PAS 2035:2019

Retrofitting dwellings for improved energy efficiency – Specification and guidance






Department for Business, Energy & Industrial Strategy

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Contents

Foreword

This PAS was sponsored by the Department for Business, Energy and Industrial Strategy (BEIS). Its development was facilitated by BSI Standards Limited and it was published under licence from The British Standards Institution. It comes into effect on 30 June 2019.

Acknowledgement is given to Dr. Peter Rickaby, BSI Retrofit Standards Task Group, as the technical author, and the following organizations that were involved in the development of this PAS as members of the steering group:

- Association for Environment Conscious Building (AECB)
- British Board of Agrément (BBA)
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- BSI Retrofit Standards Task Group
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- Building Services Research and Information Association (BSRIA)
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- Cavity Insulation Guarantee Agency (CIGA)
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- Historic Environment Scotland (HES)
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- Ministry of Housing, Communities and Local Government (MHCLG)
- National Inspection Council for Electrical Installation Contracting (NICEIC)
- National Insulation Association (NIA)
- Office of Gas and Electricity Markets (Ofgem)
- Oil Firing Technical Association (Oftec)
- Prewett Bizley Architects
- Rockwool
- Solid Wall Insulation Guarantee Agency (SWIGA)
- Sustainable Traditional Buildings Alliance (STBA)
- THS Inspection Services Ltd
- TrustMark
- United Kingdom Accreditation Service (UKAS)

Acknowledgement is also given to the members of a wider review panel who were consulted in the development of this PAS.

This PAS is not to be regarded as a British Standard. It will be withdrawn upon publication of its content in, or as, a British Standard.

The PAS process enables a Specification to be rapidly developed in order to fulfil an immediate need in industry. A PAS can be considered for further development as a British Standard, or constitute part of the UK input into the development of a European or International Standard.

Supersession

Together with PAS 2030:2019, this PAS supersedes PAS 2030:2017, which will be withdrawn on 31 January 2021.

Relationship with other publications

PAS 2035 is intended to be read, and used, in conjunction with the current version of PAS 2030.

Information about this document

The PAS provides a specification for the energy retrofit of domestic buildings and best practice guidance about domestic retrofit projects. It is intended not only to support the Each Home Counts quality mark (now known as the TrustMark Government endorsed quality scheme) for domestic retrofit (see Clause **1**) but also to be applied to any domestic retrofit work carried out in the UK.

PAS 2035 is published with the expectation that users intending to claim compliance with it will commence adoption of its provisions immediately following publication with a view to fully meeting its requirements and claiming compliance with PAS 2035:2019 and therefore also PAS 2030:2019, by 31 January 2021. During this period PAS 2030:2017 remains available for use where required but will be withdrawn on 31 January 2021.

Use of this document

It has been assumed in the preparation of this PAS that the execution of its provisions will be entrusted to a competent person or persons for whose use it has been produced.

This PAS is not to be regarded as a British Standard, European Standard or International Standard. In the event that this PAS is used to form the basis of a full British Standard, European Standard or International Standard, it will be withdrawn.

BSI permits the reproduction of PAS 2035:2019, Figure **D.1**. This reproduction is only permitted where it is necessary for the user during the decision-making process for retrofit designs during each application of the PAS. A larger version of Figure **D.1** is available.

Presentational conventions

This PAS combines requirements for retrofit of domestic buildings with guidance about best practice in undertaking domestic retrofit projects.

Both requirements and guidance are presented in roman (i.e. upright) type, but they are distinguished in Clause and annex titles. Requirements are expressed in sentences in which the principal auxiliary verb is "shall". Recommendations and guidance are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material, e.g. notes, are presented in italic type, and do not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with this PAS does not confer immunity from legal obligations.

0 Introduction

0.1 Context

0.1.1 Statutory national targets for the reduction of greenhouse gas emissions in response to the threat of climate change imply that very significant improvements need to be made in the energy efficiency of the UK's building stock, including nearly all its 27 million domestic buildings. The EU objective is to achieve Near Zero Energy Buildings throughout the EU. This PAS supports work towards those objectives by promoting and defining technically robust and responsible "whole-building" domestic retrofit work, i.e. high-quality work, that supports:

- improved functionality, usability and durability of buildings;
- improved comfort, health and well-being of building occupants and visitors;
- improved energy efficiency, leading to reduced fuel use, fuel costs and pollution (especially greenhouse gas emissions associated with energy use);
- reduced environmental impacts of buildings;
- protection and enhancement of the architectural and cultural heritage as represented by the building stock;
- avoidance of unintended consequences related to any of the above;
- minimization of the "performance gap" that occurs when reductions in fuel use, fuel cost and carbon dioxide emissions are not as large as intended or predicted.

0.1.2 The requirements and guidance presented in this PAS are intended to apply to improvement measures in the context of a holistic approach to retrofit that takes the points listed above into account. The holistic approach considers the building as a system of elements, interfaces and occupants that interact, and not as a set of elements that are independent of each other or of occupants' practices and lifestyle.

0.1.3 This PAS is intended to support both the one-off installation of improvement measures and a staged approach in which improvement measures are implemented over time. It is compatible with current national and EU schemes including the Building Performance Institute Europe scheme and Building Renovation Passports.

0.2 Each Home Counts

0.2.1 In 2015 the Government commissioned the Each Home Counts review [8] (originally known as the Bonfield Review) to determine ways of improving the confidence of both Government and consumers in the domestic retrofit industry and improving the quality of retrofit work. The report of the review published in December 2016 contains 27 recommendations including the establishment of a quality mark for domestic retrofit supported by an industry Code of Conduct, a Consumer Charter and a framework of technical standards for retrofit. The quality mark has subsequently been established as the TrustMark Government endorsed quality scheme.

0.3 The retrofit standards framework

0.3.1 PAS 2035 is the over-arching document in the retrofit standards framework, with which users of the TrustMark Government endorsed quality scheme are required to comply when carrying out domestic retrofit work. All the other standards referred to in this PAS are part of the retrofit standards framework (see Clause **16**); users of the TrustMark Government endorsed quality scheme should also comply with those standards, as appropriate. PAS 2035 may also be applied to retrofit projects outside the TrustMark quality assurance framework.

0.4 The relationship with PAS 2030

0.4.1 Designs for the installation of retrofit measures in domestic buildings that are prepared in accordance with PAS 2035 are required to be installed, commissioned and handed over in accordance with PAS 2030:2019, or in some cases in accordance with the Microgeneration Certification Scheme (MCS) standards [N7], [N8].

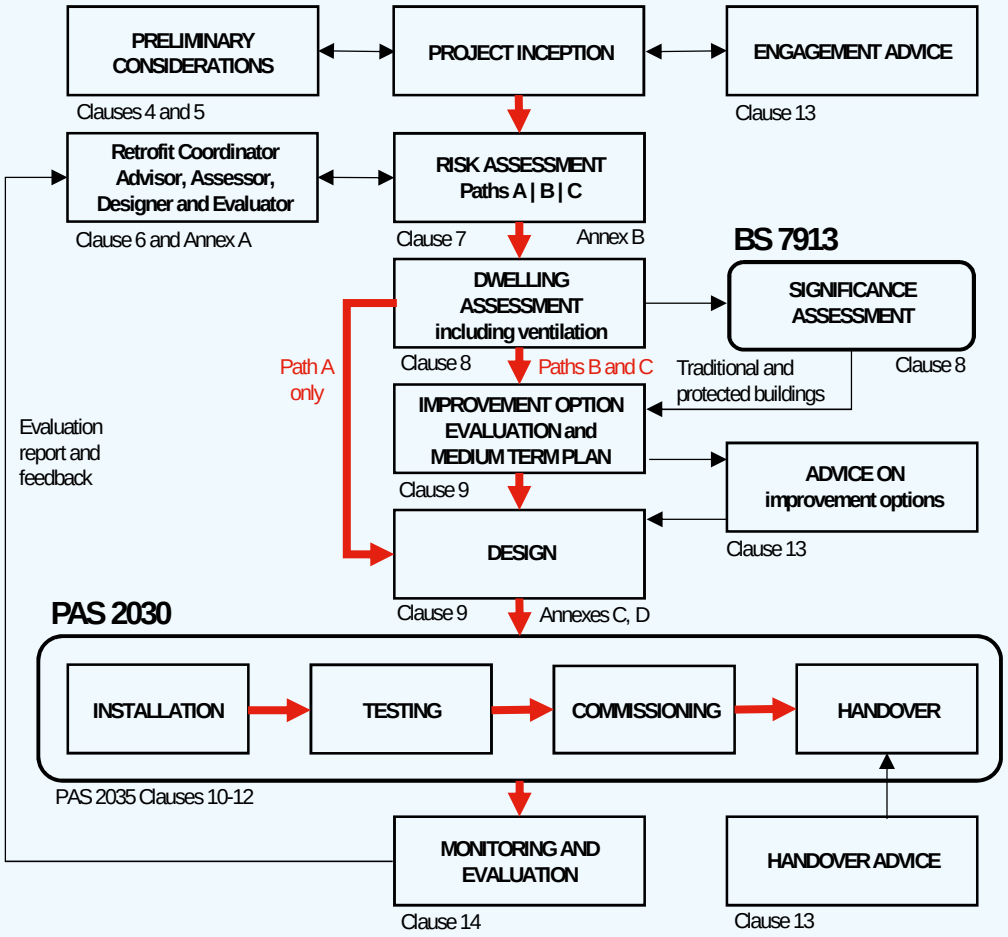
0.4.2 Requirements for the installation, commissioning and handover of retrofit measures are provided in PAS 2030, or in some cases in the MCS standards. Users of PAS 2030:2019 are required to work to designs that comply with this PAS.

0.4.3 Thus, for domestic retrofit projects, PAS 2035 and PAS 2030:2019 are effectively "locked together", because one standard may not be used without the other. The only exception is installation of some measures in accordance with the MCS standards, rather than PAS 2030, where specified.

0.5 The PAS 2035 process

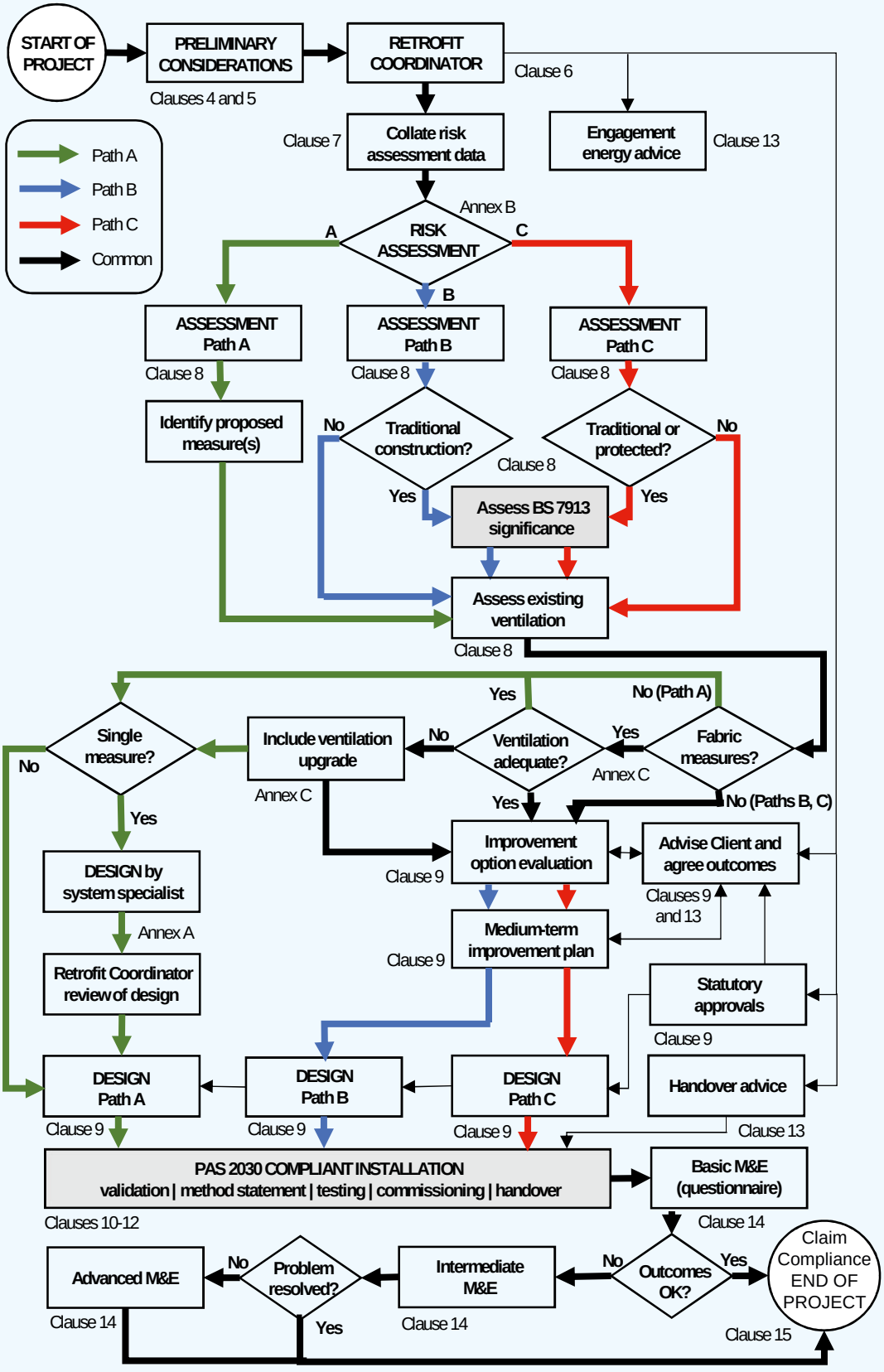
0.5.1 Figure **0.1** illustrates the broad overall process that users of PAS 2035 are expected to follow in order to comply with its requirements.

Figure 0.1 – A diagrammatic overview of the domestic retrofit process required by PAS 2035 and PAS 2030



0.5.2 Figure **0.2** illustrates in more detail the process that users of PAS 2035 are expected to follow in order to comply with its requirements.

Figure 0.2 – A flow-chart illustrating the domestic retrofit process that users are expected to follow in order to meet the requirements of PAS 2035



1 Scope

This PAS specifies requirements for retrofit of dwellings, including:

- assessment of dwellings for retrofit;
- identification and evaluation of improvement options (energy efficiency measures, or EEMs);
- design and specification of EEMs (whether individual measures or packages of multiple measures); and
- monitoring and evaluation of retrofit projects.

This PAS covers EEMs that are intended to:

- improve the insulation of the elements of the building fabric (exposed floors, walls, roofs, windows and external doors) and reduce thermal bridging;
- improve the air-tightness of the building envelope;
- establish a safe dynamic moisture equilibrium through each element of the building fabric;
- improve the resistance of the building envelope to water penetration in order to maintain the thermal properties of the building fabric and the capability of the building envelope to manage moisture in a manner suited to its construction;
- provide or upgrade ventilation to ensure good internal air quality and minimize the risk of condensation;
- minimize the risks associated with vapour or other products, for example volatile organic compounds (VOCs), released within buildings subsequent to their air-tightness being improved;
- minimize the risks associated with overheating;
- provide efficient heating and cooling systems with responsive, intelligent or "smart" controls, including systems that use low or zero carbon (LZC) technologies;
- provide efficient water heating systems with responsive controls, including systems that use LZC technologies;
- provide efficient fixed lighting with appropriate controls;
- provide efficient appliances and equipment to reduce electricity use and minimize internal heat gains;
- provide locally generated renewable electric power systems that use LZC technologies;
- provide on-site energy storage to improve the usefulness of energy generated by LZC technologies; and
- provide metering and monitoring systems to promote the efficient use of energy.

In addition to setting out requirements for the commissioning and handover of all of the above, this PAS also specifies requirements for advising building occupants about improvement options appropriate to their homes, and the efficient and appropriate use and maintenance of their retrofitted homes as well as for monitoring and evaluating retrofit projects when appropriate, and feeding back lessons learned to all parts of the supply chain, including the building occupants.

Many aspects of domestic retrofit are covered by existing standards. Where appropriate, those standards are referred to in this PAS, and compliance with the standards referred to is thereby a requirement of this PAS.

This PAS and the retrofit standards framework may be applied to all domestic retrofit activity and embrace work that is initiated, procured, funded and delivered in a wide variety of ways including:

- programmes of retrofit promoted and/or funded by national or local government schemes;
- programmes of retrofit initiated and/or funded by landlords, including social housing organizations, private landlords in the domestic sector and commercial property portfolio holders;
- retrofit of individual buildings by their owners and/or occupants, including both domestic and commercial owner-occupiers;
- retrofit that is integrated with and forms part of broader repairs, maintenance and improvement (RMI) activity related to individual buildings or building stocks.

This PAS and the retrofit standards framework may also be applied not only to retrofit work carried out by commercial building contractors and specialist installers of retrofit measures but also to work carried out by local SME builders and independent trades people working alone or in small teams.

This PAS does not apply to maintenance or repair of any element of an existing dwelling, or system installed in it, which does not involve improvement of the energy performance or ventilation of the dwelling, or a reduction of the carbon dioxide emissions associated with energy use in the dwelling. Nor does this PAS apply to "like-for-like" replacement of damaged or worn out elements or systems that do not involve improvement of the energy performance or ventilation of the dwelling, or a reduction of the carbon dioxide emissions associated with energy use in the dwelling.

NOTE *Appropriate repair and maintenance of the building fabric can improve energy efficiency and should always be the first step in energy efficiency improvements, even though it is not covered in this PAS. Otherwise an unacceptable level of risk to the future condition of the building might be introduced.*

2 Normative references

References, which form part of the retrofit standards framework, are listed in Clause **16**.

Of the documents listed in Clause **16**, the following references are central to the application of this PAS. They are referred to in the text in such a way that some or all of their content constitutes provisions of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Standards publications

BS 5250, *Code of practice for control of condensation in buildings*

BS 7913, *Guide to the conservation of historic buildings*

BS 8233, *Guidance on sound insulation and noise reduction for buildings*

BS EN 13141-1, *Ventilation for buildings – Performance testing of components/products for residential ventilation – Externally and internally mounted air transfer devices*

BS EN 13141-4, *Ventilation for buildings – Performance testing of components/products for residential ventilation – Fans used in residential ventilation systems*

BS EN 13141-6:2014, *Ventilation for buildings – Performance testing of components/products for residential ventilation – Exhaust ventilation system packages used in a single dwelling*

BS EN 13141-7, *Ventilation for buildings – Performance testing of components/products for residential ventilation – Performance testing of a mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for single family dwellings*

BS EN 13141-11, *Ventilation for buildings – Performance testing of components/products for residential ventilation – Supply ventilation units*

BS EN 31010, *Risk management – Risk assessment techniques*

BS EN ISO 14021, *Environmental labels and declarations – Self-declared environmental claims (Type II environmental labelling)*

PAS 2030:2019, *Specification for the installation of energy efficiency measures (EEM) in existing dwellings and insulation in residential park homes*

Other publications

[N1] ROYAL INSTITUTION OF CHARTERED SURVEYORS. *Surveys of residential property.* London: RICS, 2016.

[N2] BUILDING RESEARCH ESTABLISHMENT. *IP1/06 Assessing the effects of thermal bridging at junctions and around openings.* Bracknell: BRE, 2006.

[N3] CHARTERED INSTITUTION OF BUILDING SERVICES. *TM59 Design methodology for the assessment of overheating risk in homes.* London: CIBSE, 2017.

[N4] UK Climate Impacts Programme (UKCIP) at www.ukcip.org.uk.

[N5] BRITISH BLIND AND SHUTTER ASSOCIATION. *Guide to low energy shading*. Suffolk: BBSA, 2015.

[N6] AIR TIGHTNESS TESTING AND MEASUREMENT ASSOCIAION. *(TSL1) Measuring air permeability in the envelopes of dwellings.* Amersham: ATTMA September 2016.

[N7] Microgeneration Certification Scheme (MCS) *Product Standards* at https://www.microgenerationcertification.org/mcs-standards/product-standards.

[N8] Microgeneration Certification Scheme (MCS) *Installer Standards* at www.microgenerationcertification.org/mcs-standards/installer-standards.

[N9] DEPARTMENT FOR BUSINESS, ENERGY AND INDUSTRIAL STRATEGY. *Supporting the delivery of energy efficiency advice to consumers during smart meter installations*. London: BEIS, 2016.

[N10] BUILDING SERVICES RESEARCH AND INFORMATION ASSOCIATION. *Domestic ventilation systems.* Bracknell: BSRIA, 2013.

[N11] MINISTRY OF HOUSING, COMMUNITIES AND LOCAL GOVERNMENT. *The Building Regulations 2010 – Approved Document F*: *Ventilation.* 2010 ed. incorporating 2010 and 2013 amendments. London: National Building Specification (NBS), 2013.

[N12] Building Standards Technical Handbook 2017: *Domestic buildings*. Available at https://www.gov.scot/publications/building-standards-2017-domestic/

[N13] BUILDING CONTROL NORTHERN IRELAND. *Building Regulations (Northern Ireland) 2012 Guidance: Technical Booklet K: Ventilation.* Building Control NI, 2012.

[N14] BUILDING SERVICES RESEARCH AND INFORMATION ASSOCIATION. *Flexible ductwork*. Bracknell: BSRIA, 2006.

3 Terms and definitions

The following terms and definitions are considered indispensable to the understanding and application of this PAS.

3.1 client

property owner, householder, landlord and/or tenant of a dwelling that is subject to retrofit, sometimes also including the funding body

NOTE *In this PAS the term client refers to the recipient of domestic retrofit work.*

3.2 commissioning

activities that ensure that an installed retrofit measure (EEM), or a package of measures that form a retrofit design, operates within the boundaries and conditions of the design specification

3.3 conventional (construction)

masonry cavity wall construction (brick and/or block) with or without render, tile hanging or other external cladding

3.4 dwelling

a self-contained unit of accommodation such as a house or flat or park home used by one household as a home

3.5 dwelling assessment

process of assessing the characteristics of an existing dwelling, including its local context, built form, construction, services, condition and energy efficiency and occupancy, in order to provide information for the preparation of a retrofit design

3.6 (EEM) product

item intended for installation in existing buildings for the purpose of enhancing the energy efficiency of those buildings, that is not made available as an (EEM) system

3.7 energy efficiency measure (EEM)

planned work undertaken to improve the energy performance of a building by saving or generating energy

3.8 handover

process by which completed retrofit work is transferred from the retrofit project team (i.e. the Retrofit Coordinator) to the Client, together with the delivery of appropriate documentation and advice

3.9 high-rise (building)

a building over 11 metres or over four storeys in height above the ground

3.10 installation

location, placement and/or fixing of an energy efficiency measure in, or connected to, an existing building excluding any related work to enable the installation of the measure

3.11 (installation) location

building or group of buildings that are the subject of EEM installation(s)

3.12 (installation) method statement

definition of sequence of actions to be undertaken in installing one or more EEM products or systems in accordance with their specification, in a safe manner at a building

NOTE *An installation method statement can be a single document prepared specifically for this purpose or could consist of a collection of documents, in the sequence of required application, contributing to the complete definition of the intended method.*

3.13 measures interaction matrix

chart that illustrates the ways in which measures interact in a domestic building and indicates action to be taken by the Retrofit Designer when developing the retrofit design

3.14 monitoring and evaluation

process by which the effectiveness of a retrofit project is measured and evaluated after completion, with reference to the intended and actual outcomes, in order to identify and correct problems and provide feedback to improve subsequent projects

3.15 operative

person employed by the Retrofit Installer, either directly or under a subcontract arrangement, to undertake installation tasks on an EEM in accordance with the relevant method statement

NOTE Related requirements are given in PAS 2030:2019.

3.16 pre-installation building inspection

inspection undertaken by or on behalf of, the Retrofit Installer prior to commencement of installation to confirm that the EEM design provided by the Retrofit Designer is complete and can be fulfilled at the location specified

NOTE 1 Requirements on carrying out this inspection are given in PAS 2030:2019.

NOTE 2 The inspection can show that the proposed installation does not result in non-compliance with statutory requirements and/or generally accepted industry good practice.

3.17 professional qualification

recognition of building-related knowledge and capability involving registration by a professional body, based on training and/or academic study to at least degree level

Note For example, the Architects Registration Board (ARB), the Chartered Institute of Architectural Technologists (CIAT), the Royal Institution of Chartered Surveyors (RICS), the Chartered Institution of Building Services Engineers (CIBSE) or the Chartered Institute of Building (CIOB).

3.18 proprietary (EEM) system

combination of products and materials together with any related installation method, equipment requirements and performance objectives, placed on the market exclusively by a specific supplier, for installation in existing buildings for the purpose of enhancing the energy efficiency of those buildings

3.19 protected (building)

a building that is Listed as of special architectural or historic interest, or located in a Conservation Area or World Heritage Site

3.20 Recognition of Prior Experience and Learning (RPEL)

process by which prior experience and learning is assessed against relevant criteria to provide evidence for credit towards a vocational qualification

3.21 Register of Regulated Qualifications

register of nationally accredited professional and vocational qualifications maintained by Ofqual for England and by its equivalents for the devolved nations

3.22 retrofit advice

advice given to a client or householder during the retrofit process about the process, the evaluation of improvement options, the selection of improvement measures (EEM), the retrofit design, the operation and maintenance of installed measures, or how to operate a home in an energy efficient way, after retrofit

3.23 Retrofit Advisor

person qualified to deliver retrofit advice to clients and householders

*NOTE See **A.1.1** for details on the qualifications needed for this role.*

3.24 retrofit assessment

survey, inspection and assessment of a building to collate information for a retrofit design

3.25 Retrofit Assessor

person qualified to carry out a retrofit assessment

*NOTE See **A.2** for details on the qualifications needed for this role.*

3.26 Retrofit Coordinator

person qualified as a specialist retrofit project manager, taking overall responsibility for overseeing the assessment of dwellings, the identification, specification and evaluation of energy efficiency measures for installation at a given dwelling as a single project, and their subsequent monitoring and evaluation

See Clause **6** and **A.3** for details on the qualifications needed for this role.

3.27 retrofit design

package of information prepared by a Retrofit Designer that determines the unique combination of EEM systems, products, materials and their interrelationships, to be installed in a building in order to achieve specified energy efficiency and other outcomes for that building

3.28 Retrofit Designer

person qualified to prepare a retrofit design

***NOTE** See **A.4** for details on the qualifications needed for this role.*

3.29 Retrofit Evaluator

person qualified to monitor and evaluate the effectiveness of a retrofit project and provide feedback to the Client and/or the project team

***NOTE** Note See **A.5** for details on the qualifications needed for this role.*

3.30 Retrofit Installer

person or organization undertaking the physical placement of an energy efficiency measure(s) in an existing building

***NOTE** See PAS 2030 for further details.*

3.31 retrofit risk assessment

process of assessing the risks associated with a retrofit project in order to determine which of the three requirement Paths should be chosen

***NOTE** Further details on the Paths are given in Clauses **7, 8, 9** and **13**.*

3.32 system-built (building)

building of frame (timber, steel or concrete) and pre-fabricated panel (concrete or timber, or a combination) construction, or timber-framed construction with brick or stone external cladding

3.33 thermal bridge

area of the building envelope where the insulation is:

a) discontinuous or thinner than the adjacent insulation;

b) has higher thermal conductivity than the adjacent insulation; or

c) has reduced effectiveness due to the building geometry;

leading to locally increased heat loss and therefore locally reduced internal surface temperature

3.34 thermal by-pass

unintended penetration or circulation of external air on the warm side of the insulation layer in a construction, rendering the insulation ineffective

3.35 toolbox talk

meeting of the Retrofit Coordinator with the Retrofit Installer and installation operatives to explain the design intent and draw attention to key points

3.36 traditional (construction)

building construction consisting of solid brick or stone external walls, or pre-1919 timber-framed external walls with any infill

3.37 ventilation assessment

assessment of the adequacy of an existing ventilation system in a building that is to be retrofitted

***NOTE** See Annex **C** for the requirements on providing adequate ventilation.*

3.38 ventilation upgrade

replacement or improvement of an existing ventilation system as part of a retrofit process

***NOTE** See Annex **C** for the requirements on providing adequate ventilation.*

4 Guidance about retrofit building physics

4.1 Introduction

4.1.1 Persons involved in domestic retrofit projects, including Retrofit Advisors, Retrofit Assessors, Retrofit Coordinators, Retrofit Designers and Retrofit Evaluators, should have working knowledge of building physics (also known as building science), appropriate to the nature and scale of the retrofit project(s) on which they work, and the types of buildings, with emphasis on the movement of heat, moisture and air through dwellings.

4.1.2 Occupants' comfort, health and safety depend on control and management of the flows of heat, moisture and air through their homes, in order to maintain appropriate dynamic thermal and moisture equilibriums. The dynamic heat balance of a dwelling (i.e. the way in which heat losses are satisfied by heat inputs) is an important element of its energy efficiency. The moisture balance of a home is important to the maintenance of healthy internal conditions.

4.2 Building pathology

4.2.1 Building pathology is the process by which the history and condition of a building, and its suitability for improvement, are analysed systematically, as part of its assessment for retrofit.

4.2.2 This type of analysis helps to establish the condition of the building and to identify defects and performance failures. It also establishes how defects have arisen and identifies the work that should be carried out not only to repair them and restore performance, prior to retrofit, but also to prevent them from recurring.

4.2.3 It is important when a dwelling is assessed for retrofit, and when improvement options are evaluated, that the dwelling is treated as a system comprising the building envelope (or building fabric), the building services (ventilation, heating, hot water, lights and appliances), any LZC technologies or 'renewable energy systems', and the occupants.

4.2.4 The occupants are key elements of the system because they:

- require certain conditions for comfort;
- operate energy-using lights and appliances;
- give off heat;
- produce moisture and carbon dioxide through respiration; and
- produce moisture through activities such as cooking, bathing and drying clothes.

4.2.5 Internal temperature and humidity are critical to comfort, and to managing the risk of internal surface condensation and mould growth. Managing the dynamic moisture equilibrium across the building envelope (i.e. the transfer of moisture between the internal air, the materials in floors, walls and roofs and the external air) is critical both to maintaining internal air quality (IAQ) and to protecting the building fabric against interstitial condensation, rot, mould growth and decay.

4.2.6 Retrofit work designed to reduce heat loss from a dwelling, and/or reduce air infiltration and air leakage, in order to improve energy efficiency, might have unintended consequences for IAQ and for the movement of moisture through the building fabric, particularly in older (pre-1919) traditionally constructed buildings, and in non-traditional buildings constructed in the 1960s and 1970s.

4.3 Thermal models and calculations

4.3.1 Thermal models such as the Standard Assessment Procedure (SAP) and the Passive House Planning Package (PHPP) attempt to simulate whole-dwelling thermal performance, but most versions do not deal with moisture. Such models provide estimates of the energy performance of dwellings, based on limited amounts of data from surveys and assessments, but they inevitably involve a compromise between accuracy and functionality – a truly accurate prediction of energy performance requires complex simulation models that use large amounts of data that are difficult and expensive to collate, and thus are rarely used in retrofit projects.

4.3.2 Retrofit Assessors, Retrofit Designers and Retrofit Coordinators should be familiar with the use of Full SAP or PHPP software to support their work. Reduced Data SAP (RDSAP) software might be useful where detailed data are not available, and Retrofit Assessors are trained in its use, but users should be aware that RDSAP makes default assumptions about some aspects of existing dwellings. If RDSAP is used to support a retrofit assessment, then the data should be reviewed carefully, and preferably exported to Full SAP software.

4.3.3 Mathematical techniques are available for:

- calculating the thermal transmittances (*U* values) of building elements (i.e. floors, walls and roofs, etc.) from data on the thermal conductivities (λ values) of building materials;
- assessing the risk of interstitial condensation within the construction of a building element, using data on internal and external temperature and humidity and on material moisture contents and vapour pressures;
- calculating linear thermal transmittances (ψ values) and critical temperature factors (f_{Rsi}) at the corners, junctions and edges of building envelopes that are identified as "thermal bridges", i.e. places where the envelope of insulation is either thinner or discontinuous;
- calculating the component of a building's overall thermal transmittance that is due to thermal bridging (*y* value);
- calculating overall heat losses from a dwelling due to conduction, convection (i.e. air leakage), radiation, deliberate ventilation and the inefficiency of heating system(s);
- calculating overall heat gains in a dwelling from occupants, cooking, hot water, lighting, the use of appliances and solar gains through glazed openings;
- calculating the whole-dwelling ventilation rate required to maintain good IAQ and minimize the risk of condensation and mould growth;
- assessing the risk of surface condensation and mould growth using temperature factors and data on internal and external temperature and relative humidity to calculate vapour pressure differentials;
- assessing the dynamic moisture equilibrium through a building element; and
- calculating internal daylight levels from data about the sizes, locations and orientations of windows, and any local shading, and assessing requirements for artificial lighting.

4.3.4 Testing and investigation techniques are available for:

- measuring heat losses through individual building elements;
- measuring heat loss through the whole building envelope;
- assessing the air-tightness (or "air permeability") of a building envelope;
- identifying air infiltration and air leakage points;
- measuring the vapour permeabilities of building materials; and
- assessing the moisture content of building fabric.

4.3.5 There are also techniques for:

- monitoring overall energy use in dwellings, from utility meters;
- monitoring the energy use of individual systems, using sub-meters;
- monitoring internal temperatures, using sensors and loggers;
- monitoring internal relative humidity, using sensors and loggers; and
- monitoring IAQ (e.g. carbon dioxide concentration) using sensors and loggers.

4.3.6 Retrofit Assessors, Retrofit Designers, Retrofit Coordinators and Retrofit Evaluators should be familiar with the relevant techniques described or listed in **4.3.3**. Retrofit Coordinators and Retrofit Evaluators should be able to apply the techniques listed in **4.3.4** and **4.3.5**, as appropriate, and should keep themselves updated about new and emerging monitoring techniques.

4.3.7 Many academic, vocational training and Continuous Professional Development (CPD) courses deal with thermal aspects of building physics. More detailed explanations of aspects of retrofit building physics are provided in the following:

- *Code of practice for the energy efficient retrofit of dwellings* [1]; and
- *Moisture in buildings: An integrated approach to risk assessment and guidance* [2].

5 Guidance about approaches to retrofit

5.1 Retrofit performance considerations, standards and constraints

5.1.1 Domestic retrofit projects range from the installation of single improvement measures to whole-house projects involving multiple measures installed at the same time. Both types of project should be seen in the context of national emissions reduction targets; by 2050 it is necessary to reduce the average greenhouse gas (principally carbon dioxide) emissions associated with energy use in our homes by between 80% and 100% compared with current emissions, through a combination of improved efficiency and low- or zero-carbon energy supply. The Climate Change Committee sets "carbon budgets" under the Climate Change Act 2008 [3], and the Government's Clean Growth Strategy includes a commitment to improvements in Energy Performance Certificates (EPC) scores for fuel poor homes by 2030 and an aspiration for improvements in EPC scores of the wider housing stock by 2035. The Government's "Buildings Mission", under the *Clean Growth Strategy* [4], is to halve the current (2019) cost of reducing energy use in all existing buildings by 50%, by 2030.

5.1.2 However, it is not appropriate to attempt to achieve the same level of emissions reduction from every domestic building, because the same target applied to every dwelling might result in significant damage to some older, traditionally constructed buildings (which make up approximately one quarter of the housing stock), rendering them unhealthy to live in or possibly even uninhabitable, and damaging our architectural heritage. An average emissions reduction target might be appropriate, but greater reductions need to be made where they are technically feasible and safe, in order to compensate for the constraints on improvements to traditional buildings. In each case, protecting and improving occupants' health, well-being and comfort should be prioritized, then energy use and emissions should be minimized within the constraints of protecting the building and its architectural heritage.

5.2 Medium-term improvement plans

5.2.1 For any dwelling that is proposed for retrofit, consideration should be given to the scope for improving energy efficiency and reducing emissions, bearing in mind the need for significant emissions reduction. The overall scope for improvement by 2050 should be identified, even if only limited improvements can be undertaken in the short term. One way of doing this is to prepare a "medium-term improvement plan" for every dwelling (or in the case of managed housing, for every dwelling type) for implementation over a period of 20 or 30 years.

5.2.2 The purpose of a medium-term improvement plan is to guide the staged or phased improvement of a dwelling by identifying the improvements that are needed and an appropriate order for their implementation, and by highlighting critical interactions between them. Such plans should be updated to respond to changes in standards or the availability of new technologies, and to record improvements as they are made.

5.2.3 A medium-term improvement plan should:

- identify constraints imposed by the history, construction, architectural character and setting of the building, and by its pattern of use;
- identify the set of improvement measures necessary to achieve an appropriate target improvement in energy efficiency and reduction of the emissions associated with energy use, without compromising the comfort and health and of the occupants or the integrity of the building;
- identify potential interactions between measures to ensure a whole-house approach is followed and thus avoid thermal bridging and other unintended consequences;
- identify an appropriate order in which the identified measures should be installed, bearing in mind that some measures are best installed together, and that installation of some measures may preclude the later installation of other measures (or make subsequent installation more difficult);
- be presented in a format that allows it to be updated as work proceeds, and revised as new knowledge and new materials, products or technologies for energy efficiency become available.

5.2.4 The preparation of a medium-term improvement plan should be the responsibility of the Retrofit Coordinator (see **9.2**), working in collaboration with the Retrofit Designer and the Client for the project.

5.3 Retrofit at scale

5.3.1 Large-scale retrofit programmes are likely to become more common and are often driven by the objective of alleviating fuel poverty as well as improving energy efficiency and reducing emissions. There are two types:

- Programmes that seek to install a single improvement measure (or a small number of measures) in many dwellings, irrespective of their locations, in order to make incremental improvements in performance across the housing stock.

  NOTE 1 *The Government's Energy Company Obligation (ECO) programme is an example of this type.*

- Programmes that seek to install packages of multiple measures in dwellings in defined areas, in order to make more significant improvements in performance. Areas of focus might be estates owned by housing organizations, local authority areas where there is fuel poverty, or whole cities.

  NOTE 2 *The GLA's Energy for Londoners fuel poverty programme is an example of this type.*

5.3.2 In the first type of programme, because of time and budget constraints, the scope for adequate assessment of dwellings prior to improvement is often reduced, so there might be a risk of technically or architecturally inappropriate measures being installed. Risk assessment and management techniques should be carried out in accordance with BS EN 31010.

5.3.3 In the second type of programme, medium-term low carbon improvement plans should be focused on dwelling types within the areas of interest, rather than on individual dwellings, in order to identify generic solutions and economies of scale. Plans for dwelling types may be modified for individual dwellings, because very few homes are exactly the same, even those of superficially similar appearance, so individual retrofit assessments and designs are still necessary.

5.4 Fabric first

5.4.1 Whatever the scale of retrofit, a technically sound and usually cost-effective approach is the one known as "fabric first", which should always be considered when a retrofit plan is formulated. This approach prioritizes improvements in five stages.

1) Bring the building fabric into good repair, by dealing with defects that inhibit energy efficiency and compromise improvement measures. Deal with water penetration and damp (and ensure that the building fabric is properly dried out) and with structural defects (cracks, etc.) and poor pointing of masonry.
2) Implement "low hanging fruit" measures that are low cost and easy to install, e.g. energy efficient lighting, basic heating controls, better control settings.
3) Improve the building fabric by means of insulation and air-tightness measures, and by minimizing thermal bridging, in order to reduce heat losses and reduce the demand for heat and the required capacity of the heating system.

   NOTE *When the insulation and air-tightness of the building fabric are improved, adequate ventilation should be maintained.*
4) Satisfy the remaining heat demand as efficiently as possible using efficient heating technology and responsive controls.
5) Use LZC "renewable" energy technologies to reduce emissions further and "top up" the performance of the dwelling to the target level.

5.4.2 It makes sense to ensure that the existing building fabric is as energy efficient as possible before spending resources on other measures. Subsequently, because insulation measures are generally amongst the most cost effective and long-lasting, and thus the best investment, insulation is usually the most appropriate next step. Insulating the fabric first also reduces the required capacity and cost of the heating system. The heating system usually has a shorter life than the improved building fabric (typically 15 years compared with possibly 60 years), so a dwelling might have four heating systems during the life of the installed insulation. LZC systems such as solar water heating (also known as "solar thermal") and solar photovoltaic systems are the final step because they are relatively expensive (often requiring subsidy), and their capacity is often limited by available space (e.g. on the roof). Most UK dwellings cannot be heated exclusively by renewable energy systems unless they are first insulated, and the building services efficiency is improved, to reduce the remaining energy demand so that LZCs can make a significant contribution.

5.4.3 Although "fabric first" is often a cost-effective approach, sometimes other issues dictate different priorities. For example, a worn-out boiler should be replaced, even if insulation cannot be afforded (but note that when the insulation is eventually installed the boiler will be over-sized).

5.4.4 Often, architectural heritage considerations limit or rule out many insulation options, some of which are irreversible, leaving scope only for using measures that can be reversed, improving the building services or installing LZCs. In the case of older, traditionally constructed or protected buildings, a risk-based approach to the selection of improvement options is usually appropriate.

5.5 Concentrate on the interfaces

5.5.1 "Concentrate on the interfaces" is a way of approaching retrofit that complements and enhances "fabric first". It acknowledges that retrofit projects often go wrong because of poor attention to the corners, junctions and edges of building elements (where insulation and air barriers should be continuous) and the interfaces between the building fabric, the building services and the occupants. For example, heating output should be matched to heat loss, ventilation should be matched to the air permeability of the building fabric, and occupants should be able to make efficient use of systems installed in their homes.

5.5.2 "Concentrate on the interfaces" is an approach that focuses the attention of Retrofit Designers and Retrofit Installers on critical factors. It is the basis of much of the guidance and some of the requirements specified in this PAS.

5.6 Retrofit advice

5.6.1 Domestic retrofit projects should always include the delivery of retrofit advice to the occupants of the dwelling(s), at appropriate times, by a qualified Retrofit Advisor. There is evidence that where retrofit projects do not include advice, the intended outcomes are often only partially achieved, particularly with respect to fuel cost savings and reductions in the carbon dioxide emissions associated with energy use.

5.6.2 Retrofit advice should be delivered at several stages of a retrofit project, and the topics covered by advice should be appropriate to the scope of the improvement work and the stage at which it is delivered. Retrofit advice should be delivered in accordance with the requirements in Clause **13**.

5.6.3 In scale- or area-based local retrofit, the potential for peer learning through web forums, open homes events and community meetings should also be considered as a way of delivering appropriate retrofit advice.

6 Requirements for retrofit coordination and risk management

6.1 Retrofit Coordinator

6.1.1 Every domestic retrofit project compliant with this PAS shall be coordinated by a Retrofit Coordinator. Retrofit Coordinators are qualified to provide end-to-end project coordination (i.e. from the inception of a retrofit project to handover and beyond, including undertaking basic monitoring and evaluation work), and to identify, assess and manage the technical and process risks associated with domestic retrofit projects.

6.1.2 A Retrofit Coordinator shall be a person qualified in accordance with the requirements set out in Annex **A**.

6.1.3 The role of the Retrofit Coordinator shall be to protect both the Client's interest and the public interest. The Retrofit Coordinator shall be responsible for overseeing the project from inception to completion, i.e. the risk assessment (Clause **7**), the dwelling assessment (Clause **8**), the retrofit design (Clause **9**), installation (in accordance with PAS 2030), and post-completion monitoring and evaluation (Clause **10**).

6.1.4 The Retrofit Coordinator shall also be responsible for ensuring and claiming compliance with PAS 2035.

NOTE *The Retrofit Installer is responsible for claiming compliance of the process of installation of EEM with PAS 2030:2019.*

6.1.5 The Retrofit Coordinator may be employed by the Client or by an organization commissioned to undertake assessment, design, installation, commissioning or monitoring and evaluation work (or a combination of these). Where a conflict of interest arises between the Retrofit Coordinator's duty to protect the Client's interest, the public interest and the employer's interest it shall be declared to the Client so that arrangements can be made to resolve it.

6.2 Establishing intended outcomes

6.2.1 At the outset of the project, the Retrofit Coordinator shall consult the Client and agree and record the intended outcomes of the project. Intended outcomes shall take into account the initial condition of the building(s) and be expressed in terms of one or more of the following:

- reductions in energy use;
- reductions in energy costs and/or alleviation of fuel poverty;
- reductions in emissions associated with energy use;
- improvement in internal comfort;
- improvement of IAQ;
- elimination of condensation, damp and mould;
- reducing the risk of overheating;
- improvement in energy rating (e.g. SAP);
- meeting a performance standard (e.g. NZEB or Passive House EnerPHit);
- improving the usefulness or sustainability of the building;
- protecting the building against decay or deterioration;
- improving resistance to water penetration and resilience against flood risk;
- protection or enhancement of architectural heritage;
- integration of energy efficiency measures with other improvements, e.g. extension, loft conversion or general refurbishment; and
- any other issues that might be considered relevant.

7 Requirements for retrofit risk assessments

7.1 Risk assessment process

7.1.1 The Retrofit Coordinator shall ensure that a retrofit risk assessment is undertaken of each dwelling or dwelling type within the project that is subject to retrofit.

7.1.2 The retrofit risk assessment shall use data from a "triage" process (which does not require nor preclude a visit to the dwelling) and apply the criteria set out in Annex **B**.

7.1.3 The triage process shall consist of collecting the data necessary for the risk assessment (see Annex **B**) from some or all of the following sources:

- telephone enquiries with the Client and/or landlord and/or occupants;
- any existing EPCs;
- the reports of any previous energy or condition surveys or assessments;
- web-based satellite and street views (e.g. Google Earth and Google Street View);
- the Measures Interaction Matrix (see Annex **D**); and
- information obtained from a visit to the dwelling.

7.1.4 Data from the triage process shall be used to complete the risk assessment in accordance with Annex **B**, and a summary shall be retained with the records of the project.

7.1.5 For each project, the outcome of the retrofit risk assessment is an aggregate risk grade for that project of A, B or C.

7.2 Consequences of the outcome of the risk assessment

7.2.1 If the project risk grade is assessed as A, the **Path A** requirements shall apply.

7.2.2 If the project risk grade is assessed as B, the **Path B** requirements shall apply.

7.2.3 If the project risk grade is assessed as C, the **Path C** requirements shall apply.

7.3 Repeating the risk assessment

7.3.1 In the event that, during a retrofit project, circumstances change (e.g. by the addition of measures) in a way that would affect the outcome of the risk assessment, the Retrofit Coordinator shall repeat the risk assessment using updated input data.

7.3.2 If the outcome of a repeat risk assessment is that the assessed risk grade of the project changes, then the requirements of this PAS relevant to the Path associated with the new assessed risk grade (see **7.2**) shall apply.

8 Requirements for whole-dwelling assessments

8.1 The purpose of the assessment

The Retrofit Coordinator shall ensure that every dwelling that is to be subjected to energy retrofit work is first assessed by a Retrofit Assessor, to provide information about the dwelling for use by a Retrofit Designer (see Clause **9**).

***NOTE** A new British Standard for the Assessment of Dwellings for Retrofit is proposed. On publication, the new standard will supersede **8.2** to **8.6** below. Prior to publication of the new standard, **8.2** to **8.6** shall apply to all assessments of dwellings for retrofit.*

8.2 The Retrofit Assessor

8.2.1 A Retrofit Assessor shall be a person trained and/or qualified in accordance with the requirements set out in Annex **A**.

8.3 Assessment: Path A

8.3.1 The assessment shall include:

- an appraisal of the dwelling's heritage, architectural features, structure, construction and condition and the installed building services (ventilation, heating, hot water and lighting) in sufficient detail to establish the suitability of the dwelling for improvement;
- identification of any constraints imposed by the local planning authority (including requirements for planning permission, Listing as of Special Architectural or Historic Interest, Conservation Area constraints, Tree Preservation orders, etc.);
- identification of the location and severity of any existing construction defects or structural defects or leaks, and of any condensation and/or mould growth in the dwelling; and
- identification of any energy efficiency measures already installed or proposed.

8.3.2 In addition, where appropriate and in order to support an assessment of the dwelling using RDSAP or SAP, the assessment can include:

- a measured survey to establish the overall dimensions of the dwelling's heat loss envelope (including any basements and attics), the dimensions of all building elements (exposed floors, external walls, roofs, etc.) and the dimensions of all window and door openings;
- an appraisal of the dwelling's construction in sufficient detail to establish the thermal transmittances (*U* values) and moisture properties of the main building elements (exposed floors, walls and roofs) and the suitability of the dwelling for improvement; and
- identification of the installed building services (ventilation, heating, hot water and lighting systems and their controls).

8.4 Assessment: Path B

8.4.1 The assessment shall include the points listed in **8.3.1** above, together with the following additional points:

1) an appraisal of the dwelling's construction in sufficient detail to establish the main materials, thermal transmittances (*U* values) and moisture properties of the main building elements (exposed floors, walls and roofs) and the suitability of the dwelling for improvement;

   ***NOTE 1** For traditionally constructed buildings, it might not be appropriate to accept the default U values offered by RDSAP software; instead, it might be necessary to establish details of the construction in order to calculate U values.*

2) a measured survey to establish the overall dimensions of the dwelling's heat loss envelope (including any basements and attics), the dimensions of all building elements (exposed floors, external walls, roofs, etc.) and the dimensions of all window and door openings;
3) identification of constraints imposed by the site, e.g. elevation and exposure (to sun, wind and rain, major roads and industrial activity), access, party walls, rights of light, consideration of adjoining properties, etc.;
4) identification of the installed building services (ventilation, heating, hot water and lighting systems and their controls), the locations of the equipment, the areas served and confirmation that the systems are working correctly (or otherwise);
5) an appraisal of occupancy, including the number of occupants and any special considerations such as the presence of vulnerable persons, e.g. children or elderly people or those with disabilities;

6) an assessment of the existing ventilation in accordance with Annex **C**, including:
   - identification of the location and severity of any condensation and/or mould growth in the dwelling;
   - any intermittent extract ventilation fans or passive stack ventilators and where they are located;
   - any background ventilators (air inlets or "trickle ventilators"), and where they are located;
   - any other ventilation system and where it is located, including single-room heat recovery ventilators (srHRVs), positive input ventilation (PIV), whole-house mechanical extract ventilation (centralized cMEV or decentralized dMEV), and mechanical ventilation with heat recovery (MVHR); and
   - whether the identified ventilation systems are functional.

   NOTE 2 *Any intermittent or continuous extract ventilation fans should be checked in accordance with BSRIA guide BG46/2015 [5] to ensure that they are providing adequate air movement, and any incidence of inadequate air movement should be reported as part of the assessment.*

8.4.2 The data collected in accordance with **8.4.1** shall be sufficient for an estimate of annual fuel use, fuel costs and carbon dioxide emissions, under standard or actual occupancy (as appropriate) to be made by the Retrofit Assessor, Retrofit Coordinator or Retrofit Designer, using a recognized domestic energy model such as the Reduced Data Standard Assessment Procedure (RDSAP), the Standard Assessment Procedure (SAP) or the Passive House Planning Package (PHPP).

8.4.3 If the dwelling to be assessed is of traditional construction, an assessment of significance shall also be carried out in accordance with the guidance in BS 7913.

NOTE *A simplified version of the BS 7913 significance assessment will be made available by BSI within 3 months of publication of this PAS. The simplified version may be used as an alternative to the full BS 7913 significance assessment, at the users' discretion, for traditionally constructed buildings that are not protected. The simplified version will be incorporated into this PAS in a future revision.*

8.5 Assessment: Path C

8.5.1 The assessment shall adopt the principles set out in the RICS guidance note *Surveys of residential properties* [N1], at "survey level three", as defined in that document, and shall include the points listed in **8.3** and **8.4** above, together with the following additional points:

- a test of the air permeability of the building envelope, using an approved method, including identification of key leakage locations;
- any relevant in situ tests.

NOTE 1 *A test of the air permeability of the building envelope may be useful irrespective of the assessed level of risk, and should be carried out at the discretion of the Retrofit Coordinator.*

NOTE 2 *In the case of a building containing multiple dwellings (e.g. a high-rise residential block), it may be sufficient to test a sample of the dwellings, including an example of each dwelling type, in the building.*

NOTE 3 *Where invasive tests (e.g. pull-out tests to establish suitability for proposed fixings) are appropriate, then at the discretion of the Retrofit Coordinator they can be required by the design to be included as part of the pre-installation inspection required by PAS 2030:2019 instead of as part of the assessment.*

8.5.2 If the dwelling to be assessed is a protected building, or forms part of a protected building, the assessment shall also be carried out in accordance with the guidance in BS 7913 and shall include:

- an assessment of the significance of the building as defined in BS 7913; and
- at the Retrofit Coordinator's discretion, a structural engineer's report on the structural condition of the building and its suitability for any proposed improvement measures.

8.6 Reporting the assessment and handing over assessment data

8.6.1 The whole-dwelling assessment, including the ventilation assessment, shall be recorded and reported to the Retrofit Designer, including any RDSAP, SAP or PHPP data file and a photographic record of all the recorded features of the building and of any identified defects.

8.6.2 Where the project involves an assessment of similar dwellings located in blocks (e.g. blocks of flats) the assessments can be combined in a single report for each block, but the data presented shall be dwelling-specific, and any RDSAP, SAP or PHPP assessment data shall be provided for at least one example of each dwelling type in each block.

NOTE *Dwelling types may be defined by architectural layout and/or number of bedrooms, and by the position of the dwellings in the block (e.g. mid-, end or corner, and ground, mid- or top floor).*

8.6.3 Where the assessment has identified construction defects or structural defects or leaks, or condensation and/or mould growth in any dwelling(s), the report shall include identification of such defects in two categories:

- defects that need to be repaired before any retrofit work can proceed; and
- defects whose repair is recommended but not an essential prerequisite to retrofit.

8.6.4 The Retrofit Coordinator shall request confirmation from the Retrofit Designer that the information included in the assessment report is sufficient for the preparation of a retrofit design in accordance with Clause **9**.

8.6.5 If the information in the assessment is not sufficient to provide the basis of a retrofit design that complies with this PAS, the Retrofit Designer shall identify any missing information, which the Retrofit Coordinator shall arrange for the Retrofit Assessor to collate and include in an updated assessment report.

NOTE *If required by the body governing the TrustMark, the Assessor should upload the final assessment report, the RDSAP, SAP or PHPP data file and photographic records of the assessment to the TrustMark "data warehouse" for quality assurance purposes.*

9 Requirements for retrofit designs

9.1 Design: Path A

9.1.1 The Retrofit Coordinator shall ensure that the EEMs to be included in each domestic retrofit project shall be the subject of a design and specification (hereafter referred to as the retrofit design) prepared by a Retrofit Designer.

9.1.2 A Retrofit Designer shall be trained and/or qualified in accordance with Annex **A**.

9.1.3 Prior to undertaking the design and specification of retrofit work, the Retrofit Designer shall ensure that they are in possession of a retrofit assessment conforming to Clause **8** for the relevant dwelling or dwelling type, prepared by a Retrofit Assessor, on the basis of which the retrofit design shall be prepared.

9.1.4 The Retrofit Designer shall review the assessments(s) to confirm that the information included in the assessment report is sufficient for a retrofit design, conforming to Clause **8**, to be prepared.

9.1.5 If the information in the assessment(s) is not sufficient to provide the basis of a retrofit design, the Retrofit Designer shall identify any missing information and report to the Retrofit Coordinator, who shall arrange for the Retrofit Assessor to collate the required information and include it in an updated assessment report in accordance with Clause **8**.

9.1.6 On receipt of an acceptable assessment, the Retrofit Designer shall consider the list of improvements in Clause **1** of this PAS and identify the technically applicable EEMs, bearing in mind the improvement objectives listed in **0.1.1** and the constraints identified by the assessment(s).

9.1.7 The Retrofit Designer shall review the technically appropriate measures with the Client and agree the measures to be applied to each dwelling included in the project.

9.1.8 The Retrofit Coordinator shall advise the Client on the need for any statutory approvals (planning approval, Listed Building Consent, Party Wall Notices or approval under the Building Regulations) for the proposed retrofit work, and shall then either:

- make applications for any necessary statutory approvals, and negotiate them with the appropriate authorities, on behalf of the Client; or
- cooperate with the Client or any other persons (e.g. a planning consultant, an architect or the Retrofit Installer) appointed to make applications for and negotiate statutory approvals, including providing information about the retrofit assessment and the retrofit design to support the applications.

9.1.9 The Retrofit Designer shall prepare design and specification information about the EEM or package of EEMs proposed for the dwelling(s), including materials, products, processes and standards, as appropriate, and in sufficient detail for contractors and installers to work from, taking into account:

- the condition of the existing building, including the need to repair any structural defects, to eliminate the ingress of liquid water or moisture prior to the installation of retrofit measures, and to fit leak protection devices to mitigate the risk of escape of water from internal services;
- the agreed scope of the project, the intended outcomes and any agreed performance targets for the dwelling(s), and the budget;
- the information in the report(s) of the assessment(s) of the dwelling(s);
- any conditions imposed by the local planning authority or the Building Control Body as part of a statutory approval; and

NOTE *Conditions imposed by the local planning authority or the Building Control Body might not be known for some weeks after the applications described in* ***9.1.8*** *are made.*

- the assessment of any existing ventilation and any consequent requirement to upgrade it.

9.1.10 The Retrofit Designer shall ensure that the specified materials and products are compatible with the building and with each other and work as an integrated system, where appropriate. The design and specification shall be consistent with any relevant product manufacturers' installation instructions and with any relevant British or European standards or normative documents of any product or system.

9.1.11 The retrofit design shall include appropriate provision for the management of moisture within the construction, and of the dynamic equilibrium between the internal and external relative humidity and the moisture content of construction materials, specifying vapour permeable materials and vapour balanced construction as appropriate, such that moisture does not become trapped within any construction leading to risk of interstitial condensation and consequent damp and deterioration. The design shall also adopt a coherent approach to managing moisture risk, consistent with the guidance in BS 5250.

9.1.12 If any building fabric insulation or air-tightness measures are included in the package of specified EEMs, the Retrofit Designer shall consider the adequacy of the existing ventilation (if any) of the dwellings(s) as revealed by the dwelling assessment report and if necessary include in the design a specification for upgrading the ventilation of the dwelling(s). Assessment and upgrading of ventilation shall be in accordance with Annex **C** of this PAS. This requirement applies irrespective of the cost effectiveness of the ventilation upgrade as revealed by the improvement option evaluation.

9.1.13 The retrofit design shall also include provision for managing the interactions between EEMs installed in the same building. The Measures Interaction Matrix provided in Annex **D** (Figure **D.1**) identifies four types of combinations of EEMs:

- those that do not interact (shown in green);
- those that might connect or interact physically (shown in yellow);
- those that interact in other ways (shown in orange); and
- those that are incompatible and should not be combined (shown in red).

9.1.14 Where the retrofit design includes any EEMs for the improvement of the building fabric (e.g. insulation, air-tightness, replacement windows) it shall also include construction details, relevant to the measure, for the corners, junctions and edges of all affected building elements, and for all junctions with other building elements (whether those other elements have been improved or not); this includes all "yellow" combinations on the Measures Interaction Matrix (see Figure **D.1**).

9.1.15 Construction details shall be configured to maintain the continuity of the three-dimensional insulated envelope and the integrity of any air-tightness barrier, in order to eliminate thermal by-pass (i.e. the uncontrolled penetration of cold air to the warm side of any insulation layer), minimize thermal bridging and maintain an appropriate or specified standard of air-tightness. Construction details published as part of industry best practice guidance can be used; alternatively, if other details are used it shall be shown by calculating it in accordance with *IP1/06 Assessing the effects of thermal bridging at junctions and around openings* [N2] that the temperature factor (f_{Rsi}) of each detail is not less than 0.75.

***NOTE** Good practice details for the retrofit of some dwelling types are available at the Retrofit Pattern Book website [6]. In some cases these details provide a guide to good practice and a template for the details required by this PAS.*

9.1.16 Where the retrofit design includes EEMs that do not physically connect but which may interact in other ways (i.e. "orange" combinations on the Measures Interaction Matrix) the EEM specifications shall take account of the interaction. For example, the capacity of any new heating system (appliances or emitters) shall take account of the heat loss of the dwelling as affected by any improvements to insulation and air-tightness; and the design of any new ventilation system shall take account of the air permeability of the building envelope as affected by any improvements to insulation and air-tightness.

9.1.17 The retrofit design shall not include any combinations of measures that are identified as incompatible (i.e. shown "red") in Figure **D.1**.

9.1.18 The retrofit design shall also:

- make provision for ventilation for the purpose of the safe operation of all combustion appliances in accordance with the manufacturers' instructions and the relevant British Standards;
- provide for resilience against rainwater ingress (including ingress due to the failure of any critical element or construction detail);
- provide for resilience of the installed EEM against flood, where appropriate;
- ensure that the fire safety of the building is not compromised by the installation of EEMs, and if necessary include an updated fire safety strategy; and
- specify any maintenance requirements necessary to ensure the long-term integrity of the installation.

***NOTE** In providing for resilience against flood, the design should be consistent with the guidance in BS 85500.*

9.1.19 If any EEMs in the retrofit design are LZC technologies or "renewable energy systems" covered by the MCS the retrofit design shall specify that those systems comply with the relevant MCS standards [N7], [N8].

9.1.20 The retrofit design shall identify the relevant technical standards for EEMs from those listed in Clause **16**, and specify their application to the work that is the subject of the design.

NOTE *Omission from the retrofit design of reference to a relevant standard identified in this PAS does not imply that it does not apply.*

9.1.21 The retrofit design shall also specify the sequence of installation of the EEMs, especially where incorrect sequencing might adversely affect the resilience of the EEMs, the integrity of the building, its historic significance or its energy performance.

9.1.22 The Retrofit Coordinator shall provide the complete retrofit design to the Retrofit Installer(s) in writing for the purpose of costing the work and for subsequent installation of the EEMs. The design documentation shall include:

- identification of the address and precise location of the building(s) in which the EEM(s) are to be installed;
- identification of any access constraints and access instructions provided by the Client or the occupants;
- any assumptions on which the design is based, including assumptions that underpin the assessment of the dwelling(s);
- confirmation of the compliance of the design with the relevant standards, and identification of any apparently relevant standards that have been deemed irrelevant;
- specifications of the materials, products and systems to be used, and of where and how they are to be installed, whether within the building or on its exterior;
- construction details for all corners, junctions and edges of the building envelope (whether prepared by the Retrofit Designer or obtained from a system designer), or clear identification of any standards details that are to be used, and where;
- installation instructions for all new systems and equipment;
- testing requirements, including testing of any new gas systems and electrical installations (see Clause **11**);
- commissioning requirements (see Clause **11**);
- handover requirements (see Clause **12**);
- maintenance instructions (see Clause **12**);
- list of measures requiring an appropriate guarantee or warranty (see Clause **12**); and
- identification of any information required to be supplied by the Contractor or Installer to any applicable quality assurance scheme.

9.1.23 The Retrofit Coordinator shall also provide the Retrofit Installer(s) with copies of the retrofit assessment(s) for the dwelling(s).

9.1.24 The Retrofit Coordinator shall request confirmation from the Retrofit Installer(s) that the information included in the retrofit design is sufficient for costing and installation work to proceed.

NOTE *The Retrofit Installer might not be able to provide confirmation until the pre-installation building inspection required by PAS 2030 has been completed.*

9.1.25 If the information in the retrofit design is not considered sufficient for the costing and installation work to proceed, the Retrofit Installer(s) is required by PAS 2030:2019 to identify any missing information, which the Retrofit Coordinator shall arrange for the Retrofit Designer to collate and include in an updated design.

9.1.26 If the cost of installing the EEMs in accordance with the retrofit design, as reported by the Retrofit Installer(s), exceeds the agreed budget or funding available, the Retrofit Coordinator shall agree appropriate amendments with the Client, arrange for the Retrofit Designer to revise the design accordingly, and re-submit the retrofit design to the Retrofit Installer(s). The requirements of this PAS shall apply to the revised design.

9.1.27 At various stages in a retrofit project it can be beneficial for clients to receive advice to assist their decision making. Where advice in respect of a retrofit project undertaken in accordance with this PAS is to be provided to the Client, the Retrofit Coordinator shall ensure that the advice is provided in accordance with Clause **13**. Where such advice is to be provided by other parties, the Retrofit Coordinator shall ensure that the Client is aware of the potential benefit of advice being provided in accordance with Clause **13**.

NOTE *If required by the body governing the TrustMark for quality assurance purposes, the Retrofit Coordinator should upload the retrofit design(s) for the dwelling(s) to the TrustMark "data warehouse".*

9.2 Design: Path B

9.2.1 All of the design requirements for **Path A** (i.e. **9.1.1** to **9.1.27**) shall apply to **Path B**, but **9.2.2** to **9.2.9** shall also apply to **Path B.**

9.2.2 For every dwelling or dwelling type included in a retrofit assessment, before the retrofit design is prepared, the Retrofit Coordinator shall carry out an improvement option evaluation to identify an appropriate package of EEMs. The evaluation shall make use of the RDSAP, SAP or PHPP data file(s) provided as part of the dwelling assessment(s), and shall include calculation of:

- the simple pay-back period of the capital cost of each candidate EEM in fuel cost savings to occupants if installed on its own;

NOTE 1 *Simple pay-back (in years) is the capital cost of the EEM or package of EEMs divided by the estimated annual fuel cost savings. It is acknowledged that any person or organization incurring the capital cost might be different from those benefitting from the fuel cost savings.*

- the carbon cost effectiveness of each candidate EEM if installed on its own; and

NOTE 2 *Carbon cost effectiveness is the lifetime cost of the EEM or package of EEMs (i.e. capital cost less annual savings over the estimated life of the EEMs in years) divided by the lifetime reduction of carbon dioxide emissions (i.e. annual reduction multiplied by estimated life in years).*

- the simple pay-back and carbon cost effectiveness of any suggested or proposed package of EEMs.

9.2.3 When calculating the simple payback and carbon cost effectiveness of improvement measures and packages of measures for the improvement option evaluation, the Retrofit Coordinator shall:

- use capital cost rates for measures that are approved or recommended by an independent body (e.g. the Energy Saving Trust) and apply them to the relevant areas of the dwelling(s) for which they are being evaluated (taken from the SAP or PHPP assessment data) in order to establish capital costs; and
- use the actual fuel costs (i.e. tariffs) applicable to the dwelling, if available, otherwise use the national rolling average fuel costs embedded in the SAP energy rating; and
- use the carbon dioxide emissions factors embedded in the SAP energy rating, or in PHPP (but the two should not be mixed); and
- adjust the calculation to allow for the pattern(s) of occupancy of the dwelling(s) (e.g. by entering actual occupancy data into the software), unless the occupancy pattern(s) are unknown, in which case SAP standard occupancy shall be assumed.

NOTE *Capital costs used in the improvement option evaluation should be dwelling specific. Typical "per dwelling" capital costs of improvement measures should not be used, even if they are differentiated by dwelling type. Deemed savings associated with measures and dwelling types should not be used.*

9.2.4 If the dwelling to be improved is traditionally constructed, the identification of applicable EEMs shall also be consistent with the guidance given in BS 7913 and shall take account of the significance of the building as defined in the BS 7913 assessment.

9.2.5 In the event that any building fabric insulation or air-tightness measures are included in the package of proposed EEMs, the Retrofit Coordinator shall assess the adequacy of the existing ventilation (if any) of the dwellings(s) in accordance with Annex **C**, and if necessary include upgrading the ventilation of the dwelling(s) in the improvement option evaluation and in the proposed package(s) of EEMs. For the purpose of the improvement option, evaluation assessment and upgrading of ventilation shall be carried out in accordance with Annex **C**.

9.2.6 The Retrofit Coordinator shall prepare a tabular summary report of the improvement option evaluation and identify a recommended package of appropriate EEMs to form the basis of medium-term improvement plan(s) for the dwelling(s) in accordance with **5.2**.

9.2.7 The Retrofit Coordinator shall review the report of the improvement option evaluation, the recommended package(s) of EEMs and the medium-term improvement plan(s) with the Client for the project (whether householder, landlord or funding body) and agree the scope of the project, the intended outcomes and appropriate energy performance target(s) for the improved dwelling(s), and the budget.

9.2.8 The retrofit design shall include measures to inhibit overheating of the dwelling during the installed life of the EEMs. In identifying appropriate measures, the Retrofit Designer shall refer to:

- *TM59 Design Methodology for the Assessment of Overheating Risk in Homes*, in order to assess overheating risk [N3];
- the guidance and tools published by the UK Climate Impacts Programme (UKCIP) at www.ukcip.org.uk [N4], in order to assess future climate vulnerability and identify adaptation options; and
- the *Guide to Low Energy Shading* [N5].

9.2.9 The measures to be considered for inclusion in the retrofit design to inhibit overheating shall include but not be limited to:

- reduction of internal heat loads through the installation of energy efficient lighting (e.g. LED lamps) and energy efficient domestic appliances (e.g. appliances with A+++ energy ratings);
- smoothing of internal heat loads by separation of spaces with high heat gains (e.g. kitchens) from spaces with solar gains (e.g. those with south-facing glazing);
- reduction of solar gains by external shading of southerly-facing and westerly-facing glazed openings, or the provision of shutters;
- provision of facilities for secure ventilation of the dwelling at night, during warm weather; and
- moderation of internal temperature by exposing high thermal capacity building fabric (e.g. masonry or concrete) to the internal air (inside the insulated envelope) so that heat is absorbed from warm air and re-radiated later when the air is cooler.

9.2.10 The retrofit design shall also specify the sequence of installation of the EEMs, especially where incorrect sequencing might adversely affect the resilience of the EEMs, the integrity of the building, its historic significance or its energy performance.

NOTE *If required by the body governing the TrustMark for quality assurance purposes, the Retrofit Coordinator should upload the tabular summary of the improvement option evaluation(s), medium-term low carbon improvement plan(s) and the retrofit design(s) for the dwelling(s) to the TrustMark "data warehouse".*

9.3 Design: Path C

9.3.1 All of the design requirements for **Path A** (i.e. **9.1.1** to **9.1.27**) and **Path B** (i.e. **9.2.1** to **9.2.10** inclusive) shall apply to **Path C**, but **9.3.2** to **9.3.4** shall also apply to **Path C.**

9.3.2 If the dwelling to be improved is a protected building, or forms part of a protected building, the identification of applicable EEMs shall be carried out in accordance with the guidance in BS 7913 and shall take account of the significance of the building as defined in the BS 7913 assessment.

9.3.3 Where the retrofit design includes any EEMs for the improvement of the building fabric (e.g. insulation, air-tightness, replacement windows) and/or a ventilation upgrade (see Annex **C**) it shall also include an appropriate air-tightness standard for the dwelling after the work has been completed, and a requirement for the Retrofit Installer to demonstrate compliance with the air-tightness standard by means of an approved test, e.g. fan pressurization testing in accordance with *Measuring air permeability in the envelopes of dwellings* [N6].

NOTE *The Retrofit Coordinator should consider the strategy for air-tightness testing, particularly where the dwelling shares envelope with another, i.e. in terraces or multi-residential buildings. In the case of a building containing multiple dwellings (e.g. a high-rise residential block), it may be sufficient to test a sample of the dwellings including an example of each dwelling type in the building. However, in a small block of flats or maisonettes it may be more practical to pressurize the whole block because treating each flat individually would require multiple sets of equipment to pressurize adjacent units and avoid a misleading test result.*

9.3.4 Before any work to install EEMs in the dwelling(s) begins, the Retrofit Coordinator shall, on request, provide the Retrofit Installers(s) with briefings (or "toolbox talks") to explain the design intent and draw attention to key points including the intended installation sequence(s). Such briefings shall always be provided if:

- the retrofit design includes new or unusual materials, products or systems with which the Installers are not familiar; or
- the dwelling to be improved is a traditionally constructed or protected building, or forms part of a protected building; or
- the Retrofit Installers(s) have not installed the specified EEMs before; or
- the design is intended to achieve particularly challenging performance standards (e.g. with respect to air-tightness).

10 Requirements for installation of retrofit designs

The installation of the EEMs specified in the retrofit design shall be carried out in accordance with PAS 2030; where LZC technologies or "renewable energy systems" that are within the scope of the MCS are specified, the installation of those systems shall be carried out in accordance with the applicable MCS [N7], [N8] standards, instead of with PAS 2030.

NOTE *Responsibility for demonstrating and claiming compliance of installation processes and the competence or qualifications of installation operatives with PAS 2030 and/or the MCS standards rests with the Retrofit Installer. Evidence of compliance should be supplied to the Retrofit Coordinator.*

11 Requirements for testing and commissioning

11.1 Requirements for testing

11.1.1 The retrofit design shall specify any requirements for testing of the improved dwelling (e.g. air-tightness testing) before, during or after installation of the EEMs, and for testing of individual building systems (whether new or existing).

11.1.2 The testing of EEMs as specified in the retrofit design shall be carried out in accordance with the requirements of PAS 2030; where LZC technologies or "renewable energy systems" that are within the scope of the MCS are specified they shall be tested in accordance with the applicable MCS standards [N7], [N8] instead of with PAS 2030.

11.2 Requirements for commissioning

11.2.1 The retrofit design shall specify requirements for commissioning of any EEMs that are building services systems (e.g. ventilation, heating and hot water systems, etc.) and of any EEMs that are part of the building fabric but include moving parts (e.g. windows, air inlets, etc.).

11.2.2 Where there are multiple EEMs requiring commissioning, the retrofit design shall specify that all building services systems are to be finally commissioned together at the same time, not separately.

NOTE *This does not preclude pre-commissioning of individual measures by the Installer(s).*

11.2.3 The commissioning of the EEMs as specified in the retrofit design shall be carried out in accordance with the requirements of PAS 2030; where LZC technologies or "renewable energy systems" are specified, they shall be commissioned in accordance with the relevant requirements of the MCS [N7], [N8].

11.3 Test certificates and commissioning records

11.3.1 The retrofit design shall identify the test certificates and commissioning records that are to be supplied to the Client via the Retrofit Coordinator.

12 Requirements for handover

12.1 Specification of handover requirements

12.1.1 The retrofit design shall specify requirements for the handover of the completed installation of energy efficiency measures, consistent with PAS 2030. Where LZC technologies or "renewable energy systems" are specified the handover shall also be carried out in accordance with the relevant requirements of the MCS [N7], [N8].

12.1.2 The specified requirements for handover shall include:

- physical inspection of the installed measures and an explanation of their function and operation, including where appropriate demonstrations of the operation of components, devices and controls;
- information about the safe operation of the installed measure including operable components (e.g. windows, including any restrictor hardware), electrical equipment, mechanical equipment and associated control devices (e.g. boilers and heating controls);
- information about care of the installed measure to avoid detrimental effects (e.g. avoidance of penetrating air barriers by inserting fixings into internally insulated walls, regular cleaning and replacement of air filters in mechanical ventilation systems);
- information about regular maintenance of the installation to ensure that it operates safely, efficiently and effectively, in accordance with the requirements of any guarantees or warranties provided by the manufacturer or supplier;
- information about the efficient operation of the installation to facilitate the delivery of any intended reduction in energy use;
- a visual check that the person receiving the handover is able to operate components and controls;
- information about the importance of ventilation and the implications or potential consequences of switching off or disabling any installed ventilation system; and
- provision of documentation including test certificates and commissioning records, operation and maintenance instructions and manuals for all installed products and systems, warranty and guarantee certificates, and other relevant documentation, as appropriate.

***NOTE** Simplified, "user friendly", plain-language user manuals should be provided whenever possible.*

12.1.3 The Retrofit Coordinator shall retain copies of test certificates and commissioning records, operation and maintenance instructions and manuals for all installed products and systems, warranty and guarantee certificates, and other relevant documentation, necessary for the safe, efficient and effective care, operation and maintenance of the installed measures, for a period of six years or for the length of the warranties (whichever is longer). Copies of all of these documents shall be made available to the Client.

12.1.4 After the retrofit work has been handed over, the Retrofit Coordinator shall recommend to the Client that a new or updated EPC is prepared for the dwelling(s), and if the recommendation is accepted the Retrofit Coordinator shall arrange for the EPC to be prepared or updated by a Domestic Energy Assessor.

***NOTE** If the Client is a social landlord, a new or updated EPC might be necessary for updating the Client's housing stock data; if the dwelling(s) are to be re-let or sold after improvement, new or updated EPC(s) might be a legal requirement of the sale or letting process.*

12.2 Handover recipients

12.2.1 The Retrofit Coordinator shall ensure that handover is to the occupants of the dwelling(s). If the occupants are not the clients for the retrofit project, then the Retrofit Coordinator shall ensure that landlord(s) and clients are included in the handover process.

13 Requirements for retrofit advice

13.1 Qualifications for Retrofit Advisors

13.1.1 The Retrofit Coordinator shall ensure that appropriate retrofit advice is delivered as part of every domestic retrofit project.

13.1.2 All retrofit advice delivered in connection with domestic retrofit projects shall be delivered by Retrofit Advisors (except where this PAS specifies otherwise).

13.1.3 A Retrofit Advisor shall be a person trained and/or qualified in accordance with Annex **A**.

13.2 Delivery of retrofit advice

13.2.1 Retrofit Advisors shall use the guidance in *Toolkit guide: Supporting the delivery of energy efficiency advice to consumers during smart meter installations* [N9]; some aspects of this guidance are of general application.

13.2.2 Retrofit advice shall be delivered to the occupants of the dwelling that is subject to retrofit, irrespective of the type of tenure. However, where the occupants are tenants, the same advice shall also be offered to their landlord.

13.2.3 All retrofit advice shall be delivered in a form that can be understood by the occupants, i.e. taking account of language, the age of the occupants, any hearing or sight difficulties, etc.

13.3 Retrofit advice: Path A

13.3.1 Retrofit advice shall be provided to householders at the following points in the retrofit process:

- on initial engagement of a household and inception of a retrofit project; and
- at the time of or shortly after handover of the completed installation.

13.3.2 Retrofit advice delivered on initial engagement of a household shall be general domestic energy efficiency advice and may be delivered in person, by telephone, via a website or in printed form (or a combination of these). Where advice is delivered via a website, by telephone or in printed form, the material shall be originated by or approved by a Retrofit Advisor (see **13.1.3**), and in all cases this retrofit advice shall be delivered by an individual or organization independent of the PAS 2030 Retrofit Installer.

13.3.3 Retrofit advice delivered on initial engagement of a household shall be customized to the householders' needs and cover the following topics, as appropriate:

- behavioural issues, including use of ventilation, heating and hot water systems, lights and appliances and their controls; health and safety risks related to fuel poverty, damp and mould, cold and hypothermia; and the need to maintain buildings properly; and
- reducing energy costs by reviewing and (if appropriate) changing energy tariff or supplier;

NOTE 1 *Independent consumer information about changing energy supplier is available from the Ofgem website [7].*

- retrofit technologies, including building fabric measures, building services improvements, LZC and "renewable" energy systems, typical capital costs and fuel cost savings and sources of funding;
- retrofit considerations, including the PAS 2035 retrofit process, any applicable quality assurance regime (e.g. TrustMark, including the Consumer Charter), finding and selecting Retrofit Coordinators, Retrofit Assessors, Retrofit Designers and Retrofit Installers, and how to complain about poor service; and
- data considerations, including the need for data about the performance of the home and how that data might be used in monitoring and evaluation.

NOTE 2 *The report of the Each Home Counts review [8] recommended the setting-up of an Advice Hub; such retrofit advice can currently be obtained from BEIS or the Energy Saving Trust[1)] while an appropriate source of retrofit advice is established.*

[1)] BEIS contact details can be found through their website: https://www.gov.uk/government/organisations/department-for-business-energy-and-industrial-strategy and the Energy Saving Trust contact details can be found through their website: https://www.energysavingtrust.org.uk/.

13.3.4 Retrofit advice delivered at the time of or shortly after handover of the completed installation shall be coordinated with the PAS 2030:2019 Retrofit Installer and customized to reflect the EEMs installed and their intended outcomes; it shall cover:

- the installed EEMs, their operation and protection (including avoiding damage to any installed air-tightness layer) and their intended effect on the energy performance of the dwelling(s) and the level(s) of comfort provided;
- behavioural issues, including use of any installed ventilation, heating and hot water systems, lights and appliances and their controls, how to get the best performance from them, and the potential consequences of switching off or disabling ventilation;
- how repair and maintenance of the building and the installed EEMs can help sustain the building and contribute to its energy efficiency; and
- any applicable quality assurance regime (e.g. TrustMark), any audit and inspection processes that might apply, the guarantees and warrantees attached to the installed EEMs, and the procedures for claiming.

13.4 Retrofit advice: Paths B and C

13.4.1 Retrofit advice shall be provided to householders at the following points in the retrofit process:

- on initial engagement of a household and inception of a retrofit project;
- on completion of the improvement option evaluation;
- on completion of the retrofit design; and
- at the time of or shortly after handover of the completed installation.

13.4.2 Retrofit advice delivered on initial engagement of a household and inception of a retrofit project shall be in accordance with **13.3.3.**

13.4.3 Retrofit advice delivered after completion of the improvement option evaluation shall be delivered by the Retrofit Coordinator who carried out the improvement option evaluation; it shall cover:

- any consultations that have taken place with the local authority's planning department regarding the retrofit options and their impact on external appearance, particularly where external EEMs are being considered or where Conservation Area or Listed Building constraints apply;
- an explanation of the improvement options (EEMs) considered, their compatibilities and incompatibilities and any other associated opportunities or constraints;
- the estimated capital costs and fuel cost savings associated with the options considered, and their cost effectiveness (including their carbon cost effectiveness);
- identification of the recommended options and priorities included in the medium-term whole-dwelling improvement plan; and
- recommendation of the EEMs to be included in the immediate retrofit project.

NOTE *Where advice includes estimated fuel cost savings arising from improvement measures, the savings should be those calculated using a full SAP or PHPP assessment; capital costs of measures should be dwelling-specific and derived from rates obtained from sources independent of the manufacturer, supplier or installers of the EEMs; see also* ***9.2.3****.*

13.4.4 Retrofit advice delivered on completion of the retrofit design shall be delivered by the Retrofit Designer who prepared the design or by the Retrofit Coordinator; it shall cover the key features of the design including all the proposed EEMs, and a brief explanation of the installation process.

13.4.5 Retrofit advice delivered at the time of or shortly after handover of a completed installation shall be in accordance with the requirements of **13.3.4**.

14 Requirements for monitoring and evaluation

14.1 The purpose of monitoring and evaluation

The Retrofit Coordinator shall ensure that every retrofit project is subject to monitoring and evaluation to determine whether the intended outcomes of the retrofit project have been realized, and to identify and learn from any project-specific or systematic problems with the retrofit risk assessment, the dwelling assessment, the retrofit design, the installation of EEMs or the testing, commissioning or handover of EEMs.

***NOTE** A new British Standard is proposed for Building Performance Evaluation, covering domestic retrofit projects. On publication, the new standard may supersede the guidance in **14.2 to 14.6** below. Prior to publication of the new standard, **14.2 to 14.6** should apply to all domestic retrofit projects.*

14.2 Retrofit Evaluator

14.2.1 Monitoring and evaluation shall be carried out by a Retrofit Evaluator.

14.2.2 A Retrofit Evaluator shall be a person trained and/or qualified in accordance with Annex **A**.

14.3 Levels of monitoring and evaluation

14.3.1 Three levels of monitoring and evaluation shall be carried out, as appropriate:

- **Basic** monitoring and evaluation shall be applied to every completed domestic retrofit project (irrespective of the level of risk assessed under Clause **8**).
- **Intermediate** monitoring and evaluation shall be applied to projects for which (in the opinion of the Client, the Retrofit Coordinator or the Retrofit Evaluator) basic monitoring and evaluation indicates that the outcomes are significantly different from those originally agreed and intended, or there are unintended consequences of the retrofit work.

***NOTE** In some cases occupants who experienced fuel poverty prior to retrofit and were consequently unable to heat their homes adequately might take the benefits of retrofit in increased comfort rather than as monetary savings; this should be taken into account in the monitoring and evaluation process.*

- **Advanced** monitoring and evaluation shall be applied to projects for which (in the opinion of the Client, the Retrofit Coordinator or the Retrofit Evaluator) intermediate monitoring and evaluation indicates that further investigation is required to understand and resolve any discrepancy between predicted performance and outcome performance, or to explain any unintended consequences.

14.3.2 Intermediate and advanced monitoring involve access to the dwelling(s), possibly on several occasions, and advanced monitoring might require intrusive investigation of the building fabric, so the Client's and occupants' consent shall be obtained by the Retrofit Evaluator; intermediate and advanced monitoring and evaluation shall not proceed without such consent.

14.4 Basic monitoring and evaluation

14.4.1 Basic monitoring shall include the use of a measures-specific questionnaire distributed to the Client and the occupant(s) (if different) of the dwellings that have been retrofitted to establish, as far as possible:

- whether the agreed intended outcomes of the project (see **6.2**) have been achieved;
- whether there have been any unintended or unexpected consequences of the work;
- whether the Client and occupant(s) are satisfied with the outcomes;
- whether the Client and occupant(s) are satisfied with the process of assessment, design, installation, testing, commissioning and handover of retrofit measures;
- the identification of any specific points of dissatisfaction;
- the identification of any elements of the installation that are not working as expected; and
- any other comments the Client and occupant(s) might want to make.

14.4.2 The Retrofit Evaluator shall collate the information provided by the Client and the occupant(s), summarize it, formulate recommendations for any remedial actions required and any changes to the retrofit process that may be appropriate, and circulate the summary and recommendations to the Client, the Retrofit Coordinator, the Retrofit Assessor, the Retrofit Designer and the Retrofit Installer.

***NOTE** Not all Clients and occupants may complete and return the basic monitoring and evaluation questionnaire, but most of those who consider the outcomes unsatisfactory are likely to do so. The Retrofit Evaluator's report can only cover dwellings for which questionnaires have been completed and returned. Dwellings for which completed questionnaires are not returned may be assumed to have satisfactory outcomes, unless the Client indicates otherwise.*

14.4.3 Basic monitoring and evaluation shall be completed and reported within three months after handover of the retrofit project.

14.5 Intermediate monitoring and evaluation

14.5.1 Intermediate monitoring and evaluation shall include:

- a review of the report of the basic monitoring and evaluation carried out;
- an inspection of the dwelling to check that all the installed EEMs are in place and functioning correctly, and to identify any instances of condensation, damp or mould;
- post installation air-tightness testing (if an air-tightness standard was specified, improvement measures that might have affected air-tightness were installed or there is any evidence of condensation or mould);
- fuel use monitoring for a period long enough to acquire useful information, using data from the occupants' fuel bills, meter readings or smart meters, and taking account of the occupancy pattern during the monitoring period;
- recording of internal temperature and relative humidity throughout the monitoring period;
- brief questionnaire-based occupant interviews, covering the points identified in **14.4.1** and the following additional points: the functionality of the installed EEMs; and the ability of the occupants to achieve satisfactory comfort conditions, including temperature and internal air quality; and
- identification of any occupancy factors or occupants' actions that might be contributing to poor outcomes.

NOTE *Fuel use monitoring should preferably be carried out during the heating season.*

14.5.2 The Retrofit Evaluator shall collate the information obtained during the monitoring process, summarize it, formulate recommendations for any remedial actions required and any changes to the retrofit process that might be appropriate, and circulate the summary and recommendations to the Client, the Retrofit Coordinator, the Retrofit Assessor, the Retrofit Designer and the Retrofit Installer.

14.5.3 Intermediate monitoring and evaluation shall be completed and reported within six months after basic monitoring and evaluation have been completed, or as soon as seasonal weather conditions allow.

14.6 Advanced monitoring and evaluation

14.6.1 Advanced monitoring and evaluation shall include all the elements of intermediate monitoring (**14.5.1**) and in addition shall also include, as appropriate:

- a post construction review to confirm exactly what was installed and whether the installation is consistent with the retrofit design;
- a post occupancy evaluation based on two detailed questionnaire-based interviews with occupant(s), carried out with an interval of one year between them;
- a thermographic survey of the dwelling(s);
- monitoring of internal conditions including temperature, relative humidity, and carbon dioxide concentration for a period of at least one year;
- monitoring of moisture levels within the building fabric and/or at the interfaces between insulation and masonry;
- sub-metering of energy use by any new building services systems including ventilation, heating and hot water, lighting and any LZC or "renewable energy" technologies (e.g. solar thermal systems, solar photovoltaics) for a period of at least one year; and
- investigation of any defects revealed by monitoring (at any level), the post construction review, the post occupancy evaluation, the inspection, the air-tightness test, the thermographic survey, or the monitoring of fuel use and internal conditions.

14.6.2 The Retrofit Evaluator shall collate the information obtained during the monitoring process, analyse and interpret it to establish the root cause(s) of any performance discrepancy, summarize it including tables and charts as appropriate, formulate recommendations for any remedial actions required and any changes to the retrofit process that might be appropriate, and circulate the summary and recommendations to the Client, the Retrofit Coordinator, the Retrofit Assessor, the Retrofit Designer and the Retrofit Installer.

14.6.3 Advanced monitoring and evaluation shall be completed within two years after basic monitoring and evaluation has been completed.

NOTE *It might be appropriate, with the permission of the Client, to supply copies of evaluation reports (at any level) to any external quality assurance body such as TrustMark, or (on request) to a funding organization or guarantee provider. Such bodies might require more extensive or detailed monitoring or investigation, over and above the requirements of this PAS.*

15 Claims of compliance

15.1 General

15.1.1 Where claims of conformance to PAS 2035 are made, the provisions in **15.2** and **15.3** shall apply. These provisions include identification of the basis of the claim (**15.2**) and requirements for how the claim shall be expressed (**15.3**).

15.2 Basis of claim

15.2.1 General

The claim shall identify the type of conformity assessment undertaken as one of the following:

a) independent third-party certification in accordance with **15.2.2**;

b) other-party validation in accordance with **15.2.3**; or

c) self-assessment in accordance with **15.2.4**.

15.2.2 Independent third-party certification

Retrofit Coordinators seeking to demonstrate that the energy retrofitting of any dwelling(s) has been independently verified as being in accordance with this PAS shall undergo assessment by an independent third-party certification body or organization accredited by the National Accreditation Body (UKAS).

NOTE 1 *Details on providing assessment and certification are given in Regulation EC765/2008 to ISO/IEC 17065.*

NOTE 2 *Independent third-party certification of compliance with PAS 2035 is not currently (2019) available or in development, and is not intended, but the option is included here because it might become a requirement of a user such as TrustMark, in the future.*

15.2.3 Other-party validation

Retrofit Coordinators claiming conformance with this PAS for any particular project, or their sub-contractors claiming compliance with relevant parts, and using a method of validation involving parties other than those qualifying as accredited independent third parties, shall satisfy themselves that any such party is able to demonstrate compliance with recognized standards setting out requirements for organizations providing services for the assessment of processes and/or individuals.

NOTE 1 *Other-party assessment bodies are those undertaking assessment services without having achieved accreditation from the authorized accreditation service (e.g. UKAS in the UK). Such bodies could include those which, although independent of the organization undertaking the assessment, cannot demonstrate complete independence (e.g. a quality assurance scheme such as TrustMark providing assessment services for its members or a consultant employed for such a purpose).*

NOTE 2 *An example of such recognized standards is ISO/IEC 17065.*

15.2.4 Self-assessment

Retrofit Coordinators claiming conformance with this PAS for any project, or their sub-contractors claiming compliance with relevant parts of it, shall be able to demonstrate that the activities involved have been undertaken in accordance with this PAS, and make supporting documentation available on request. The self-assessment and presentation of the results shall be carried out in accordance with BS EN ISO 14021.

NOTE *Retrofit Coordinators for whom neither independent third-party certification nor other-party validation is a realistic option may rely on self-assessment. In so doing they should be aware that independent validation could be required in the event of a challenge and that stakeholders and interested parties could have less confidence in this self-assessment option.*

15.3 Permitted forms of disclosure

Claims of conformity with this PAS shall be made by Retrofit Coordinators using the appropriate form of disclosure, as follows:

a) For claims of conformity based on independent third-party certification in accordance with **15.2.1a**):

"Retrofit project undertaken at [insert unambiguous identification of relevant property] in accordance with PAS 2035 by [insert unambiguous identification of the claimant], [insert unambiguous identification of the certification body] certified."

b) For claims of conformity based on other-party validation in accordance with **15.2.1b)**:

"Retrofit project undertaken at [insert unambiguous identification of relevant property] in accordance with PAS 2035 by [insert unambiguous identification of the claimant], [insert unambiguous identification of the validating body] validated."

c) For claims of conformity based on self-assessment in accordance with **15.2.1c):**

"Retrofit project undertaken at [insert unambiguous identification of relevant property] in accordance with PAS 2035 by [insert unambiguous identification of the claimant], self-assessed."

16 References

16.1 Retrofit framework standards

COMMENTARY ON Clause 16

These standards are included in the Retrofit Standards Framework. Therefore, users of the TrustMark should comply with them.

16.1.1 Standards publications

PAS 2030, *Specification for the installation of energy efficiency measures in existing dwellings and insulation in residential park homes*

BS 5250, *Code of practice for control of condensation in buildings*

BS 5410-1, *Code of practice for oil firing – Part 1: Installations up to 45 kW output capacity for space heating and hot water supply purposes*

BS 5410-2, *Code of practice for oil firing – Part 2: Installations of 45 kW and above output capacity for space heating, hot water and steam supply service*

BS 5440-1, *Flueing and ventilation for gas appliances of rated input not exceeding 70kW net (1st, 2nd, 3rd family gases) – Part 1: Specification for installation of gas appliances to chimneys and for maintenance of chimneys*

BS 5440-2, *Flueing and ventilation for gas appliances of rated input not exceeding 70 kW net (1st, 2nd and 3rd family gases) – Part 2: Specification for the installation and maintenance of ventilation provision for gas appliances*

BS 5482-1, *Code of practice for domestic butane and propane gas burning installations – Part 1: Permanent dwellings*

BS 5864, *Installation and maintenance of gas-fired ducted air heaters of rated heat input not exceeding 70 kW net (2nd and 3rd family gases) – Specification*

BS 5918, *Solar heating systems for domestic hot water – Code of practice for design and installation*

BS 5970, *Code of practice for thermal insulation of pipework and equipment in the temperature range of -100°C to +870 °C*

BS 6100-1, *Building and civil engineering – Vocabulary – Part 1: General terms*

BS 6262-2, *Glazing for buildings – Part 2: Code of practice for energy light and sound*

BS 6262-3, *Glazing for buildings – Part 3: Code of practice for fire security and wind loading*

BS 6262-4, *Glazing for buildings – Part 4: Code of practice for safety related to human impact*

BS 6262-6, *Glazing for buildings – Part 6: Code of practice for special applications*

BS 6262-7, *Glazing for buildings – Part 7: Code of practice for the provision of information*

BS 6644, *Specification for installation of gas-fired boilers of rated inputs between 70 kW (net) and 1.8 MW (net) (2nd and 3rd family gases)*

BS 6798, *Specification for installation and maintenance of gas-fired boilers of rated input not exceeding 70 kW net*

BS 6891, *Installation of low-pressure gas pipework of up to 35 mm (R1 1/4) on premises*

BS 7386, *Specification for draughtstrips for the draught control of existing doors and windows in housing (including test methods)*

BS 7593, *Code of practice for treatment of water in domestic hot water central heating systems*

BS 7619, *Extruded cellular unplasticized white PVC (PVC-UE) profiles – Specification*

BS 7671, *Requirements for electrical installations – IET Wiring Regulations*

BS 7880, *Code of Practice for draught control of existing doors and windows in housing using draughtstrips*

BS 7913, *Guide to the conservation of historic buildings*

BS 8000-0, *Workmanship on building sites – Part 0: Introduction and general principles*

BS 8102, *Code of practice for protection of below ground structures against water from the ground*

BS 8123-4, *Windows and doors – Part 4: Code of practice for the survey and installation of windows and external doorsets*

BS 8550-0, *Flood resistant and resilient construction – Guide to improving the flood performance of buildings*

BS 8558, *Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages – Complimentary guidance to BS EN 806*

BS 8660-1, *Gas-fired micro-cogeneration appliances of rated thermal input not exceeding 70 kW net – Part 1: Specification for selection, installation, inspection, commissioning, servicing and maintenance of Stirling engine micro-cogeneration appliances*

BS EN 3781, *Refrigerating systems and heat pumps – Safety and environmental requirements – Basic requirements, definitions, classification and selection criteria*

BS EN 3783, *Refrigerating systems and heat pumps – Safety and environmental requirements – Installation location and personal protection*

BS EN 3784, *Refrigerating systems and heat pumps – Safety and environmental requirements – Operation, maintenance, repair and recovery*

BS EN 8061, *Specifications for installations inside buildings conveying water for human consumption – General*

BS EN 8064, *Specifications for installations inside buildings conveying water for human consumption – Installation*

BS EN 8065, *Specifications for installations inside buildings conveying water for human consumption – Operation and maintenance*

BS EN 1264-1, *Water based surface embedded heating and cooling systems – Part 1: Definitions and symbols*

BS EN 1264-2, *Water based surface embedded heating and cooling systems – Part 2: Floor heating: Prove methods for the determination of the thermal output using calculation and test methods*

BS EN 1264-3, *Water based surface embedded heating and cooling systems – Part 3: Dimensioning*

BS EN 1264-4, *Water based surface embedded heating and cooling systems – Part 4: Installation.*

BS EN 1264-5, *Water based surface embedded heating and cooling systems – Part 5: Heating and cooling surfaces embedded in floors. Determination of the thermal output*

BS EN 1670, *Building hardware* – Corrosion resistance – Requirements and test methods

BS EN 12828, *Heating systems in Buildings – Design for water-based heating systems*

BS EN 12831-1, *Energy performance of buildings – Part 1: Method for calculation of the design heat load – Space heating load, Module M3-3*

BS EN 12831-3, *Energy performance of buildings – Part 3: Method for calculation of the design heat load – Domestic hot water systems heat load and characterisation of needs, Module M8-2, M8-3*

BS EN 13120, *Internal blinds* – Performance requirements including safety

BS EN 13141-1, *Ventilation for buildings – Performance testing of components/products for residential ventilation – Part 1: Externally and internally mounted air transfer devices*

BS EN 13141-4, *Ventilation for buildings –. Performance testing of components/products for residential ventilation – Part 4: Fans used in residential ventilation systems*

BS EN 13141-6, *Ventilation for buildings – Performance testing of components/products for residential ventilation – Part 6: Exhaust ventilation system packages used in a single dwelling*

BS EN 13141-7, *Ventilation for buildings –. Performance testing of components/products for residential ventilation – Part 7: Performance testing of a mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for single family dwellings*

BS EN 13141-8, *Ventilation for buildings – Performance testing of components/products for residential ventilation – Part 8: Performance testing of un-ducted mechanical supply and exhaust ventilation units (including heat recovery) for mechanical ventilation systems intended for a single room*

BS EN 13141-9, *Ventilation for buildings – Performance testing of components/products for residential*

ventilation – Part 9: Externally mounted humidity controlled air transfer device

BS EN 13141-10, *Ventilation for buildings – Performance testing of components/products for residential ventilation – Part 10: Humidity controlled extract air terminal device*

BS EN 13141-11, *Ventilation for buildings – Performance testing of components/products for residential ventilation – Part 11: Supply ventilation units*

BS EN 13561, *External blinds and awnings – Performance requirements including safety*

BS EN 13659, *Shutters and external venetian blinds – Performance requirements including safety*

BS EN ISO 14021, *Environmental labels and declarations – Self-declared environmental claims*

BS EN 14336, *Heating systems in buildings – Installation and commissioning of water-based systems*

BS EN 15316-4-8, *Heating systems in buildings – Method for calculation of system energy requirements and system efficiencies – Space heating generation systems, air heating and overhead radiant heating systems*

BS EN 16484-1, *Building automation and control systems (BACS) – Part 1: Project specification and implementation*

BS EN 16883, *Conservation of cultural heritage – guidelines for improving the energy performance of historic buildings*

BS EN 62446-1, *Photovoltaic (PV) systems – Requirements for testing, documentation and maintenance – Part 1: Grid connected systems – Documentation, commissioning tests and inspection*

BS EN ISO 11600, *Building construction – Jointing products – Classification and requirements for sealants*

16.1.2 MCS standards:

MCS *Installer Standards* [N7]

MCS *Product Standards* [N8]

16.1.3 Insulation standards and guides

- *Specification for the installation of external wall insulation ensuring the safety and operation of fuel burning appliances* [10]
- *External Wall Insulation Specification for Weathering and Thermal Bridge Control* [11]
- *External Wall Insulation pre-installation building inspection checklist* [12]
- *Retrofit Floor Insulation Guidance* [13]
- *CITB Loft Insulation Guide TRM 152/1* [14]
- *Room in Roof Insulation Guide* [15]

16.1.4 Ventilation standards and guides

Ecodesign Commission Regulation (EU) 1253/2014 (energy efficiency of ventilation) [16]

BESA DW 144, *Guidance on Ductwork for MVHR* [19]

BESA DW 154, *Specification for Plastics Ductwork* [20]

BSRIA Guide 46/2013, *Domestic Ventilation Systems* [21]

BSRIA Guide 43/2013, *Flexible Ductwork* [N14]

16.2 List of references (other than formal standards, for guidance only)

Climate Change Tools online guidance for architects consisting of seven guides:

1 *Climate Change Briefing*
2 *Carbon Literacy*
3 *The Principles of Low Carbon Design and Refurbishment*
4 *Low Carbon Standards and Assessment Methods*
5 *Low Carbon Design Tools*
6 *Skills for Low Carbon Buildings*
7 *Whole-Life Assessment for Low Carbon Design*

Royal Institute of British Architects, London, 2009

Annex A (Normative) Qualifications

COMMENTARY ON Annex A

RPEL is Recognition of Prior Experience and Learning. To meet the requirements of this PAS, RPEL processes should lead to a nationally recognized vocational or professional qualification that appears in the Register of Regulated Qualifications maintained by Ofqual for England and by its equivalents for the devolved nations.

A.1 Qualifications for Retrofit Advisors

A.1.1 A Retrofit Advisor shall be either:

- a person who has completed the City & Guilds Energy awareness and energy advice training and passed the associated examination and practical test, or who is working towards that qualification via a recognized training course or RPEL process;

  ***NOTE** This qualification is no longer available but is still relevant to those who have completed it previously.*
- a Green Deal Advisor certified and registered by a recognized certification body; or
- a Retrofit Coordinator qualified in accordance with **A.3**.

A.2 Qualifications for Retrofit Assessors

A.2.1 For projects assessed as risk grade A, to which the requirements of **Path A** apply, a Retrofit Assessor shall be a Retrofit Coordinator qualified in accordance with **A.3**, or a Domestic Energy Assessor certified and registered by a UKAS-accredited assessor body, or who is working towards such certification and registration via a recognized RPEL process or via a training course that appears on the register maintained by Ofqual (for England), the Council for Curriculum Examinations and Assessment (for Northern Ireland), the Scottish Qualifications Authority (for Scotland) or Qualifications in Wales (for Wales).

A.2.2 For projects assessed as risk grade B or C, to which the requirements of **Path B** or **Path C** apply, a Retrofit Assessor shall be a Domestic Energy Assessor certified and registered by a UKAS-accredited assessor body, or who is working towards such certification and registration via a recognized RPEL process or via a training course that appears on the register maintained by Ofqual (for England), the Council for Curriculum Examinations and Assessment (for Northern Ireland), the Scottish Qualifications Authority (for Scotland) or Qualifications in Wales (for Wales).

A.2.3 For projects assessed as risk grade B or C, to which the requirements of **Path B** or **Path C** apply, where the dwelling to be assessed is a protected building, the Retrofit Assessor shall meet the requirements of **A.2.2** and shall also hold one of the following qualifications:

- the Level 3 Award in Energy Efficiency and Retrofit of Traditional Buildings;
- the Scottish Level 6 Award in Energy Efficiency Measures for Older and Traditional Buildings; and
- the Welsh Level 3 Award in Energy Efficiency Measures for Older and Traditional Buildings.

***NOTE** These three qualifications are almost identical and may be regarded as interchangeable for the purpose of this PAS. The Scottish qualification has been withdrawn and the Welsh qualification is no longer available, but holders of these qualifications still meet the requirements of **A.2.3**.*

A.3 Qualifications for Retrofit Coordinators

A.3.1 A Retrofit Coordinator shall be a person who holds a Level 5 Diploma in Retrofit Coordination and Risk Management, or who can provide evidence of currently working towards such a qualification via a recognized RPEL process or via a training course that appears on the register maintained by Ofqual (for England), the Council for Curriculum Examinations and Assessment (for Northern Ireland), the Scottish Qualifications Authority (for Scotland) or Qualifications in Wales (for Wales).

***NOTE** Building-related professional or vocational qualifications are required as pre-requisites for the Level 5 Diploma in Retrofit Coordination and Risk Management. Contact the Awarding Body or an appropriate training organisation for further information.*

A.4 Qualifications for Retrofit Designers

A.4.1 For projects assessed as risk grade A, and to which the requirements of **Path A** apply:

- where the only improvement measure proposed is a single measure, a Retrofit Designer shall be a specialist designer or specifier of that measure, who holds or who is working towards a measure-specific recognized qualification via a recognized RPEL process or via a training course that appears on the register maintained by Ofqual (for England), the Council for Curriculum Examinations and Assessment (for Northern Ireland), the Scottish Qualifications Authority (for Scotland) or Qualifications in Wales (for Wales);
- where the only improvement measure proposed is a single proprietary system, a Retrofit Designer shall be a specialist designer or specifier of that system, who has been trained and approved by the manufacturer or supplier of that system;
- where the only improvement measure proposed is a combustion appliance, the Retrofit Designer shall be a specialist designer or specifier who has been trained and approved by the manufacturer and/or for gas installations holds Gas Safe registration or for oil heating holds competent person registration; and
- where a measure is a system covered by the MCS [N7], [N8], the Retrofit Designer shall be a specialist designer or specifier of the system who is MCS certified.

In all of the above cases, the design prepared shall be reviewed by a Retrofit Coordinator qualified in accordance with **A.3**, and any concerns shall be reported to the specialist designer.

A.4.2 For other projects assessed as risk grade A, and to which the requirements of **Path A** apply, a Retrofit Designer shall be either:

- a Retrofit Coordinator qualified in accordance with **A.3**; or
- a Chartered Architectural Technologist (MCIAT) registered by the Chartered Institute of Architectural Technologists (CIAT), or who is working towards such registration via a recognized RPEL process or training course.

A.4.3 For projects assessed as risk grade B, and to which the requirements of **Path B** apply, a Retrofit Designer shall be:

- a Retrofit Coordinator qualified in accordance with **A.3**; or
- a Chartered Architectural Technologist (MCIAT) registered by the Chartered Institute of Architectural Technologists (CIAT), or who is working towards such registration via a recognized RPEL process or training course; or
- an Architect registered by the Architects Registration Board (ARB); or
- a professional member of the Chartered Institute of Building (MCIOB); or
- a Chartered Building Surveyor (MRICS or FRICS only).

A.4.4 For projects assessed as risk grade B, and to which the requirements of **Path B** apply, and the building to be improved (or any part of it) is traditionally constructed, the Retrofit Designer shall also be a member of a certification/accreditation building conservation scheme run by one of the following organizations:

- the Chartered Institute of Architectural Technologists (CIAT);
- the Chartered Institute of Building (CIOB);
- the Conservation Accreditation Register for Engineers (CARE);
- the Register of Architects Accredited in Building Conservation (AABC);
- the Royal Institute of British Architects (which incorporates the Royal Society of Architects in Wales and the Royal Society of Ulster Architects (RIBA, RSAW, RSUA);
- the Royal Institution of Chartered Surveyors (RICS);
- the Royal Incorporation of Architects in Scotland (RIAS).

A.4.5 For projects assessed as risk grade C, and to which the requirements of **Path C** apply, a Retrofit Designer shall be:

- a Chartered Architectural Technologist (MCIAT) registered by the Chartered Institute of Architectural Technologists (CIAT), or who is working towards such registration via a recognized RPEL process or training course; or

- an Architect registered by the Architects Registration Board (ARB), who is also either a Retrofit Coordinator qualified in accordance with **A.3** or holds one of the qualifications listed in **A.2.3**; or
- a professional member of the Chartered Institute of Building Services Engineers (CIBSE) who is also either a Retrofit Coordinator qualified in accordance with **A.3** or holds one of the qualifications listed in **A.2.3**; or
- a professional member of the Chartered Institute of Building (MCIOB or FCIOB) who is also either a Retrofit Coordinator qualified in accordance with **A.3** or holds one of the qualifications listed in **A.2.3**; or
- a Chartered Building Surveyor (MRICS or FRICS only) who is also either a Retrofit Coordinator qualified in accordance with **A.3** of this PAS or holds one of the qualifications listed in **A.2.3**.

A.4.6 For projects assessed as risk grade C, and to which the requirements of **Path C** apply, and the building to be improved (or any part of it) is traditionally constructed or protected, the Retrofit Designer shall also be accredited or certified in building conservation via a scheme run by one of the following organizations:

- the Chartered Institute of Architectural Technologists (CIAT);
- the Chartered Institute of Building (CIOB);
- the Conservation Accreditation Register for Engineers (CARE);
- the Register of Architects Accredited in Building Conservation (AABC);
- the Royal Institute of British Architects (which incorporates the Royal Society of Architects in Wales and the Royal Society of Ulster Architects (RIBA, RSAW, RSUA);
- the Royal Institution of Chartered Surveyors (RICS),
- the Royal Incorporation of Architects in Scotland (RIAS);

and where the dwelling is protected and such scheme provides for more than one level of accreditation or certification the accreditation or certification shall be at the highest level available.

A.5 Qualifications for Retrofit Evaluators

A.5.1 A Retrofit Evaluator shall be a Retrofit Coordinator qualified in accordance with **A.3**.

NOTE *Although the role of Retrofit Evaluator is filled by a Retrofit Coordinator, the separately defined role of Retrofit Evaluator is retained so that specialist qualifications that are proposed for this role can be added to later editions.*

A.5.2 A Retrofit Evaluator for a project involving any traditionally constructed or protected building shall also hold one of the qualifications listed in **A.2.3**.

A.6 Multiple roles

NOTE *It is not a requirement that the roles of Retrofit Advisor, Retrofit Assessor, Retrofit Coordinator, Retrofit Designer and Retrofit Evaluator be filled by separate individuals. The same person can have two or more of these roles provided that he or she is qualified for each role, as defined in this Annex of this PAS, and either there is no conflict of interest involved or any conflict of interest is reported to the Client and appropriately managed.*

A.6.1 Where basic monitoring and evaluation (see **14.3**) is carried out, the Retrofit Evaluator and the Retrofit Coordinator may be the same person. Where intermediate and/or advanced monitoring and evaluation (see **14.3**) is carried out the Retrofit Evaluator may not be the same person as the Retrofit Coordinator, and shall be independent of the Retrofit Assessor, the Retrofit Coordinator, the Retrofit Designer and the PAS 2030 Retrofit Installer.

Annex B (Normative) Risk Assessments

B.1 The risk assessment process (**7.1**) shall consist of the assessment of risk grades for each of five criteria and their aggregation into an overall risk grade that is used to determine the relevant compliance path for the application of this PAS, in accordance with Table **B.1** and Table **B.2**.

Table B.1 – Risk assessment table for determining PAS 2035 Path

Criterion 1: Number of dwellings in the project		
The number of dwellings to be improved	**Risk grade**	**Assessed grade**
1–10	A	
11–30	B	
More than 30	C	
Criterion 2: Number of measures per dwelling[A)]		
The average number of improvement measures per dwelling	**Risk grade**	**Assessed grade**
1–2	A	
3–5	B	
More than 5	C	
Criterion 3: Measures proposed		
The inherent technical risk of the highest risk measure (from Table **B.2**)	**Risk grade**	**Assessed grade**
1	A	
2	B	
3	B	
Criterion 4: Combination of measures		
The highest risk combination of measures (from the Measures Interaction Matrix, Figure **D1**)	**Risk grade**	**Assessed grade**
GREEN	A	
ORANGE	B	
YELLOW	B	
Criterion 5: Construction and Built Form		
Construction and built form of buildings	**Risk grade**	**Assessed grade**
Conventional[B)], not high-rise, not protected[C)]	A	
Traditional[D)], not protected[C)]	B	
System-built[E)], not high-rise, not protected[C)]	B	
High rise[F)], any construction	C	
Protected[C)], any construction or built form	C	

Table B.1 – Risk assessment table for determining PAS 2035 Path *continued*

Overall Risk Grade		
Highest assessed grade (from Criteria 1 to 5 above)	**PAS 2035 Path**	**Assessed Path**
A	A	
B	B	
C	C	

[A] For this risk assessment, the number of measures excludes any ventilation upgrade required by Annex **C**.

[B] Conventional means masonry cavity wall construction (brick and/or block) with or without render, tile hanging or other external cladding.

[C] For the purpose of this PAS, protected buildings include Listed Buildings and buildings in Conservation Areas or World Heritage Sites.

[D] Traditional means constructed with solid brick or stone walls, or timber-framed walls with any infill.

[E] System-built means frame (timber, steel or concrete) and pre-fabricated panel (concrete or timber, or a combination) construction, or timber-framed construction with brick or stone external cladding.

[F] High-rise means over 12 metres or over four storeys in height above the ground.

***NOTE** The format of Table **B.1** is provided as an example only; users of this PAS may meet the requirement for use of the content of the table in whatever manner is appropriate to their operation.*

Table B.2 – Inherent technical risks of energy efficiency measures (EEMs)

Measure	IHT	Measure	IHT
Internal solid wall insulation (IWI)	3	Passive stack ventilation	2
External solid wall insulation (EWI)	2	Single-room heat recovery ventilators	1
Cavity wall insulation	2	Decentralized mechanical extract ventilation	2
Party cavity wall insulation	2	Centralized mechanical extract ventilation	2
Loft insulation (between and over joists)	2	Positive input ventilation	3
Loft insulation between/under/over rafters	2	Mechanical ventilation with heat recovery	3
Flat roof insulation	3	Radiator reflector panels	1
Room in roof insulation (all elements)	3	District / communal heating – connection	3
Floor insulation (solid or suspended)	3	District / communal heating – heat meters	1
Hot water cylinder insulation	1	Air source heat pump	3
Primary pipework insulation	1	Ground source heat pump	3
Draught-proofing / air-tightness measures	1	Biomass boiler	2
New or replacement windows	1	Micro combined heat and power	3
New or replacement external doors	1	Solar photovoltaics	2
Boiler replacement	2	Micro wind-power	2
New central heating system	2	Micro hydro-power	3
Replacement of electric storage heaters	1	Solar water heating	2

Table B.1 – Risk assessment table for determining PAS 2035 Path *continued*

Measure	IHT	Measure	IHT
New warm air heating	2	Energy efficient lighting	1
Heating and hot water controls	1	Energy efficient appliances	1
Flue gas heat recovery	2	Park home insulation	3
Intermittent extract ventilation	1	Other EEMs, including innovations	3
***NOTE** The inherent technical risk of measures is rated comparatively on a scale of 1 to 3.*			

B.2 Where the intended Retrofit Installer operates under an industry quality assurance scheme that has the features listed in **B.6**, the inherent technical risk scores for the measure(s) covered by that scheme in Table **B.2** may be reduced by one.

B.3 Where a measure complies with the MCS standards, [N7], [N8] and is installed by an MCS certified installer the inherent technical risk score for that measure in Table **B.2** may be reduced by one.

B.4 For the installation of external solid wall insulation (EWI), if the construction details in the NIA/INCA/SWIGA guide *External wall insulation specification for weathering and thermal bridge control* [11] are not used, or the details coded amber are used (rather than those coded green), the inherent technical risk score for the relevant measure in Table **B.2** shall be increased by one.

B.5 Any industry quality assurance scheme used to claim a reduction of inherent technical risk, as referred to in **B.2**, shall apply only to measures that are proprietary systems (not individual materials and components) and shall have at least the characteristics set out in **B.6**.

B.6 The industry quality assurance scheme shall:

1) be operated by a body independent of the system provider and the installer (referred to here as the scheme operator);
2) subject system providers to initial and regular assessments of their technical and financial resources and documented management systems;
3) include provision for the imposition of sanctions (including possible removal from the scheme) on members who do not comply with the scheme rules;
4) require maintenance by the scheme operator of expertise to investigate complaints and assist with their resolution;
5) require that:

- systems and their components are subject to independent technical approval by a UKAS accredited body;
- the UKAS accredited body carries out independent checks of manufacturing activity at least annually;
- any equipment used to install a system is tested, calibrated and plated for the system;
- procedures are in place to ensure that only installers approved by the system providers can purchase or install their systems;
- materials and components for systems are appropriately stored and handled, and traceable via an audit process;
- systems' documentation includes generic method statements for their correct installation;
- systems' documentation includes appropriate care and maintenance instructions;
- systems are covered by independent guarantees of the materials and products used, and of any designs prepared by system providers; and
- system providers hold appropriate professional indemnity assurance;

6) require independent checks of compliance with any requirements for independent surveillance of pre-installation inspections;
7) provide for random targeted quality inspections by the scheme operator of installations at a rate of not less than 1% of installations by each scheme member;
8) require system providers to:
   - train installers of their systems;
   - assess installers' qualifications and competence;
   - issue system-specific "competence cards" to qualified and competent operatives;
   - provide qualified and competent operatives with CPD; and
   - re-assess competence at least bi-annually, and maintain records of their training and CPD.
9) require system providers to make comprehensive good practice guidance available in relation to their systems, covering:
   - assessment for suitability;
   - installation;
   - dealing with non-standard installations;
   - guidance on handover to users;
   - guidance for users;
   - complaint handling; and
   - remedial procedures;
10) require system providers to make available regularly updated technical notes to advise installers of trends, identified technical issues, system changes or changes to installation procedures or requirements for qualifications and competence;
11) subject installers of systems to regular random quality inspections by the scheme operators, at a rate not less than 1% of all installations; these inspections shall be additional to any certification body surveillance and shall focus on system-specific performance and quality;
12) require installers of systems to provide the scheme operator with evidence of compliance with the Building Regulations 2010 [22] through membership of a Competent Person Scheme (where applicable), and of certification under PAS 2030:2019;
13) require installers to provide independent guarantees of their work covering pre-installation inspections, any designs they prepare, and installation workmanship;
14) require installers to operate complaints handling procedures and to provide customers with access to alternative dispute resolution; and
15) require installers' compliant handling procedures to be audited annually by the scheme operator.

Annex C (Normative) Requirements for provision of adequate ventilation

COMMENTARY ON Annex C

Reference is made in this annex to The Building Regulations 2010 – Approved Document F: Ventilation [N11] (applicable in England) (referred to in this Annex as "Approved Document F". The equivalent references for the devolved administrations are:

- *for Wales, The Building Regulations 2010 – Approved Document F: Ventilation [N11];*
- *for Scotland, the Scottish Building Standards Technical Handbook 2017: Domestic [N12];*
- *for Northern Ireland, Building Regulations (Northern Ireland) 2012 Guidance: Technical Booklet K: Ventilation [N13].*

The requirement for those undertaking the specification, design and installation of EEM in an existing dwelling to ensure that ventilation at least complies with all relevant requirements of Approved Document F is fully recognized in this PAS but is not a requirement of this specification (see also reference to contractual and legal considerations in the Foreword). The technical requirements of this PAS are not, however, restricted to those included in Approved Document F and in some instances might go beyond the requirements of that document where this is judged to deliver better outcomes.

C.1 Introduction

C.1.1 Traditionally, UK dwellings have relied on wind-driven air infiltration and air leakage to provide adequate ventilation, i.e. to expel "stale" air (containing pollutants such as moisture and high concentrations of carbon dioxide), to provide a supply of "fresh" (i.e. external) air and to maintain IAQ. The average air permeability of dwelling envelopes in the UK (with fans and background ventilators sealed), as measured by BRE research [23], is approximately 10 m^3/m^2h at 50 Pa, and infiltration and air leakage provide most (approximately three-quarters) of the required ventilation.

C.1.2 Since the 1970s the installation of double-glazed, draught-stripped windows, the draught-stripping of external doors and the insulation of lofts and cavity walls have improved energy efficiency but also reduced the air permeability of many homes, reducing infiltration and air leakage. In some cases, this has been compensated for by introducing intermittent extract ventilation fans into "wet" spaces (kitchens and bathrooms) to expel moist stale air and by installing background ventilators (air inlets, commonly known as trickle ventilators) in other spaces to provide balancing supplies of fresh air. However, the existence of a ventilation system is not proof that a building is adequately ventilated, and many existing buildings are not adequately ventilated.

C.1.3 Improving the air-tightness of a dwelling to reduce "adventitious" or uncontrolled wind-driven air infiltration and air leakage, when combined with the provision of adequate controlled ventilation, significantly improves energy efficiency. However, without adequate ventilation, the installation of any additional insulation or air-tightness measure anywhere in the building, or the blocking of any existing ventilator, reduces the infiltration and air leakage rate, and increases the risk that there is insufficient ventilation to maintain adequate IAQ. Poor IAQ includes high relative humidity (which carries a risk of condensation and mould growth) and high concentrations of pollutants such as carbon dioxide and VOCs and dust mites, all of which are associated with serious health risks for occupants or potential damage to building finishes, fabric and structure.

C.1.4 When installing any insulation or air-tightness measures, or replacing windows, in existing buildings, the adequacy of the existing ventilation shall be assessed and if necessary improved.

NOTE *Air-tightness measures include draught-stripping, window replacement and any other measure designed to reduce the infiltration rate of the building envelope. Like-for-like replacement of a window that is already draught-stripped and/or equipped with a background ventilator should not be counted as an air-tightness measure.*

C.2 Assessment of existing ventilation

*NOTE Subclause **8.4** requires Retrofit Assessors to identify and assess existing ventilation systems and confirm that they are working correctly as part of the whole-dwelling assessment.*

C.2.1 For every dwelling proposed for improvement, the Retrofit Designer shall use the information provided by the Retrofit Assessor to assess the adequacy of the existing ventilation according to the following criteria.

C.2.2 Existing ventilation shall be assessed as inadequate for the improved dwelling if one or more of the following are apparent:

- there is evidence of condensation and/or mould growth in the dwelling;
- there is no ventilation system, or the ventilation system is incomplete (see **C.2.3**) or not functional;
- there are not undercuts of at least 7 600 mm^2 beneath all internal doors, above the floor finish, to allow air to move through the dwelling; or
- there is no provision for purge ventilation of each habitable room (e.g. by opening windows) as required by Approved Document F [N11].

C.2.3 An acceptable, complete ventilation system shall be:

- an intermittent extract ventilation (IEV) system consisting of correctly sized extract fans in all "wet" rooms and correctly sized background ventilators (to admit "fresh" external air) in all living spaces and bedrooms; or
- a passive stack ventilation (PSV) system consisting of passive stack ventilators serving all "wet" rooms, and correctly sized background ventilators (to admit "fresh" external air) in all living spaces and bedrooms; or
- a continuous positive input ventilation (PIV) system that supplies "fresh" air, combined with correctly sized background ventilators (to allow moist `stale' air to escape) in all living space and bedrooms;
- a continuous mechanical extract ventilation (MEV) system that extracts moist, "stale" air from all "wet" rooms combined with correctly sized background ventilators (to admit "fresh" external air) in all living spaces and bedrooms;
- a whole-house supply and extract MVHR system that extracts moist "stale" air from all wet rooms, supplies "fresh" eternal air to all living spaces and bedrooms, and has been properly commissioned and balanced.

NOTE 1 Wet rooms include kitchens, bathrooms, shower rooms, utility rooms, and WCs without openable windows; a procedure for sizing background ventilators is given in Approved Document F *[N11].*

NOTE 2 If the only factor rendering the ventilation inadequate is a lack of intermittent extract ventilation fans in all wet rooms, the ventilation can be rendered adequate by providing such fans.

NOTE 3 If the only factor rendering the ventilation inadequate is a lack of background ventilators, the ventilation can be rendered adequate by providing such ventilators.

NOTE 4 If the only factor rendering the ventilation inadequate is a lack of undercuts beneath all internal doors, the ventilation can be rendered adequate by providing such undercuts.

NOTE 5 If the only factor rendering the ventilation inadequate is lack of provision for purge ventilation, the ventilation can be rendered adequate by provision of an opening window in each room.

NOTE 6 Evidence that a ventilation system is not working properly would be a lack of significant air flow through the extract or supply grilles, or fans. This can be measured easily with a simple vane anemometer.

C.2.4 However, if the proposed energy efficiency improvement measures are either intended to reduce the air permeability of the building envelope below 5 m^3/m^{2}h at 50 Pa or might do so, then existing IEV or PSV as described in **C.2.3** shall be assessed as inadequate.

C.3 Upgrading of ventilation

*NOTE 1 A new British Standard for air-tightness and ventilation for domestic retrofit is proposed. On publication, the new standard supersedes **C.3.1** to **C.3.15** below. Prior to publication of the new standard, clauses **C.3.1** to **C.3.15** are applicable to all domestic retrofit projects.*

*NOTE 2 Some of the following clauses (**C.3.3** to **C.3.11** inclusive) refer to the ventilation equipment testing standard series BS EN 13141. The relevant clauses of each part of BS EN 13141 are specified in Approved Document F, Table 5.3 [N11].*

C.3.1 Where the existing ventilation is assessed as inadequate, and any insulation or air-tightness measures are proposed, the Retrofit Coordinator shall ensure that the Retrofit Designer includes upgrading of the ventilation in the retrofit design.

NOTE Air-tightness measures include (but are not limited to):

- *draught-stripping of existing windows and doors;*
- *secondary glazing;*
- *replacement of existing windows and doors (irrespective of whether the original units were draught-stripped or the new units include background ventilators);*

- *the provision of a new air barrier layer in the construction or lining of any exposed floor, wall or roof;*
- *sealing up of existing chimneys and flues; and*
- *the replacement of any open-flued heating or hot water appliance with a room-sealed appliance (i.e. one with a balanced flue).*

C.3.2 Where the existing ventilation is assessed as inadequate, but no insulation or air-tightness measures are proposed, the Retrofit Coordinator shall bring the results of the ventilation assessment to the attention of the Client and the Retrofit Designer, with a recommendation that the ventilation system is upgraded. For projects with assessed risk grades of B or C (**Paths B** or **C**) upgrading of the ventilation system shall be included in any medium-term improvement plan for the dwelling required by **9.2.4**.

C.3.3 Where ventilation is to be upgraded and it can be shown by fan pressurization testing (or another accepted method) that the air permeability of the building envelope, after installation of the proposed energy efficiency measures, is not less than 5 m^3/m^2h at 50 Pa, then an acceptable type of ventilation shall be IEV tested in accordance with BS EN 13141-4, or PSV in all "wet" spaces combined with correctly sized background ventilators tested in accordance with BS EN 13141-1 in all living spaces and bedrooms. In either case, the ventilation system capacity shall be determined in accordance with the procedures set out in Approved Document F [N11], but assuming occupancy equal to the number of bed-spaces in the dwelling, i.e. two persons in each double bedroom and one in each single bedroom, to ensure adequate capacity. In the case of PSV, the apertures of the air extract grilles (in wet spaces) shall be automatically controlled in response to internal relative humidity (RH).

C.3.4 Due consideration shall also be given to building location, local topography, orientation and internal layouts and dimensions to confirm that natural ventilation (IEV or PSV) is effective. If this is not the case, then neither IEV nor PSV is acceptable, and the ventilation system shall be upgraded in accordance with **C.3.5**.

NOTE *Whether IEV is likely to be effective should be determined in accordance with the procedures set out in* Approved Document F, Appendix A *[N11].*

C.3.5 In all other cases where ventilation is to be upgraded the minimum acceptable type of ventilation shall be:

- continuous MEV consisting of one or more fans tested in accordance with BS EN 13141-6 and extracting moist "stale" air from all "wet" spaces, combined with background ventilators tested in accordance with BS EN 13141-1 in all living spaces and bedrooms to admit a balancing supply of "fresh" external air;
- continuous whole-dwelling MVHR tested in accordance with BS EN13141-7, extracting moist "stale" air from "wet" spaces and providing a balanced supply of "fresh" external air to all living spaces and bedrooms; or
- continuous PIV tested in accordance with BS EN 13141-11, providing a supply of "fresh" external air to the centre of the dwelling, combined with background ventilators tested in accordance with BS EN 13141-1 in all living spaces and bedrooms to allow moist "stale" air to escape.

NOTE 1 *MVHR provides benefits from the recovery of heat from exhaust air, reducing heating demand. The use of MVHR is a requirement of the Passive House EnerPHit standard [24], if it is adopted. MVHR was developed for new dwellings, so it requires careful design to install it in existing dwellings, especially smaller ones. To ensure adequate performance and heat recovery efficiency, fan boxes, heat exchangers and ductwork should not be installed in unheated spaces, and cold air ducts should be insulated to reduce condensation risk. To achieve adequate performance and noise levels, ductwork should be as short and straight as possible. Attention should be given to balancing and commissioning MVHR systems in accordance with manufacturers' instructions and recommendations.*

NOTE 2 *PIV fans are often mounted in a roofspace so that the systems can benefit from some degree of solar heat gain in the roof (or heat loss from the house into the roofspace), and supply air that is slightly warmer than external air. However, PIV systems can drive warm moist air through gaps and holes into cold parts of the construction, and into construction voids (e.g. beneath floors), with a consequent risk of condensation and mould growth.*

C.3.6 Assessment of the suitability of a proposed ventilation system should take account of the air permeability of the building envelope and the fact that after retrofit the air permeability might be lower. In all cases where ventilation is upgraded, provision shall also be made for purge ventilation in any habitable room that does not already have such provision; see Approved Document F [N11] for details on providing purge ventilation.

NOTE *Purge ventilation can be provided by means of openable windows, or by mechanical means if window opening is not possible.*

C.3.7 Any fan specified as part of any of the ventilation systems described in **C.2** shall be an energy efficient model compliant with EcoDesign Commission Regulation (EU) 1253/2014 [16]. Ventilation systems shall conform to *Domestic ventilation systems* [N10].

C.3.8 If MEV is installed, it may be either centralized (cMEV, i.e. a single central fan with ducts) or decentralized (dMEV, i.e. one fan in each "wet" room, with only minimal ducting connecting the fans to the exterior, if required). If dMEV fans are used, they shall either meet the requirements for listing on the SAP Product Characteristics Database (PCDB) [17] or they shall be tested in accordance with BS EN 13141-6; the effect of wind on the performance of a dMEV system shall not reduce the air flow rate by more than 10%. Continuous extract fans can also be used, provided they have the capability to achieve the minimum flow rates specified in Approved Document F, Table 5.1a [N11] for intermittent extract fans.

***NOTE** For dMEV fans, the installation configuration of the fan unit is specified in BS EN 13141-6:2014, **5.2.2** and the test conditions (e.g. normal conditions, wind conditions, temperature, electrical conditions) are specified in BS EN13141-6:2014, **5.2.4**. The wind conditions specified in BS EN 13141-6:2014, **5.2.4.1.2** are applied with a counter pressure of 5 Pa.*

C.3.9 Whichever of the options (**C.3.5**) is adopted, the ventilation system shall be capable of providing a whole-dwelling background ventilation rate equivalent to at least the "minimum low rate" of whole-dwelling ventilation specified in Approved Document F [N11], assuming occupancy equal to the number of bed-spaces in the dwelling, i.e. two persons in each double bedroom and one in each single bedroom, to ensure adequate capacity. The system shall also provide sufficient additional capacity to ensure that adequate ventilation is maintained throughout the year. Additional ventilation capacity shall also be available intermittently to achieve at least the "minimum high rate" specified in Approved Document F [N11].

***NOTE** Approved Document F [N11] specifies that the "minimum low rate" of whole-dwelling ventilation should be based on the highest of three rates, calculated according to the number of wet rooms, the number of bedrooms (adjusted for occupancy) and the floor area. This approach should be adopted here, but with the bedroom occupancy level assumed as defined above.*

C.3.10 Whichever of the options (**C.3.5**) is adopted, the whole-house ventilation rate shall be controlled automatically so that it can maintain good internal air quality and avoid waste of energy. Controls shall be provided that sense and monitor a control parameter in order to automatically regulate ventilation rate(s) either on a whole house basis or room-by-room in order to match them with demand. Ventilation shall not be controlled solely via light switches or manual switches.

***NOTE 1** The automatic control process is sometimes referred to as "demand control". Demand control complements the provision of adequate capacity in a ventilation system (over and above minimum regulatory requirements) by eliminating unnecessary energy use and noise.*

***NOTE 2** A control parameter is a measurable variable or variables that are assumed to be representative of the ventilation demand, e.g. the level of RH, carbon dioxide, VOC or other gases, or presence, motion or occupancy detection from infrared body heat or from reflection of ultrasonic waves, electrical signals from human operation of lights or equipment.*

***NOTE 3** If RH is used as a control parameter, then any humidity-controlled air terminal or air inlet devices should be tested in accordance with BS EN 13141-9 and BS EN 13141-10.*

C.3.11 Single-room heat recovery ventilators (SRHRVs) or alternate flow heat recovery (AFHR) fans tested in accordance with BS EN 13141-8 can be specified to complement an existing or new ventilation system where appropriate (e.g. in a room that is difficult to connect to a whole-dwelling system), but multiple SRHRVs or AFHR fans shall not be used as a whole-dwelling system.

C.3.12 Any metal or plastic ductwork specified as part of any of the ventilation systems shall conform to the *Domestic ventilation compliance guide* [N14]. Flexible ductwork shall only used for final connections to fan boxes, extract grilles or terminals, and shall conform to *Flexible ductwork* [N14].

***NOTE** Specifiers may also wish to consider BESA guidance DW 144: Specification for sheet metal ductwork [19] or DW 154: Specification for plastics ductwork [20], as appropriate.*

C.3.13 Where any new or upgraded ventilation system is proposed, the ventilation system design shall include calculations provided by a technical consultant, specialist designer or the supplier of the system, to demonstrate that the whole-dwelling ventilation rates specified in **C.3.7** are provided by the equipment proposed.

C.3.14 The ventilation system design shall include provisions to ensure that the location, configuration and fixing of ventilation systems allow them to operate as quietly as possible, without unnecessary noise or vibration, inside or outside the home. For intermittent ventilation systems, the maximum acceptable noise level when the ventilation system is working shall be 30 $dB_{LAeq,T}$ in habitable rooms. For continuous ventilation systems, the maximum acceptable noise level when the ventilation system is working at its background capacity shall be 30 $dB_{LAeq,T}$ in habitable rooms. Ventilation system designers shall take account of the acoustic data provided by fan manufacturers to ensure that system noise levels are acceptable and do not cause annoyance to occupants. Noise levels lower than those specified might be desirable in bedrooms, and higher noise levels might be acceptable in less sensitive rooms, such as kitchens and bathrooms. Noise levels shall be measured as specified in BS 8233 and in accordance with the guidance in Approved Document F [N11].

C.3.15 The retrofit design shall specify that the ventilation system is to be installed by operatives holding suitable qualifications identified in the Register of Regulated Qualifications maintained by Ofqual for England (and by its equivalents for the devolved nations) and approved by the manufacturer or supplier of the system.

NOTE *In the temporary absence of suitable training courses on the Register of Regulated Qualifications, installers should be trained via the competent persons course available from the National Inspection Council for Electrical Installation Contracting (NICEIC) [18].*

Annex D (Normative) Requirements for dealing with interactions between EEMs

D.1 Introduction

D.1.1 When energy efficiency measures are installed in any existing building it is essential to take account of the fact that some measures can impact upon the performance of other measures or can themselves be impacted by those measures. There are also energy efficiency measures that when installed in a building without appropriate care can significantly impair the functionality of the building.

D.1.2 For this reason this PAS emphasizes the need for the Retrofit Designer to consider and make adequate provision for the interfaces between the energy efficiency measures in the retrofit design. PAS 2030 also imposes responsibilities on installers of energy efficiency measures to be alert to these potential issues and to closely follow the retrofit design. This extends to the requirement for installers to pay attention to such matters during the pre-installation building inspection and to bring any perceived issues that they believe not to have been adequately provided for in the retrofit design to the attention of the Retrofit Coordinator.

D.2 Avoidance of thermal bridging

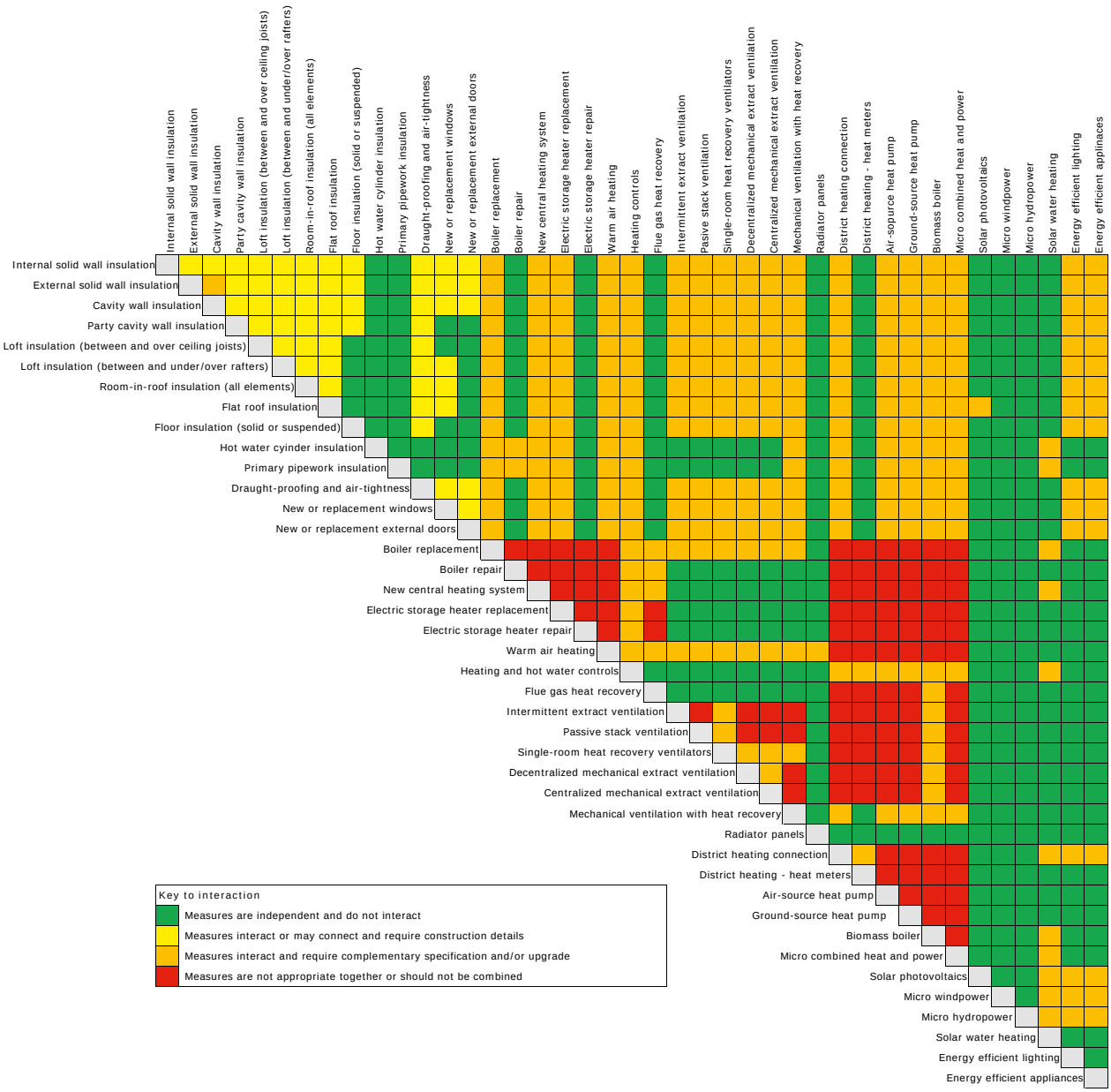
The retrofit design shall include construction details for eliminating thermal bypass and minimizing thermal bridging at corners, junctions and edges of insulation layers either occurring because of geometry or resulting from discontinuity of the insulation or from insulation being thinner than in the adjacent area (e.g. at window reveals, around meter boxes, etc.).

NOTE *These construction details should be based on accepted industry guidance or standards. e.g. External Wall Insulation Specification for Weathering and Thermal Bridge Control [11] (see **10.9.1**). Alternatively, temperature factors for construction details should be calculated in accordance with IP1/06 [N2]. Temperature Factors (f_{Rsi}) should be not less than 0.75.*

D.3 The Measures Interaction Matrix

Figure **D.1** provides information about the nature of relationships between co-installed EEMs, identifying measures that are independent and do not interact and measures that are not appropriate together and shall not be combined; other intermediate relationships (e.g. when a construction detail is required for an interface) are also identified. These relationships shall be taken into account by the Retrofit Designer when developing the retrofit design.

Figure D.1 – The measures interaction matrix



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