipework is kept to a minimum to minimise heat losses. All other DHW use is provided by direct electric Point of Use.

Dean Park Primary School Extension – The City of Edinburgh Council

Client: The City of Edinburgh Council
Architect: Sustainable Construction Delivery, The City of Edinburgh Council
Contractor: Not yet appointed
Location: Balerno, Edinburgh
Project design objective: Passivhaus Classic Certification
Project Type: Education

Outcome

Designed energy performance – Passivhaus Classic (Certified) Heating Load Criteria <10 kWh/m2/year

MVHR installed – Yes

Energy performance monitored? Yes

Other ventilation system? Not available

IAQ monitored? Not Available

Information on construction materials
The construction is a CLT superstructure with 290mm of insulation, externally finished with Brick and Sto-render rainscreen cladding.

Lessons learned

To achieve the Passivhaus criteria, the building requires enhanced insulation and airtightness as well as a PV array.

One of the key challenges in the design development of the massing has been optimising the form factor and orientation of learning spaces - trying to maximise the area of south-facing façades on a site orientated north-to-south. Classroom elevations have been prioritised and positioned on the south and north facing elevations to maximise useful solar gains & daylight, whilst minimising the risk of overheating. To fit on the available site, however, the longest elevations face east and west.

Key features:

The project is for the provision of 6 additional classrooms and breakout space. In Accordance with The City of Edinburgh Council policy, the building has been designed to achieve Passivhaus Classic standard as well as the embodied carbon objectives of the new Scottish governments Net Zero Carbon Public Sector

Liberton Community Campus – The City of Edinburgh Council

CClient: The City of Edinburgh Council
Architect: JM Architects
Contractor: Balfour Beaty
Location: Edinburgh
Project design objective: Passivhaus Classic
Project type: Education
Floor area:12,000m2

Outcome

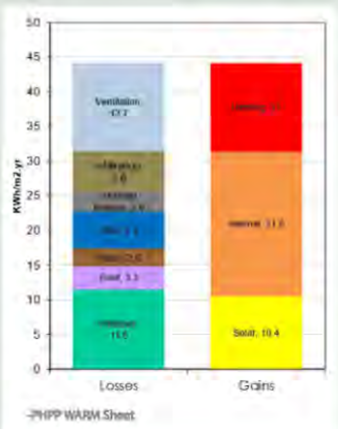
Target heating energy energy performance – Passivhaus classic <15kWh/m2/year

MVHR installed –

Energy performance monitored? Yes

Information on construction materials

•Concrete in situ frame with pile foundations.
•SFS wall infill and in situ concrete shear walls.



Lessons learned

Avoids use of steel frame based on lessons from previous scheme.

Key features:
A replacement 1200 pupil high school building incorporating community facilities and a GP Surgery.

Pilot scheme for governments Net Zero Public Sector Building Strategy (NZPSBS)

The external areas of the campus will also be redeveloped to enhance outdoor learning and improve connectivity.

The new building will be designed to Passivhaus Classic standard incorporating high levels of thermal insulation, triple glazing and Mechanical Ventilation and Heat Recovery. Photovoltaic panels mounted on the roof.

The building's heating system will be provided by air source heat pumps.

Science facilities utilise LPG to allow natural gas.

Case Study Conclusions

The above case studies are inconsistent in terms of the data collected and although some are being monitored there is insufficient data available at this point to allow us to make recommendations on whether the way forward for Scotland is to adopt Passivhaus wholesale or to adopt a 'Passivhaus equivalent' alternative. However, we had no difficulty in finding organisations willing to share their experiences and gathered a significant number of examples.

- From discussions at the workshops there is concern about achieving and maintaining high standards of indoor air quality in relation to all building types – public and private sector/ domestic and non-domestic. Another point raised both in the workshops and the case study discussions was the risk of negative impacts on performance by adopting a lighter touch approach. If a 'passive house' design is not certified, and if Passivhaus approved components are substituted by 'equal and approved' components would this result in unacceptable sacrifices in environmental and energy performance?

- There is some evidence from the ECD case study on the Drymen project for Hanover Housing, that cost savings on airtightness tapes and membranes can result in unforeseen problems such as inability to locate wall studs – which in this case resulted in time related costs. The conclusion here was that increased costs in materials can save time and improve accuracy. So 'equivalence' in terms of materials may be a false economy.

- Early examples such as Fyne Homes in Dunoon (2010) highlighted the need for better understanding of MVHR – which was a long running issue for this project – as was airtightness, but once resolved the project achieved 120kWh/m^2/year (double the current Passivhaus Classic Primary Energy demand). The Dormont Passivhaus certified homes in Dumfries (2011) achieved a similar standard.

- Monitoring results from the other domestic projects are not yet available, but all aim for the Passivhaus Classic heating energy demand of 15 kWh/m^2/yr. Similarly, the non-domestic case studies identified are all at design or construction stages and no data is yet available.

- What is clear from the case studies is that the social housing sector, a few early adopters in the private housing sector (rental and homeowners), and the public sector (particularly in the area of educational buildings) is ready, willing and able to deliver to the standards required for full certification.

- There are already a number of tier 1 contractors upskilling to meet the challenges – both in terms of site practices and inhouse expertise. In addition, timber frame producers such as CCG are also upskilling and changing delivery practices to make these solutions cost effective to deliver and robustly detailed to minimise on site failures at the testing and certification stage on the basis of 'right first time'.

- As information gathering and monitoring of many of the projects was at an early stage, further discussions took place with some of those involved in delivery in orders to build a clearer picture – particularly regarding motivation and incentive. An overriding message was certainty – Passivhaus is a single clear approach – complex but not complicated – this gave contractors clarity and only one new skillset to learn rather than the current approaches which vary from Local Authority to Local Authority. This is further discussed below.

05.

Follow on research

Chapter 5. Follow on research

Further discussions on the implications of adopting Passivhaus principles versus Passivhaus Certification were discussed with Scottish Futures Trust (SFT), the City of Edinburgh and the Royal Incorporation of Architects in Scotland (RIAS) this time with a focus on non-domestic and domestic/ mixed use buildings. Views differed on adoption of a full, certified Passivhaus approach but there was agreement around the idea of adopting quality assured/ compliance tested approaches to affordable/ social domestic buildings and non-domestic buildings in the public estate. It was also suggested by SFT the if the Scottish Government decided to adopt a fully certified Passivhaus approach – perhaps this could start with non-domestic public buildings and gradually be extended to other building types.

Edinburgh Home Demonstrator[23]

SFT highlighted how through the Edinburgh Home Demonstrator project, using Offsite Manufacturing System demonstrator projects, they are exploring how to achieve building regulation compliance and beyond without certification. Working with a number of housing providers and house builders, they are taking a fabric first, air tightness focussed approach to delivering ultra-low energy homes.

The Edinburgh Home Demonstrator Programme was established to develop and test a new business model for the construction of affordable homes using offsite construction methods.

The research found considerable potential advantages from greater use of offsite construction in terms of costs, quality and speed of delivery. It also, through the greater precision that can be achieved, strengthens the pathway to building affordable homes to net zero standards.

However, to realise those benefits, the researchers recommended a major change in the way housing development was being done, moving to a model based on design for manufacture rather than for onsite construction. The Edinburgh Home Demonstrator project was established to develop and test that model and apply it to the construction of 1,000 homes.

The Scottish Government's Affordable Housing Supply Programme is currently concluding the delivery of 50,000 homes across Scotland via a range of funding mechanisms for affordable housing providers, and by supporting the Local Housing Strategies of Scotland's local authorities.

The Scottish Government and partners began to explore the possibilities offered by greater use of offsite construction, commissioning Edinburgh Napier University to research and report back on whether that would be of benefit.

A key aspect of this is that due to standardisation of approach and the benefits of offsite manufacturing combined with a highly efficient thermal envelope on quality control, it is envisaged that there will be no need to go down the route of Passivhaus certification. The aim is to embed ultra-low energy design in all new housing delivery

[23] Conversation with SFT 05.05.2023

but for now the focus is on affordable homes and social housing in particular. The first Pilot is currently onsite (see EHD Pilot 1 Granton – Case Study).

Partners include: City of Edinburgh Council; West Lothian Council; East Lothian Council; Midlothian Council; Fife Council; Scottish Borders Council and Offsite Solutions Scotland; Scottish Futures Trust; City of Edinburgh Council; Scottish Government; BE-ST; Edinburgh Napier University.

The view expressed by SFT was why make perfect the enemy of very, very, very good? However, their Learning Estate Investment Programme (LEIP)[24] does require an energy consumption target of 67kWh/m^2/annum[25] (for all energy with the exception of exclusions) – which is based on the Passivhaus figure for non-domestic buildings.

Edinburgh (Passivhaus) Schools Programme[26]

The City of Edinburgh took the decision to adopt a certified Passivhaus standard in 2017 following the identification of construction, and environmental and indoor air quality issues in its PFI and Edinburgh Schools Partnership delivery programmes around 2015-2016. They had also identified energy performance gaps in both their newbuild and refurbishment programmes.

Justification for adopting a certified Passivhaus approach was linked to the fact that poor energy performance issues was linked to mechanical services engineers expressing concern about having to service poorly designed and constructed buildings – leading to inefficient system operation and energy profligacy.

Edinburgh was not the first council to do this as Fife and Perth and Kinross had already gone down this route.

Experience to date has been positive with their tier 1contractors proactively rising to the challenge by sending their operatives and designers / inspectors on training courses. Feedback points to the fact that contractors view the expansion of Passivhaus in schools across a number of LAs as a positive move because it provides clarity and certainty rather than then having to change tack every time a border is crossed. Moreover, this allows for forward planning and demonstrates justifiable investment – financially and in staff training.

Any resistance thus far has come from professionals, the reasoning for which is not entirely evident – but seems to be anecdotally linked to them deflecting the council towards their 'own' standards using the argument that this avoids the need for certification – which, from Edinburgh's viewpoint completely misses the point. If there is no certification, things slip off the table.

The council argues that adopting a certified Passivhaus approach provides clarity for those delivering, certainty with regard to compliance for the council and a level playing field. They also argue that the cost of certification is nominal and not a

[24] https://www.scottishfuturestrust.org.uk/page/new-education-infrastructure-programme
[25] https://www.scottishfuturestrust.org.uk/storage/uploads/leipmetricstermsandconditionsfundingoutcomes.pdf (page 3)
[26] Conversation with Patrick Brown 11.05.2023

reason not to do it. Passivhaus has rigour – Passivhaus equivalent depends on those implementing and is thus inconsistent.

They now have a framework with 6 Passivhaus designers and 8 people trained internally.

Eight LAs have followed the same path and include both newbuild and retrofit (EnerPHit) projects.

Edinburgh argues that as Passivhaus/ PHPP is opensource, there is no reason why the Scottish Government/ BSD could not become the certifier as is the case in Mexico, Vancouver and Belgium, if there is concern about use of the private sector. Alternatively, this role could be undertaken by LA Building Control teams. As the standard evolves this could automatically be updated in our standards – removing an administrative load – with the research aspect of this sitting within the Passivhaus Institute rather than Building Standards.

Although work undertaken by Passivhaus Assessors has to be certified by the institute, CEC take the view that not certifying introduces risk of dilution and lack of clarity. They argue that the true value of PHPP is its prescriptive nature – it 'does what it says on the tin', no ambiguity. They also argue that it addresses comfort and fuel poverty proportionately, through a fabric first approach.

Other advantages of being part of a recognised, existing scheme include access to a wider network of designers and delivery teams that can provide support and access to buildings where challenges had been met and overcome.

A final point made by CEC was that if Scottish Government is uncomfortable with the name Passivhaus – there is nothing to stop them from adopting and certifying under a wider umbrella – i.e. it might be that to meet Scottish Building Standards buildings need to be Passivhaus Certified., not that Scottish Government is changing its regulations to Passivhaus. Again, it was argued that requiring the standard to be Passivhaus is clear, unambiguous and leaves to delivery of the solution to the design team and contractor, simplifying the process.

Royal Incorporation of Architects in Scotland (RIAS)

The RIAS has also been discussing the issue following the Scottish Government's announcement. RIAS has discussed with BSD their view that the Passivhaus Standard comprises 4 building blocks. Three of these effectively already exist in the Scottish system and can be built up. The fourth runs counter to existing legislation. Their views assumed that the use of SAP and SBEM would continue in order to produce EPCs – whether or not this would remain the case is a key point in the discussion and arrival at a solution.

1. **A calculation methodology: PHPP**

PHPP like SAP and SBEM meets the requirements of BS ISO EN 13790. Like these it is complicated, but not complex. It is not simulation. This is a key point – as many Passivhaus experts cite PHPP as being superior to SAP in terms of its accuracy – this may well be the case – but that is because it is more complicated and takes more into account – not because it is a more accurate model – both SAP and PHPP are steady state calculations.

BSD has no influence over the PHPP methodology and how it may develop in future and PHPP does not have the capability to produce EPCs. Adoption of PHPP would therefore require a parallel calculation process. BSD do have the capability to set thresholds of compliance relative to SAP and SBEM outputs and the nature of the calculation methodologies is that it should be possible to identify the key criteria that would deliver equivalence. Attempts at this have been done in the past with other tools and are currently being looked at in the development of SAP11.

2. **Meaningful Compliance Thresholds**

BSD has no influence over the performance thresholds adopted by the Passivhaus Institute. The RIAS supports more challenging thresholds of compliance, with a bias to fabric first. Scottish legislation requires Scottish Minister to set compliance requirements, primarily through the Technical Standards and as noted above it is logical to set these relative to SAP and SBEM outputs.

3. **Quality Assurance**

BSD has no influence over the quality assurance environment created by the Passivhaus Institute. The Passivhaus Institute is not subject to audit by BSD. Scottish legislation allows for the creation and operation of Certification of Design Schemes. The RIAS and BRE both operate Certification of Design (Section 6 – Energy) for both Domestic and Non-domestic. This model demonstrates that a precedent already exists for certification scheme that sits alongside Building Standards if required. The existing schemes could be adapted to include Passivhaus certification and already have in place the quality assurance environment required of Approved Certifiers of Design. Both are subject to audit by BSD. This might ease the passage of Passivhaus certification. Scottish Ministers have the power to mandate the requirement for Certification – in the past European legislation has been cited as a barrier to this, but of course this no longer applies.

4. **Prescriptive Design Approach**

Regardless of the merits of the design approach, which Passivhaus Certification requires, a prescriptive approach to design is counter to current Scottish legislation, which is performance based. Adoption of Passivhaus Certification would therefore require, they believe, a change to legislation, rather than simply being adopted into the current Technical Standards.

Passivhaus Certification, like other guidance, (such HES: Practitioner Guide 6) can already be used as the basis for demonstrating compliance. However, such projects will still require a SAP or SBEM compliance calculation as well as an EPC on completion. Plus, there is a host of other requirements in Section 6 and both the Domestic and Non-domestic Building Services Guides, which lie outwith an energy calculation, which must be addressed in a warrant application, where applicable.

The implications of the above combined with the workshop reviews are presented in the following section.

06.

Summary and conclusions

Chapter 6. Summary and Conclusions

Research to date demonstrates that a growing number of local authorities and other social housing providers are already going beyond building regulation requirements in terms of the building standards they are adopting. Some go as far as Passivhaus and others set their own targets. Some, but not all specify minimum energy performance standards and some but not all specify and test airtightness levels and controlled ventilation requirements beyond current building standards plus additional measures such as monitoring performance and thermographic surveys to check insulation integrity. This spills over into compliance checking.

- We identified one large pilot that is exploring MMC rather than Passivhaus as a route to high performance building. The project has won a number of awards, and early signs from occupant satisfaction with lower than expected heating costs are positive, but results of performance monitoring are not yet available. SFT is involved in a project that is pursuing a similar approach, however, results are not yet available.

- While many on the Passivhaus Workshop expressed concern about the value of designing and building to a Passivhaus Standard without certification, others were less concerned as long as sufficient effort went into ensuring that site supervision extended to checking of details at each stage. It was also suggested that as the Building Standards direction of travel with regard to air tightness, ventilation provision and a fabric first approach, many of the risks were already mitigated.

- Wider soundings with the SFT, CEC and the RIAS provided both coalescing and conflicting viewpoints. Much of this related to the fact that adopting a Passivhaus approach would require a complete rethink of our energy regulations and the way in which they have evolved. In recent years Section 6 of Building Standards has embraced a flexible, performance-based approach. This is at odds with Passivhaus, which is much more prescriptive. However, as Scottish Government strives to deliver Net Zero Emissions in the built environment by 2045, it is already evident that regulations will have to respond. There are already changes taking place in areas such as prescribed standards for retrofitting of homes and public non-domestic buildings, air-tightness testing is becoming more stringent, and post-COVID 19 discussions are taking place around the impact of more airtight homes on health and wellbeing and the potential need and implications of whole house ventilation.

- Workshops 1 and 2 overwhelmingly indicated that the construction industry is looking for certainty but as they try to prepare for what might be required local authorities are travelling in similar but (not necessarily) unaligned directions, particularly with regard to domestic buildings. On public buildings and in schools in particular, there are a number of local authorities (currently around 8) coalescing around briefs that require a certified Passivhaus approach and anecdotal evidence suggests that Tier 1 contractors are rising to this challenge by training staff to deliver to this standard. The argument used is that Passivhaus as a brand – is clear and unambiguous. The requirements are complicated but not complex. And if applied unilaterally there is only one system to learn – there are no nuances from local authority to local authority.

- Although some reservations were raised (as outlined in the SWOT analysis and workshop outcomes reports), on the whole, the workshop participants expressed readiness and willingness to do whatever Scottish Government required to meet the Net Zero targets by 2045. The main concern was lack of certainty and understanding of how best to focus their upskilling efforts in order to meet the challenges ahead.

- On adoption of Passivhaus in regulations, discussions in Workshop 3 with Passivhaus experts and proponents were unambiguously for this approach – as might be expected. Soundings were therefore taken from the Local Authority Passivhaus Delivery Forum, (via the City of Edinburgh); SFT and the RIAS in order to add a more pragmatic aspect to that discussion.

Overall, views were positive in respect of adopting Passivhaus into regulations although the value of doing so without certification was not resolved. Passivhaus proponents felt that certification was the most important aspect of the approach, other felt that even if we chose not to certify, adopting the principles was a huge stride forward.

- The RIAS's view was more nuanced, it did highlight what might be possible and how that might be implemented alongside other aspects of the regulations. So, while it could be argued that Passivhaus is a proprietary brand, linked to a single organisation, the Scottish (and UK) Government already work with partners such as BRE, the RIAS, CIBSE (the Chartered Institution of Building Services Engineers), the Chartered Institute of Architectural Technologists (CIAT) on compliance schemes such as SAP and SBEM, and Certification of Design (Section 6 – Energy) for both Domestic and Non-domestic, therefore such barriers are not insurmountable – as evidenced by the adoption of Passivhaus into regulations in countries such as Canada[27], Mexico[28] and Belgium[29]. This highlights the fact that it is possible to find a way of adapting or developing a commercial or proprietary scheme such as Passivhaus for use at a national level without risking impartiality. In addition, it was suggested that it might be worth exploring whether Passivhaus could be blended with schemes such as Certification of Design and raised the issue of how the use of Passivhaus might sit with existing compliance through EPCs. However, if Passivhaus sits alongside current requirements the two systems could operate in parallel – i.e. not an 'either / or' scenario.

- The City of Edinburgh representative also pointed out that as Passivhaus's PHPP calculation method is open-source, it could be developed to provide a bespoke Scottish Regulation Compliant version in conjunction with the Passivhaus Institute, as was highlighted in Workshop 3.

[27] https://vancouver.ca/green-vancouver/build-a-passive-house.aspx
[28] https://passipedia.org/basics/passive_houses_in_different_climates/passive_house_in_tropical_climates/building_passive_houses_in_mexico_laif
[29] https://passivehouseplus.ie/magazine/insight/how-brussels-went-passive

- The construction industry in Scotland has undoubtedly made significant progress in implementing net zero standards. By following a rigorous workflow approach, building professionals can protect against extended liability and ensure compliant and efficient design. Despite the challenges, such as finding and utilising appropriate tools, compliance with regulations, and addressing the performance gap, we can achieve consistent targets by seizing various opportunities to achieve the net zero transition. These opportunities include building warrant inspection, establishing certification based on performance requirements, and adopting the standard sector-by-sector. As we move towards the net zero transition, it's crucial to enforce proper certification and consider the technical aspects and implementation throughout all stages of the construction industry and local authorities.

- The construction industry has successfully implemented several net zero standards, providing significant benefits to building professionals. This includes the ability to confidently follow a rigorous workflow approach to protect against extended liability and ensure compliant and efficient design. Additionally, the approach allows for the collection of design and construction evidence. The building warrant inspection workflow is crucial to achieving the consistent targets of either 50kWh or 15kWh. By adhering to a specific methodology, building professionals can confidently meet the necessary standards and adhere to the building warrant inspection workflow.

- Scotland's construction industry is making significant strides towards achieving net zero standards. By implementing a robust workflow approach and taking advantage of various opportunities, building professionals are demonstrating their dedication to this ambitious goal. While there are still some hurdles to overcome, such as acquiring suitable tools, bridging the performance gap, and complying with regulations, we must continue to move forward by prioritising proper certification and considering technical aspects and implementation at every stage. By working together with determination and collaboration, we can successfully tackle these challenges and reach net zero standards in the construction industry.

07.

Recommendations

Chapter 7. Recommendations

Thus far and as evidenced by the number of Local Authorities and other organisations developing their own standards, there is clear appetite for change. However, approaches currently being adopted vary hugely in terms of what is included and how far they go. For example, the Glasgow Standard includes a wide range of issues from space and accessibility and secure by design requirements through to energy and materials, many of which are already covered by Building Standards but others which are not.

- Many local authorities are rolling in wider sustainability targets to their design guidelines. There is also evidence of a move to adopt energy performance-based targets (kWh/m^2/annum) rather than fabric standards and U-value based solutions – although how these are achieved also varies considerably. This has made it difficult to make meaningful comparisons across the board.

- Discussion with the SFT, City of Edinburgh and the RIAS highlighted that there is an option to follow a hybrid path and that this could simplify the existing system. Notwithstanding testing and certification, following the Passivhaus requirements could remove the need to constantly review our own standards but would not remove the option to continue to use SAP and SBEM (or alternatives that may follow), provided that any conflict in terms of in-built syetems (heat pumps, ventilation options) are streamlined.

- It is worth noting that most local authorities included in the research make reference to Section 7 within their local standards. This reinforces the general progression towards holistic standards and points to the need to continue to develop this section of Building Standards as we move forward on shaping the delivery of Net Zero through building regulation.

- The Belgian and Mexican experiences offer much to learn from, although we have not quite bottomed out how well they are running at this point in time. The recommended reading on the Belgian case study provides significant insights which could support a way ahead. The exact nature of the relationships both countries have with the Passivhaus Institute remains unknown, but under investigation. A similar exercise is underway for the model being adopted in Vancouver.

- While the expert group had mixed views about the value of Passivhaus without certification, the Belgian model suggests that high performance levels are possible through the building standards, particularly if airtightness levels are strictly applied and buildings are monitored. Given the direction of travel of our current Section 6 standards with respect to air tightness, fabric energy efficiency and ventilation requirements it could be argued that if a Passivhaus equivalent fabric and ventilation standard is adopted, the outcomes will inevitably be a significant improvement on the status quo. If we want to move towards net zero in one step, some level of certification will be required. This could tie in with current work on compliance.

- The implementation of net zero standards in the construction industry in Scotland is not without its challenges. Building professionals may struggle to find and utilise appropriate tools like PHPP. Additionally, compliance with regulations is heavily reliant on local authorities and councils. To achieve net zero targets, the performance gap – the difference between design and actual construction – must be addressed. The U-value testing methodology is not yet fully established in the construction industry, especially for non-domestic buildings. It is also crucial to ensure that building systems, such as heat pumps and MVHR systems, are not oversized to prevent unnecessary energy consumption and increased costs. Addressing these challenges with confidence is necessary to transition to net zero standards in the construction industry successfully. There remains a question over the clash between the potential health benefits of whole house, controlled ventilation vs the maintenance of the systems providing the fresh air. For owner occupiers and private landlords, maintenance will come at a cost and will require willingness to deliver, within local authorities and social housing providers, this is arguably something that can be built into maintenance schedules, but it still comes at a cost. Alternatives such as DMEV have similar issues. The risk is that something could be written into regulation that backfires due to associated unintended health risks.

- Key aspects that appear to be supported by all include: the need for a fabric first approach to ensure a just transition and guidance on the following (as these are at variance): evidence-based recommendations on mechanical ventilation and heat recovery; the benefits (or otherwise) of adopting minimum energy performance targets and what these should be; standards / regulations on testing, compliance and monitoring of performance; the role, application and effectiveness of renewables; and guidance on passive design.

Appendices

Appendices

Appendix A: Workshop 1 & 2 report and list of participants

Scottish Building Standards: Energy Standards

Workshop 1 & 2 summary report

Prepared by:
Built Environment - Smarter Transformation

Overview:
This report captures the feedback from Scottish Building Standards: Energy Standards Workshops for Research + Innovation of Energy Standards. The workshops were facilitated by Construction Scotland Innovation Centre, on behalf of the Scottish Building Standards Division, on the 24th 25th March & 29th April and sought to capture feedback from a range of industry, academic and policy experts.
The feedback contained in this report is not attributed to any individual or organisation and provides a summary of key and recurring points raised by contributors.

Workshop 1

Challenges & Barriers

The workshop initially focused on identifying perceived key challenges and barriers associated with the adoption of low carbon construction techniques and methods. It considered a variety of perspectives relating to design, specification, construction and occupancy stages, as well as issues relating to workforce, policy, and supply chain development. Key points are captured below;

A competent workforce and resilient supply chain

- Ensure all organisations have access to training, ensuring skills needed to deliver/ ensure that the technology supply chain is robust and ready Competence (All sectors) of operatives, supervisors and managers Consumer/client education is key
- We need consistency in language being used in the way targets are being set Labour resources and skills shortages, skills mismatch
- How do we embed competence through the supply chain? We need to remain competitive on labour
- Project budgets and false economies
- Lack of performance in-use requirements is a barrier

Challenges and Barriers

Policy + Procurement

- Big increase in adoption from contractors - policy as a driver is useful
- Funding mechanisms need to be clear and aligned with policy

Enabling infrastructure

- Crossover with Embodied Requirements/ future regulation of embodied carbon Embodied energy must be considered
- Embodied carbon – insurance
- Poor SAP capability/ Timelines tight for new skills

Opportunities

Having discussed and identified areas that challenged the construction sector. The focus was then on what are the opportunities and, in many cases, although identified as a barrier there was often a result as a solution.

<u>A competent workforce and resilient supply chain</u>

- Scotland should be able to lead using the skills and solutions we already have - e.g., familiarity with timber kit
- Setting baseline quality standards will accelerate upskilling AECB standards/work of orgs like SEDA etc
- Increased use of certification / qualified professionals

Opportunities

Policy + Procurement

- Construction Accord and quality improvement collaboration
- Demonstrate compliance through following high-quality standards and processes
- Net zero strategy for life cycle of building/ net zero strategy within the building regulations

Enabling infrastructure

- Embody and improved reporting, supporting towards a green industry rather than just greening the building
- Construction Embodied Carbon (A Modules of WLC) could be a good fit next step, as it can be verified by handover
- Circular economy
- Energy performance calculations - can we change / adjust / improve these to minimise performance gap?
- Can we accept other calcs to meet the standard such as PHPP?

Fabric First

- Passivhaus, building fabric
- Opportunity to learn from various Low Carbon approaches (in addition to Passivhaus)

Opportunities

<u>Modern Method of Construction (MMC)</u>

- Opportunity for upscaling offsite manufacture on a larger scale
- Standardise delivery through Design for Manufacture and Assembly
- Role of Offsite/ MMC in delivering consistency
- Enhanced use of timber and engineered timber systems
- Circular economy /design for deconstruction

<u>Implementation & Standardisation</u>

- Opportunity to use design principles to drive positive change + green the construction industry
- Inspection regimes and performance gap. More scrutiny at completion / testing

Unlocking value

Keeping these key areas and topics in mind, the workshop then focussed on developing the discussions around how the industry can collaborate and take specific opportunities forward.

Sharing Knowledge

- Knowledge, communication, clarity and transparency of standards Consumers are ready and accepting of new technologies
- Role of Offsite/MMC
- Future regulation of embodied carbon
- Alignment with retrofit applications of low carbon heat technologies

Implementation & Standardisation

- Standardised terminology and reporting methodology
- Grid Readiness and electrical demand
- Coordination required with government Mainstreaming good practice
- Standardisation of design and system specifications

A competent workforce and resilient supply chain

- Access to the skills needed to deliver requirements Supply chain is robust and ready
- Baseline quality standards to accelerate upskilling
- The role of colleges and local authorities in facilitating delivery

Costs & Funding

- Cost effective solutions
- Cost argument benefits of net zero
- Performance linked funding

Workshop 2

The workshop focussed on next steps and recommendations outlined in Workshop 1 - Support effective knowledge exchange and better collaboration. What needs to change to ensure we have a skilled, knowledgeable, and competent workforce and finally how can funding mechanisms and approaches be better aligned with policy aspirations?

Opportunities & Considerations

As we prepare for enhanced standards in 2024, what can we do now to support effective knowledge exchange that prepares businesses to respond to the anticipated changes? How can we support better collaboration between key stakeholders to adopt and mainstream future standards more effectively? How can funding mechanisms and approaches be better aligned with policy aspirations? How do we ensure procurement models are incentivising best practice? Are there good examples we can learn from?

Opportunities & Considerations

Knowledge Exchange

- Create a data base/mapping exercise of all work groups taking place
- A library of best practice examples/case studies - covering methodologies (covering tools, processes etc)
- BE-ST act as central knowledge base - disseminating best practice showcase best practice examples, Passivhaus and EnerPHit project
- Demonstrator programmes need clear targets now so that industry know what & where they are aiming for/going towards
- Value of comparing monitoring with modelling
- Database of buildings that have already achieved the target performance

Workforce & Skills

- Partnership working, knowledge and learning exchanges.
- Competency assessment & skills gap analysis undertaken
- Information/signposting training routes and organisations
- Establish a consensus on Objectives and invite write-ups of solutions to get there
- Scaling up availability of assessors if we move e.g., to Passivhaus
- Break down silos between architectural, built environment and engineering courses - AECB have Carbon Lite rates per institution that could be explored to access resources immediately

Opportunities & Considerations

Dissemination

- Strategy for increasing offsite construction for affordable housing
- Early identification and sharing of targets
- Create and industry we need a road map with clear language and targets
- Promote case study tours including Scottish specific buildings
- Run learning and knowledge sharing events
- Public Education and Engagement Programme Element of Hub: behaviours and operation - inviting the public along and explaining what is happening and why (mass-accessibility and dissemination through a variety of formats)

Collaboration

- Involve academic institutions/colleges - prepare education to cover new standards and the ambition
- Individual road maps - domestic /non domestic /retrofit Energy Sector Involvement
- Create a strategic plan - i.e. a carbon roadmap
- Live project involving clients
- Collaboration that focuses on tools and delivery seasonal commissioning Living Futures Europe
- Demonstrate/evidence the benefits to organisations of partnership working/sharing expertise.
- Organisations such as Passivhaus Trust, AECB, LETI (The London Energy Transformation Initiative)
- Better understanding required on 'value' of low energy buildings from surveyors - engage with RICS

Opportunities & Considerations

Targets

- Align with Warmer Homes, Heat in Buildings Strategy, SFT (Scottish Futures Trust)
- SFT approach for LEIP (Learning Estate Investment Programme) has worked well
- Smart controls in performance measurement Dealing with emissions factors (underway)
- A feedback loop and POE programme need be in place to verify the performance of new standards at scale
- Need to balance the needs and asks of planning gain with the provision of high performance homes which comes at a cost.

Standards

- Whole Life Carbon Benchmarking (by typology - LETI / RIBA Standards exist Certified designers, QA certifiers of buildings, certified components
- A feedback loop and POE programme need be in place to verify the performance of new standards
- Standard methods of measurement
- SFT /Scottish Government net zero standard for encourage more use of performance linked funding i.e. LEIP
- PHPP as a compliance tool, already used widely on low energy projects around the UK - recognised as an accurate and useful tool
- Align with industry expert groups - LETI-CIBSE Zero carbon definitions Passivhaus Low Carbon Building standard
- Create opportunities and expanded roles for BSD's Accredited Schemes (e.g. Approved Certifier of Design - Energy)
- Don't sink time into developing a new standard when others exist and work i.e., LETI, Passivhaus etc
- Measured performance for EPCs Passivhaus accredited components
- Encourage all councils to set mandatory higher standards for social housing

Opportunities & Considerations

Finance, Funding & Procurement

- Engagement with surveyors and mortgage valuers to reflect intrinsic value in zero carbon homes
- Customer engagement - how do people want to live, what are their priorities. Overcoming commercial know how and first mover advantage
- A feedback loop and POE programme need be in place to verify the performance of new standards at scale
- Fund training/ support colleges/ Uni's etc to deliver the 'new' skills
- Fund training for contractors in Passivhaus and Retrofit Skills -ongoing to 2024 and beyond
- Value creation from lenders, valuators, insurers to recognise the benefit of NZ homes to offset costs

Development needs

What needs to change to ensure we have a skilled, knowledgeable, and competent workforce equipped to deliver on the future pipeline of work? Are there supply chain development needs we should focus on?

Knowledge

- Maintenance is as important (if not more) as installation
- More tools required to measure building performance
- Growing local supply chains important rather than importing
- Educate customers on everyday living in all electric homes
- Architecture schools, engineering schools, construction colleges etc connected to BE-ST to embed building performance into their students learning

Skills

- Targeted incentives for gas installers, build on existing gas frameworks Upskilling required - fabric performance skills
- More skills to develop electrification of homes and communities
- Need to look at skillsets of clients and designers (and other consultants) as well as supply chain
- Design & technical skills for low carbon technology Digital skills essential
- Upskilling required in building services
- Some work has commenced on demand modelling for skills required and this should be accelerated

Next Steps

The outputs from these workshops will support and inform the Energy Standard Report. The Energy Standard Report will cover the following areas.

Summarise current activity in the application and delivery of Passivhaus certified buildings in the UK at this time. This will include industry views on implementation options and an interrogation of the benefits of enabling such an approach on a regulatory basis.

Undertake a literature review and route map with successful case studies and the benefits and risks of taking an approach to regulation which follows that of Passivhaus and low carbon building standards in terms of design components, prescription on performance and certification.

An examination on a sectoral/sub-sector basis–new homes, new commercial, new public sector, specific and more specialised building types in this context. Consider application of such a standard in the context of broader heat decarbonisation policy as set out in the Heat in Buildings Strategy, including the proposals for the 2024 New Build Heat Standard.

This process should lead to ongoing discussion with industry and stakeholders on what capacity there is for further improvement to energy standards in the short term and what alternatives to current consultation proposals and approach may be viable considerations.

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Note: Built Environment Smarter Transformation has been engaged to carry out this consultative work as an independent advisor to the Scottish Building Standards Division. To provide feedback on this report please contact Caitriona Jordan: cjordan@be-st.build

Scottish Building Standards: Energy Standards

Workshop 1 & 2 summary report

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Appendix B: Workshop 3 Draft report and list of participants

Scottish Building Standards: Energy Standards

Workshop 3 summary report

Prepared by: Built Environment – Smarter Transition

Overview

This report captures the feedback and discussion from the **Scottish Building Standards: Energy Standards - Good practice in the delivery of very low energy new buildings Workshop.** This workshop was facilitated by Built Environment – Smarter Transition on behalf of the Scottish Building Standards Division on 14th of October 2022. The workshop sought to capture feedback from a range of industry experts.

The feedback contained in the report is not attributed to any individual or organisation and provides a summary of key and recurrent themes raised by contributors.

Certification, standards compliance + risks

Theoretically could the industry deliver to Passivhaus standard using current practices?

Feedback & Key Considerations

- Certification is required to help enforce change.
- Possibility of testing one year after build to ensure quality of build.
- Building warrant inspection workflow, could accommodate testing.
- Mechanism to retest once the building is operational.
- Standards adopted and fully integrated in industry.
- Using the right tools - PHPP Planning Package.
- Could a few local authorities take the lead and provide the service to other authorities on a consultancy basis?
- Don't even need to mention 'passivhaus; just outline the performance requirements!
- A transition agency, informed by Passive House Institute which establishes frameworks within the existing building warrant process, so the checks are seamlessly built in.
- Need to reduce resistance from councils.
- Don't make the mistake that Dublin did - energy performance standards - rather than 'passivhaus'.
- Without proper monitoring/testing exposes risk of not meeting standard.
- Performance gap between initial design and post op evaluation.
- Range of standards rather than a defined 'passivhaus' standard.
- Post Occupancy Evaluation needs to be more robust.

Changes to construction practices
What changes to construction practice might be required?

- Culture change, too much resistance to change.
- Some U-Value modelling guidance showing true modelling requirements for steel frame the basic construction of non-domestic buildings in Scotland.
- Constraints on grid a critical consideration
- Predictions for new 'de-carbonised' sites are grossly oversized.
- Risk of oversizing Heat Pumps
- Passivhaus system integrated to the Building Control system-qualified within each council team.
- Short term agency and longer-term Building Control officer trained.

- When ‘passivhaus’ construction becomes more integrated
- LA/COSLA resistance? light touch training for Building Control Officers
- A transition agency leading to adoption within Building Control over time.
- Architects/industry professionals post Hackett report recommendations will need to undertake regular competency testing for CDM
- Collation of design and construction evidence, efficient compliant design, and extended liability for building professionals.
- Taking a robust workflow is better protection against this extended liability.

Passivhaus standards – pro’s & con’s (considering social and developer led housing)

How would we ensure compliance without certifying?

Are there other risks associated with not certifying?

Are these significant in terms of performance improvement over the status quo?

- Belgium sector by sector approach, some sectors more receptive
- Sector by sector basis adoption
- Unless its whole neighbourhoods across major public spend, billions will go into this infrastructure to deal with essentially decreased demand on the grid
- Methodology is the same with 50kWhh or 15kWh, key is the building warrant inspection workflow as it can fully accommodate it
- All ties in with the building safety bill. the golden thread. all this change is coming whether people like it or not.

Alternatives to Passivhaus;

The direction of travel across Europe is on Minimum Energy Performance Standards (MEPS) based on annual energy consumption figures in kWh/m2/annum. The targets vary from country to country based on 4 defined climate zones (Mediterranean, Oceanic, Continental and Nordic). Scotland aligns with the Oceanic group.

What might be the Scottish alternatives to current practice if we adopt an MEP approach?

Passivhoos, Carbon Lite, AECB, other Local Authority or independent standard?

- The PHI developed a tool for undertaking PHPP calculations in hot and humid climates, based on Passivhaus algorithms (DEEVi - Diseño Energéticamente Eficiente de la Vivienda)[30] specifically for Mexico. While the technical side is good and very similar to the 'passivhaus' standard, problem was the implementation through the industry and contractors and local authorities not keeping up with the changes.
- Liliana Campos-Arriaga could be a good point of contact to discuss the lessons learned about the implementation.
- LETI guidance is a good model to build upon
- LETI standard says everything except 'passivhaus', without so much focus on U–Values
- Review of what happened in Brussels? made their own version - own certifications, 2015 adoption in Brussels.
- Using the right tool PHPP Planning Package

30 https://passipedia.org/basics/passive_houses_in_different_climates/passive_house_in_tropical_climates/building_passive_houses_in_mexico_laif

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Appendix C: Passivhaus

Passivhaus

Passivhaus has three options:

Passivhaus Classic; **Passivhaus Low Energy Building**, **Passivhaus Plus and Passivhaus Premium**

The tables below refer to the **Passivhaus Classic** standard has a specific target for space heating demand (of 15 kWh/m^2/annum) and then an overall primary energy target for all energy uses. Whilst this can be achieved in several ways, a typical average sized dwelling has been modelled.

The **Passivhaus Plus** standard is similar to the Passivhaus Classic standard other than the delivered energy demand reduces from 60 kWh/m^2/annum to 45 kWh/m^2/annum inclusive of an allowance for storage losses of around 30%. The space heating demand limit remains at 15 kWh/m^2/annum. This standard is very difficult to achieve with a gas boiler but, is achievable using an Air Source Heat Pump. Passivhaus Plus also introduces a renewable energy generation requirement of 60 kWh/m^2/annum based on the building footprint area.

Finally, **Passivhaus Premium** is similar to Passivhaus Plus other than the delivered energy demand reduces further to 30 kWh/m^2/annum including storage losses and the generation requirement increases to 120 kWh/m^2/annum. This standard is only achievable by reducing space heating demand further as well as reducing hot water demand and unregulated energy.

The **Passivhaus Low Energy Building** standard is identical to the Passivhaus Classic standard other than the space heating demand is relaxed to 30 kWh/m^2/annum. This is relevant in cases where buildings which do not comply with one or more of the Passivhaus or EnerPHit criteria may still satisfy the PHI Low Energy Building Standard.

Passivhaus Standards beyond **Classic** have a requirement for on-site energy generation in order to minimise delivered energy requirements, based on % rook given over to solar pv panels and energy storage.

Further information on the range of options being considered and adopted, beyond current Section 6 (2015) Standards are outlined below. It should be noted that these standards do not compare like with like as the required elements of one approach do not apply to another. We have focused on the comparable elements as much as possible and have summarised the specifics of the highlighted standards below each table.

Appendix D: Other organisations delivering beyond building standards

Architects

John Gilbert Architects

John Gilbert Architects (JGA) have built several housing projects to S7 Silver and Gold standard and to the Glasgow Standard for a range of clients (mainly social housing providers). We are working on projects to EnerPHit standard and AECB retrofit standard but have not been completed yet.

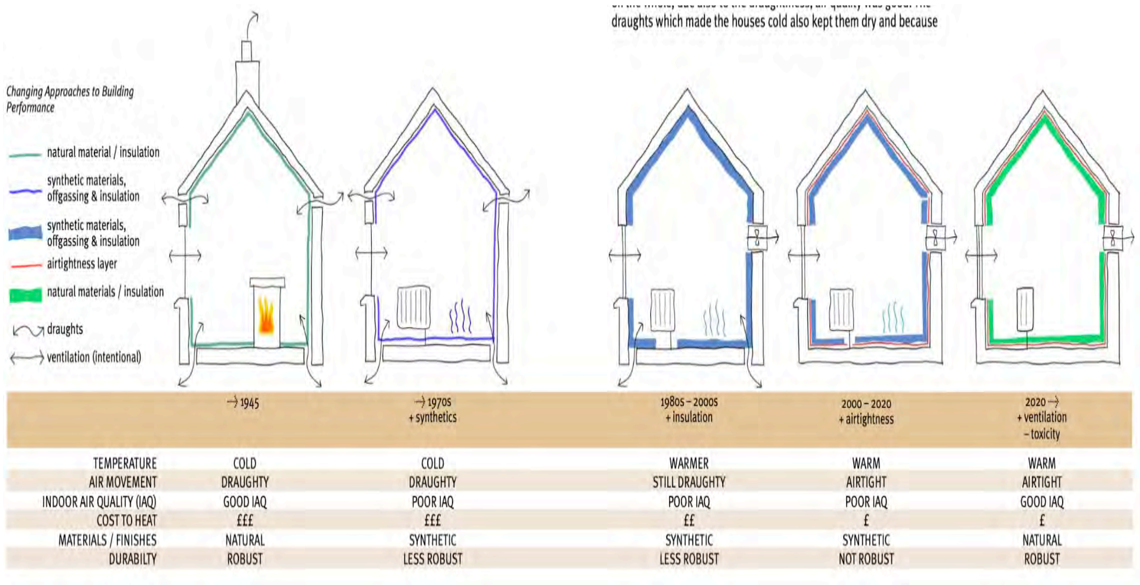

Figure AD 1 Progression to net zero avoiding risks (JGA with Stewart & Shields)

Key projects:

- Passivhoos KTP (2019 to 2022) with assorted documents and knowledge (unfortunately this was very much disrupted by the pandemic);
- Closeburn Passivhoos project (3 houses), constructed, certified Passivhaus and monitored by JGA as part of the Passivhoos KTP (see case studies);
- St Boswells Passivhoos project (3 houses), constructed, certified Passivhaus and monitored by JGA as part of the Passivhoos KTP (see case studies);
- Carntyne Church Passivhoos project (5 flats) constructed, certified Passivhaus and monitored by JGA as part of the Passivhoos KTP (see case studies);
- Linn Walk (10 dwelling) - Passivhaus standard but not certified;
- Halton Mill (20 dwellings) - Passivhaus certified;
- Niddrie Road Retrofit project;
- Hab-Lab retrofit monitoring and project work;
- *Sussed* non-domestic Passivhaus projects of around £200m development in design phase.

Anderson Bell + Christie
Anderson Bell + Christie developed the net zero standard for newbuild housing for City of Edinburgh Council based on their net zero standard.

Gokay Deveci
Delivery of the first Passivhaus social housing development in Scotland - Tigh-Na-Cladach – in Dunoon, for Fyne Homes (see case studies).

Architype
Deliver Passivhaus as standard on all projects wherever possible, client willing.

Smith Scott Mullan Associates
Smith, Scott, Mullan developed the Midlothian Design Guide for newbuild and retrofit (domestic and non-domestic) buildings.

White Hill Studio
Dormont Estate Passivhaus homes were designed by White Hill studio Architects and delivered in association with CCG using modern methods of construction/ closed panel timber frames delivered by lorry for erection on site. The homes were delivered in 2011 to Passivhaus Standards and still exceed current building regulation standards for energy efficiency (see case studies).

Neil Sutherland Architects
Gale Centre (see case studies).

ECD Architects
Hanover Housing (see case studies).

Contractors and Developers

Contractors and developers that are already geared up and delivering to Passivhaus and other local authority specific standards are listed below:

Barratt's
Campion Homes (Kingdom HA)
CCG
Coldwells
Cruden
HOME Group
Igloo
Morrison's
Robertson's
Stewart Milne
Stewart and Shields

Clients: Registered Social Landlords/ Community Trusts
The Registered Social Landlords (RSLs) listed below were identified as already adopting a Passivhaus or non-certified 'Passivhaus Standard' (i.e. meeting all the criteria of Passivhaus – but without formal certification); or a standard of their own that is 'towards' Passivhaus (i.e. adopting what they consider to be deliverable now). There may be more adopting a similar approach, but the following were identified

through the Passive House Trust and leading passive house designers in the field and are considered to be representative of best practice. These case studies are explored in more detail later in this document.

- Fyne Homes – Tigh-na-Cladach
- West of Scotland - https://www.sfha.co.uk/news/news-category/sector-news/news-article/wsha-given-go-ahead-for-glasgows-largest-passivhaus-development
- Sanctuary - https://www.sfha.co.uk/news/news-category/sector-news/news-article/sanctuary-delivers-energy-efficient-homes
- Kingdom - https://www.sfha.co.uk/news/news-category/sector-news/news-article/passivhaus-development-gets-underway-in-fife
- Eildon - https://www.sfha.co.uk/news/news-category/sector-news/news-article/eildon-continues-to-deliver-new-homes-across-the-borders
- Shettleston - https://www.sfha.co.uk/news/news-category/sector-news/news-article/first-passivhaus-development-opened-in-glasgow
- Hanover - https://www.sfha.co.uk/news/news-category/sector-news/news-article/work-starts-on-hanovers-first-passivhaus-social-housing-development
- Loreburn - https://www.sfha.co.uk/news/news-category/sector-news/news-article/loreburn-housing-association-and-rbs-agree-additional-20m-funding-for-new-social-housing

Appendix E: Summary of progress to date in EU member states.

Country/ Region	Was nZEB legislation in place for public buildings by January 2019?	Was nZEB legislation in place for all buildings by January 2021?	Is there a numerical indicator of primary energy use expressed in kWh/m^2 per year	Are renewable energy requirements clearly specified?
Austria	Y	Y	**X**	Y
BE: Brussels	Y	Y	Y	**X**
BE: Flanders	Y	Y	**X**	Y
BE: Wallonia	Y	Y	Y	**X**
Bulgaria	**X**	**X**	Y	Y
Croatia	Y	Y	Y	Y
Cyprus	Y	Y	Y	**X**
Czechia	Y	Y	Y	**X**
Denmark	Y	Y	Y	Y
Estonia	Y	Y	Y	**X**
Finland	Y	Y	Y	**X**
France	Y	Y	Y	Y
Germany	**X**	Y	**X**	Y
Greece	**X**	**X**	Y	Y
Hungary	**X**	**X**	Y	Y
Ireland	Y	Y	Y	Y
Italy	Y	Y	**X**	Y
Latvia	Y	Y	Y	**X**
Lithuania	Y	Y	Y	Y
Luxembourg	Y	Y	**X**	**X**
Malta	Y	Y	Y	**X**
Netherlands	Y	Y	Y	Y
Poland	Y	Y	Y	**X**
Portugal	Y	Y	**X**	Y
Romania	Y	Y	Y	Y
Slovakia	Y	Y	Y	**X**
Slovenia	Y	Y	Y	Y
Spain	**X**	Y	Y	Y
Sweden	Y	Y	Y	**X**

Appendix F: EU Member States - Retrofit Milestones

Member States were required to provide new comprehensive long-term renovation strategies (LTRS) by 10 March 2020 that includes:

- Milestones (indicative) for 2030, 2040 and 2050
- Explanation of the contribution to the overall EU energy efficiency target for 2030
- Overview of the national building stock
- Expected share of renovated buildings in 2020
- Approaches to renovation relevant to the building type and climatic zone, including potentially relevant trigger points
- Policies and actions to stimulate cost-effective deep renovation of buildings, including staged deep renovation, for example by introducing an optional scheme for building renovation passports
- Policies and actions to target the worst-performing segments of the national building stock, split incentive dilemmas and market failures
- Actions that contribute to the alleviation of energy poverty
- Policies and actions to target all public buildings
- Initiatives to promote smart technologies and well-connected buildings and communities • Initiatives to promote skills and education in the construction and energy efficiency sectors
- An estimate of expected energy savings and wider benefits, such as those related to health, safety and air quality.

Member States must also carry out a public consultation on the strategy, include a summary of the results of the consultation as an annex to the strategy, and continue inclusive consultations during implementation.

The LTRS should also include details on progress with implementation of the current strategy, submitted to the European Commission in 2017. Member States will need to update their strategy by June 2024 as part of their NECP (National Energy and Climate Plans) under the Governance Regulation [13] and supply a further new and updated version by January 2029 as part of the second NECP [14].

The EPBD also says that Member States may use LTRS to addresses fire safety and risks related to intense seismic activity that affect energy efficiency renovations, indicating another way in which non-energy related renovation can be combined with energy efficiency upgrades. To develop and deliver a renovation strategy Member States should complete all the sections and follow a series of key steps, divided into six phases (kick-off, technical appraisal, socio-economic appraisal, policy appraisal, policy package design and implementation). The steps also include a stakeholder consultation throughout the process and a feedback loop to review and regularly update the strategy (Figure AF 1).

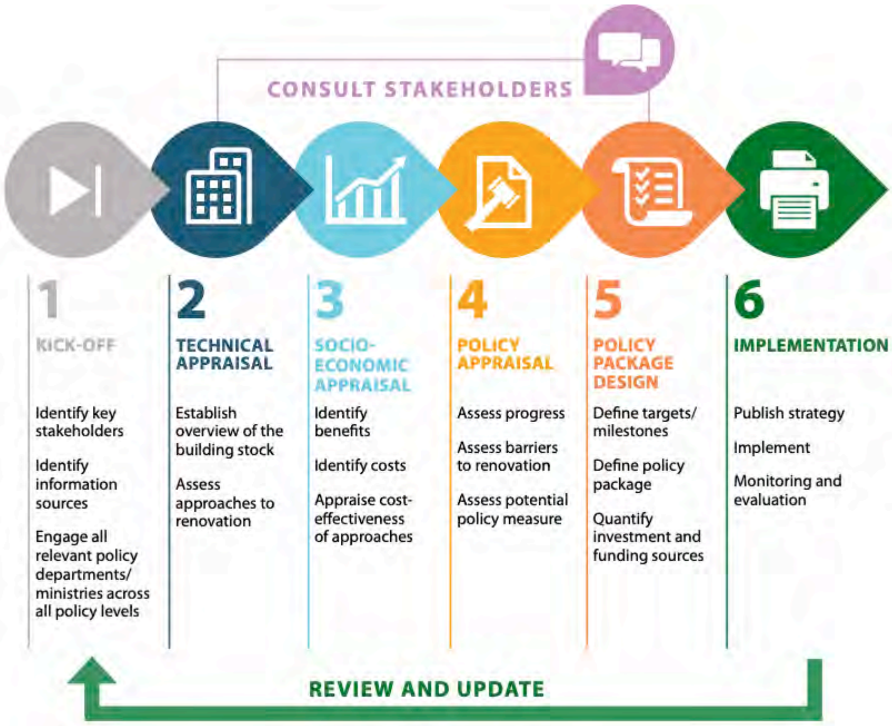

Figure AF 1 - Phases in developing a renovation strategy (BPIE - guidebook to building -policy)[31]

Trigger points

Trigger points are key moments in the life of a building (e.g. rental, sale, change of use, extension, repair or maintenance work) when carrying out energy renovations would be less disruptive and more economically advantageous than at other moments, since a renovation or a building intervention would happen regardless, making it an ideal time to execute energy performance upgrades as well.

The EPBD refers to a trigger point as “an opportune moment in the life-cycle of a building, for example from a cost-effectiveness or disruption perspective, for carrying out energy efficiency renovations”, and states that Member States shall identify cost-effective approaches to renovation considering potential relevant trigger points in the life-cycle of a building.

Taking advantage of these occasions would facilitate investment decisions to undertake energy renovation works. They can be prompted by practical opportunities (e.g. a need for repairs or maintenance, or building an extension), personal circumstances (e.g. a new-born in the family, retirement or children moving out), or change of ownership (e.g. new tenants, new owners, putting a property on sale), as well as unexpected events like a fire, earthquake or flood.

Including energy efficient renovations at trigger points provides the chance of making the entire process of upgrading a building more cost-effective, limiting the risk of missing opportunities to renovate and increase possible synergies with other actions (i.e. avoiding lock-in effects) as well as delivering additional benefits such as

[31] https://www.bpie.eu/publication/a-guidebook-to-european-building-policy-key-legislation-and-initiatives/

improved indoor air quality, with a positive impact for comfort, health and productivity.

To guarantee the expected results, policies identifying trigger points could be tailored to the building type (e.g. single-family buildings vs. multi-family buildings, schools and kindergartens vs. office buildings, etc.), accompanied by additional targeted measures promoting deep renovation (such as building renovation passports and minimum energy performance requirements for specific building types, like commercial and public buildings), and properly integrated into medium- and long-term planning.

Examples from EU Member States

Italy: Mandatory requirements in case of building extensions

In the autonomous province of Bolzano, from 2019, owners of buildings have been allowed to expand the surface of their dwelling by up to 20%, or up to 200 m^2 , but only if the refurbished building achieves an energy need for heating below 70kWh/m2 /year.

Poland: Improvement of energy performance in case of other works

In Poland, in case of building renovation, the reconstructed elements must meet the existing levels of thermal insulation for new buildings. For example, if an external wall is rebuilt it must be insulated respecting current U-value requirements.

France: Mandatory renovation within a specific timeframe

In France, the energy transition law19 for green growth foresees a renovation obligation for private residential buildings whose primary energy consumption exceeds 330 kWh/m². This affects all buildings with an energy performance rating in either of the two lowest bands, F or G. These buildings, both rented and owner-occupied, must be renovated as follows:

• By 2025, all class F and G buildings must be renovated. Improvements should be close to the performance of a new building.

• By 2050, all buildings must be in class A or B (based on the French EPC), reaching BBC20 levels or equivalent.