Maximising the Benefits of Passivhaus:

A Guide to Supporting Older Occupants

Foreword

From the outset of our improvement programme in 2009, Eastlands Homes has sought to go beyond the traditional boundaries of stock improvement to incorporate enhancements that would make a long-term difference to our customers and neighbourhoods. At Erneley Close we recognised that a significant change would be required.

The layout and access to the blocks of maisonettes meant that new build was not cost effective. Our Board decided that we would attempt an innovative solution, utilising Passivhaus principles, which would leave a legacy for the area and provide us with valuable learning. We sat down with specialist design consultants, R-gen, and set ourselves the challenge of improving one of our lowest rated buildings to the highest possible standard. We wanted to learn about new technologies and retrofitting using modern materials but we also wanted to create a sense of place, transform the living experience and inspire those living in the surrounding neighbourhood.

If the challenge of retrofitting to this standard, on this scale was not significant enough, we then added an aspiration to retain as many of the existing residents as possible, many of whom were elderly. We therefore commissioned Manchester University to investigate best practice, to help us devise an approach to support customers and to identify the changes in behaviour that would be integral to living comfortably and efficiently in the newly refurbished homes.

Our residents have recently returned to their new homes. We already know that levels of fuel consumption and noise transmission have greatly reduced. Feedback from customers indicates that the feeling of pride in the home has significantly increased. All of these factors will drive improved levels of mental wellbeing and tenancy sustainability, to add to the social return on investment already achieved as a result of the project, which we estimate could be in the region of £11m.

Dr Lewis has interviewed some of the leading exponents in the U.K., reviewed studies from across Europe and spent a significant amount of time with our customers in order to develop this guide. We have learned a massive amount along our journey that will help us deliver similar exciting projects in the future. I hope that this guide will enable and inspire others to take on similar projects and to continue advance the development of low energy homes in the UK.

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1. What is the Passivhaus Standard?

1.1 Introduction

In the UK, an increasing number of dwellings are being built to Passivhaus standards, where heat loss is minimised through the use of high levels of insulation to the extent that conventional heating is rendered unnecessary.

While Passivhaus dwellings offer benefits in terms of low energy bills and high thermal comfort, maintaining thermal comfort in a home without conventional heating can be challenging. Social housing tenants, who have not chosen to adopt the lifestyle changes associated with living in a Passivhaus, can find it particularly difficult to adapt.

This guidance document, for housing providers and architects, provides recommendations on how to enable occupants to adapt to living in Passivhaus dwellings and gain the maximum benefits available. In particular, the guide considers what support should be given to older occupants. Retirees' relatively low income can prevent many older people from adequately heating their homes. Living in cold environments can exacerbate health problems such as heart and respiratory disease, which are prevalent in the older population. Cold dwellings are believed to contribute to the 27,000 excess winter deaths that occur in the UK each year. Housing constructed to Passivhaus standards offers a potential solution, providing warm and dry environments with stable internal temperatures requiring little energy to heat.

While there is much diversity within the older population, some of the challenges associated with ageing, such as cognitive impairments or sight loss, could make it difficult for some older occupants to adapt to living in a Passivhaus. Drawing on research funded by Eastlands Homes, and on the findings of previous studies, this guide considers what support should be given to older occupants to enable them to adapt to living in a Passivhaus.

1.2 The Passivhaus Concept

The term 'Passivhaus' refers to a performance-based energy-efficiency standard for buildings. In a house constructed to Passivhaus standards, heat loss is minimised through the use of high levels of insulation and mechanical ventilation with heat recovery, to the extent that the need for conventional heating is almost eliminated. In consequence, houses built to Passivhaus standards use substantially less energy for space heating than conventional new-build homes, and offer high levels of thermal comfort and air quality.

The Passivhaus concept is similar to that of the thermos flask in which internal temperatures are preserved by an insulating layer. A building's heat loss can be reduced in a number of ways, such as through the use of high levels of thermal insulation in the walls, triple glazed windows, and mechanical ventilation with heat recovery. Crucially, if a building's annual space heat demand is reduced below 15kWh/(m2a), then the heat demand will be in the same order of magnitude as heat gains from sunlight, occupants' body heat, and electrical appliances (Figure 1). It is therefore unnecessary to actively heat the building, as passive sources of heat should provide sufficient warmth for the occupants. The dwelling's airtight insulating layer also excludes external heat in summer months, which along with the use of shading reduces the need for summer cooling.

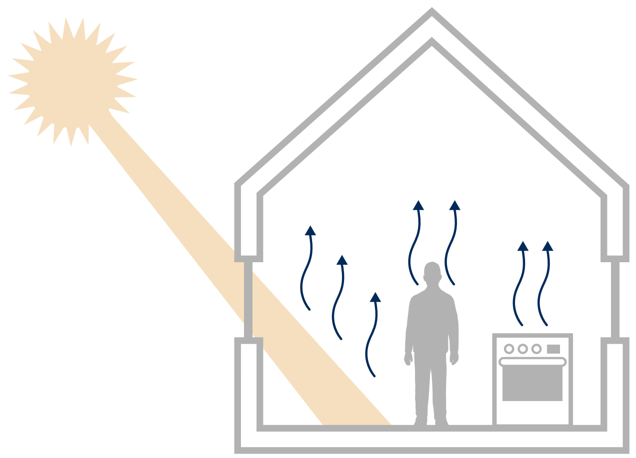


Figure 1. A Passivhaus is warmed by heat from sunlight, occupants and electrical appliances.

1.3 The Origins of the Passivhaus Standard

In 1988 Wolfgang Feist, in collaboration with Bo Adamson, devised the Passivhaus standard. Feist subsequently developed the concept, using computer simulations to demonstrate the theoretical feasibility of such houses.

The first dwellings to comply with the Passivhaus standard were built in 1991 in Darmstadt, Germany. Subsequently the Passivhaus Institute, established and led by Feist, monitored the performance of these dwellings.

The American energy-efficiency pioneer Amory Lovins contributed to the transformation of the Passivhaus concept from a scientific experiment to a practical building standard, by demonstrating how construction costs could be reduced through the simplification of building details. Over 200 dwellings were built and tested under the European Commission-funded project 'Cost Efficient Passive Houses as European Standards' (CEPHEUS), and this led to the widespread adoption of the Passivhaus standard throughout Europe, and increasingly throughout the world, since 2000. To date more than 30,000 Passivhaus dwellings have been realised.

1.4 The Passivhaus Standard

For a building to be certified as a Passivhaus, certain performance targets must be met.

Specific Heating Demand (or) Specific Heating Load	≤ 15kWh/m2.yr ≤ 10W/m2
Specific Cooling Demand	≤ 15kWh/m2.yr
Specific Primary Energy Demand	≤ 120kWh/m2.yr
Airtightness	≤ 0.6ach @50pascals (n50)

Either the Specific Heating Demand or the Specific Heating Load must be met. The Primary Energy Demand target must also be met in all cases, with this figure incorporating energy used for space heating, domestic hot water, lighting, fans, pumps (where applicable), and electrical appliances. The building should also be sufficiently airtight such that it can achieve 0.6 air changes per hour at 50 pascals. In addition, even without heating during the coldest winter months, a certified Passivhaus should not fall below 16°C.

1.5 The EnerPHit Standard

The Passivhaus standard was intended for new-build developments.

While it is possible to achieve the Passivhaus standard in the refurbishment of an existing building, it is often difficult to achieve without undertaking major work and at great cost. In recognition of this, the Passivhaus Institute developed the EnerPHit standard as a guide to good practice in the refurbishment of existing buildings. The criteria for achieving the EnerPHit standard are slightly more generous than those for the Passivhaus standard.

Criteria	Passivhaus	EnerPHit
Specific Heat Demand	≤ 15 kWh/m².yr	≤ 25 kWh/m².yr
Primary Energy Demand	≤ 120 kWh/m².yr	≤ 120 kWh/m².yr
Airtightness	n50 ≤0.6	n50 ≤1.0

2. The Typical Features of a Passivhaus

The typical features of a dwelling built to Passivhaus or EnerPHit standards are intended to minimise heat loss and permit controlled solar heat gain.

2.1 Insulation

The most important feature of a dwelling built to Passivhaus standards is a continuous layer of thermal insulation, applied around the building's exterior.

It is important that there are no thermal bridges in this layer, that is, no points where there is inadequate insulation between interior and exterior leading to cold spots on interior surfaces. A thermal bridge can cause condensation on internal surfaces, and reduces the effectiveness of the building's layer of insulation.

It is recommended that the walls, floors and roofs of a dwelling achieve a U-value of ≤ 0.15 W/m²K, for a building to attain Passivhaus standards. With this level of insulation, heat losses from the building will be negligible, even in winter. In addition, the temperature of internal surfaces will be the same as the indoor air temperature, providing a comfortable indoor climate for occupants, and reducing the possibility of damage caused by moisture from humid indoor air condensing on cold surfaces. The high level of insulation will also prevent temperature stratification and draughts.

During the summer, the high thermal insulation will also protect occupants from excessive heat, when combined with well-designed solar shading and adequate ventilation.

A building's thermal envelope can be weakest around external doors and windows. Consequently, given the UK's climate, for dwellings to achieve Passivhaus standards windows must be triple-glazed, achieving U-values ≤ 0.85 W/m²K once installed. External doors must achieve U-values ≤ 0.80 W/m²K. As with the wall insulation, the aim is not only to reduce heat loss through doors and windows, but also to ensure that internal surfaces (including for glazing) are similar in temperature to the indoor air. This reduces the possibility of mould growth and the radiant sensation of cold from cold surfaces.

2.2 Airtightness

Unwanted air leakage can contribute to heat loss, significantly increasing a dwelling's space heating requirement, and causing discomfort to occupants due to draughts.

Consequently it is important to ensure that a building achieves an airtightness of 0.6 air changes per hour at 50 pascals, usually checked through a blower-door test, in order to achieve Passivhaus standards. Airtightness is generally maintained through the use of multiple continuous airtight seals in conjunction with robust gearing for doors and windows.

2.3 Mechanical Ventilation with Heat Recovery (MVHR)

In a well-insulated building, a significant proportion of the heat losses can come from ventilation.

Particularly in winter months, if the building is ventilated naturally through the opening of windows, as warm air leaves the building, all of the heat contained in the air is also lost. In a Passivhaus dwelling, heat loss through ventilation is minimised through the use of mechanical ventilation with heat recovery (MVHR). This is known as a balanced mechanical ventilation system, as it extracts air from certain rooms and supplies an equal quantity of fresh air to other rooms. Typically air is extracted from kitchens and bathrooms, where the relative humidity is often highest. Before this air is exhausted to the outside, it passes through a heat exchanger, so that the heat it contains can be transferred to incoming outdoor air, although the two air masses remain separate. Incoming fresh air is usually supplied to living rooms and bedrooms.

In order to minimise heat losses through ventilation, the MVHR unit must be certified by the Passivhaus Institute and have a heat recovery efficiency of ≥ 75% (calculated according to the Passivhaus Institute methodology) and a specific fan power of 0.45 Wh/m3. There are also strict installation criteria to reduce unwanted noise transfer from the MVHR unit and between rooms. The MVHR ducts should be easily accessible for cleaning, and filters are required to prevent the deposition of dust. As heat recovery is undesirable outside the heating season, where the ventilation system is to be used in summer months, it must be possible to bypass the heat exchanger. Some MVHR units have a built-in bypass to allow automatic switching of heat recovery, depending on outdoor and indoor air temperatures.

2.4 Orientation Relative to South

Essential to the Passivhaus concept is the use of solar gains in winter to reduce the heating demand.

In order maximise solar gains Passivhaus buildings should be oriented within 30° of south. Ideally, habitable rooms such as living rooms and dining rooms should be on the south side of the dwelling, while WCs, bathrooms and storerooms can be placed on the north side. Many of the Passivhaus dwellings built in Continental Europe since the 1990s have large areas of glazing on the south side, often in excess of 50% of the façade. However, recent research indicates that window size has limited influence on winter heating demand, but can have a major impact on solar gain in the summer. Consequently it is advisable to use conventionally sized windows on both south and north sides of Passivhaus dwellings.

2.5 Solar Shading

For a building to attain Passivhaus certification, internal temperatures exceeding 25°C must not occur for more than 10% of the year.

Placing fixed external shading devices over windows can reduce overheating in summer months. Fixed shading devices include brise soleil, which usually consist of louvered screens placed on the building's façade, but shading can also be achieved through the use of roof overhangs or balconies. While south-facing windows can benefit from fixed shading, east and west-facing windows generally receive less benefit, as even in summer months the sun will be too low in the sky for the shading to act as an effective barrier.

Moveable external shading devices include shutters, awnings, and external Venetian or roller blinds. An advantage of moveable shading is that it can be withdrawn on dull days, thus maximising the daylight that enters a dwelling. However, moveable shading generally requires more maintenance than fixed shading. External shading reduces solar gain more effectively than internal blinds. The effectiveness of shading should be tested using the Passivhaus Planning Package to ensure the maximum performance of glazing and shading.

2.6 Supplementary Heating

Throughout most of the year, a dwelling built to Passivhaus standards will be capable of maintaining an indoor temperature of 20°C without the need for conventional heating, relying solely on heat gains from the sun, the occupants and from electrical appliances.

Occasionally, in the coldest months, a small amount of supplementary heating might be necessary. Typically this is provided via heating coils in the MVHR system, or by small towel rails or under floor heating in the bathroom. It should be noted that a poorly designed supplementary heating system could lead to overheating.

3. How to Maintain Thermal Comfort in a Passivhaus

3.1.1 MVHR – Usage

For most MVHR units, the default rate of ventilation is set during the installation process, and may or may not be within the occupant's control, depending on the unit's design and any management decisions made by the housing provider.

The default ventilation rate is usually set to take account of the number of occupants normally inhabiting the dwelling.

Most MVHR units afford occupants some degree of control, and typically there will be three settings:

- Normal
- 'Vacation' or 'weak'
- 'Strong' or 'boost'

The 'boost' setting is for times when occupants are undertaking activities that require an increased ventilation rate, such as showering or cooking. The 'weak' setting is for when the dwelling is unoccupied for a length of time, but can also be used in winter to increase humidity levels. The method by which these settings are selected varies from unit to unit, but controls can take the form of a boost button (usually located in the kitchen, with a duplicate placed outside the bathroom), or a dial, or a digital display unit. In some cases, the boost setting is partly controlled by a timer mechanism, which causes the system to revert to the default setting after a set period of time.

The temperature of incoming air is controlled by a thermostat, which may or may not be accessible to the occupant. Heat recovery is regarded as undesirable outside of the heating season, that is when external temperatures rise above 15°C. Most MVHR units will have a summer bypass mode, which allows mechanical ventilation to be used without the fresh air passing through the heat exchanger. In some units, the bypass mode is activated automatically. MVHR units without the bypass option should be switched off during the summer. The exception to this rule is when the external temperature rises above 25°C for a significant number of hours in each day, when it is generally best to use the heat exchanger. While the heat exchanger is in use, windows should be kept closed during the day in order to keep warm air out of the dwelling, and opened only during the night to allow in colder air.

3.1.2 MVHR – Maintenance

The filters on a MVHR unit should be replaced (or cleaned) regularly, typically every 3-6 months, in order to maintain hygiene, to avoid high-pressure drops, and to prevent the unit from becoming noisy.

If the dwelling is located in a geographical area with poor air quality, such as beside a busy road, the filters will require changing more frequently than those for a dwelling located in a rural area. Filters are relatively cheap and easily installed, and generally a professional is not required to replace filters, although as with conventional boilers every MVHR unit should be maintained by a specialist on a regular basis to ensure it continues to work at full capacity.

Occupants should be advised to keep MVHR air vents free from obstructions. It might be helpful to provide occupants with photographs of MVHR vents, so that vents can be recognised. It is also important that the gaps beneath internal doors are not blocked, as air needs to flow from those rooms where air is supplied to those where air is extracted.

3.2.1 Window Opening – Winter

In order to prevent heat loss from the dwelling, during the heating season (approximately from November to March) the MVHR unit should provide all ventilation and windows should remain shut, except when:

- There are more than twice the number of people in the dwelling than the MVHR unit is set to accommodate
- Heavy smokers are present (although light smokers should experience no problems)
- Painting or decorating is being undertaken

The window should be open for no more than fifteen minutes in each case.

Figure 2. During hot weather, it is often best to open the windows of a Passivhaus at night only, in order to exclude warm air during the day.

3.2.2 Window Opening – Summer

During the summer (mid-May to mid-September), windows can be opened fully provided the MVHR unit is in bypass mode (see page 11).

If external temperatures rise above 25°C for a significant number of hours in each day, then the most effective way to cool a Passivhaus dwelling is to re-engage the MVHR unit's heat exchanger, and to use night purging where windows are opened at night (when the external air is cool) and kept closed during the day when the external air is warm (Figure 2). This approach is effective only when used in conjunction with strict solar shading to south and west-facing windows. The effectiveness will also be greater where it is possible to achieve cross-ventilation, such that air enters on one side of the building and leaves on the opposite side.

Figure 3. During winter months, it is advisable to draw back curtains, blinds, shutters and awnings to maximise the heat received from sunlight.

3.3 Controlling Solar Gain

As the Passivhaus concept centres on the use of passive sources of heat, it is important for occupants to learn how to manage solar gain in order to benefit from the sun's warmth during the winter and to minimise heat gain from sunlight during the summer.

During winter months, shutters, blinds and curtains on south, east and west-facing windows should be drawn back during the day to maximise the amount of sunlight that enters the dwelling (Figure 3). While fixed solar shading devices (such as brise soleil) require no adjustment, during the summer any moveable shading devices such as blinds, shutters or awnings should be used to minimise the amount of sunlight that enters the dwelling (Figure 4). It should be noted that the most effective shading devices are those on the building's exterior.

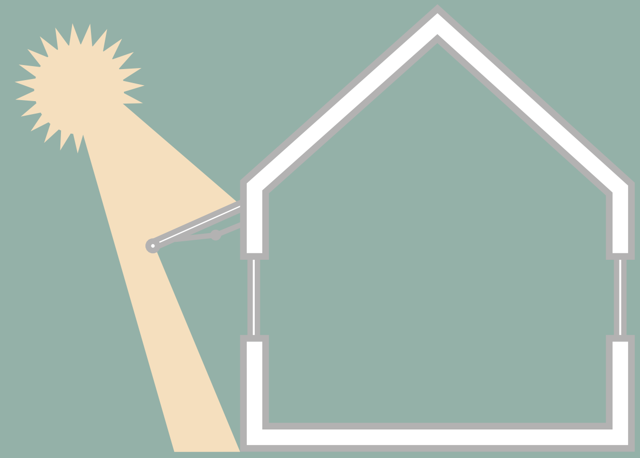


Figure 4. Awnings, shutters or fixed solar shades should be used to control the amount of sunlight that enters the home during summer months, to prevent the dwelling from becoming excessively warm.

3.4 Heat Gains from Appliances

All of the electrical energy used in the dwelling ultimately will be converted into heat.

During winter months, the heat gain from electrical appliances can cover a significant proportion of the heat losses from a Passivhaus. The Passivhaus standard includes a requirement for the primary energy demand, which includes all electrical appliances. This requires the use of energy-efficient electrical devices, including A++ rated washing machines and dishwashers and low-energy lighting. This ensures that the space heat demand is not reduced at the expense of large internal gains from electrical appliances, and discourages the use of direct electrical heating. It also helps to prevent the dwelling from overheating in the summer, when heat gains from electrical appliances can be unwelcome.

3.5 Supplementary Heating System

Where supplementary heating is provided, the room thermostat for the supplementary heating should be set to the same temperature as the MVHR unit's thermostat

It is recommended that the supplementary heating is set to prevent the ambient temperature from dropping below a specific level, usually 18°C.

4. Adapting to Living in a Passivhaus

4.1 Anxieties about the Lack of a Conventional Heating System

Social housing tenants, who have not necessarily "bought into" the to Passivhaus concept, can experience anxieties about the lack of a conventional heating system. These anxieties are usually dispelled over time, as occupants adapt to living in a Passivhaus.

4.2 Slow Heating Response

As described above, the Passivhaus principle is that heat lost through the dwelling's fabric is replaced by heat from passive sources where possible, such as from human body heat and solar gain.

Rapid rises in room temperature are often difficult to achieve using passive heat sources alone, except where strong sunlight is permitted to enter the dwelling. Where supplementary heating is provided via fresh air preheating within the MVHR unit, rapid room temperature rises can also be difficult to achieve, due to the low power of the heater. It can take several hours for occupants to detect temperature changes. Many occupants struggle to become accustomed to the slow response rate of the warm air heating system, as they are often used to the more immediate feedback provided by the thermostat and radiators of a conventional heating system. This can cause occupants to be dissatisfied with the controllability of the warm air heating system.

4.3.1 MVHR – Usage

Occupants' ability to control the MVHR unit can vary hugely between individuals.

Occupants often draw on their experience of previous technologies, such as conventional boilers or smart phones (which have an operating logic similar to the digital controls for some MVHR units). This can sometimes lead to confusion, particularly where the previous technology is only superficially similar to the MVHR unit. For example, some occupants mistakenly believe that activating the MVHR boost will cause their dwelling to warm up, believing the MVHR controls to be comparable to the thermostat on a conventional boiler. Other occupants have more success in operating the MVHR as they regard it as similar to a mechanical extractor fan.

One of the biggest challenges Passivhaus occupants face is in learning to remove moisture from bathrooms and kitchens using the MVHR unit. This problem can be compounded where a boost switch, which temporarily increases the rate of ventilation to the kitchen and bathroom, is provided for the kitchen only, as this can lead to the misconception that it does not affect bathroom ventilation. The easiest solution to this problem is to provide a second boost switch for the bathroom. Another challenge for occupants is in learning how to use the summertime bypass, unless the switching is automatic. Giving occupants too many controls for the MVHR can result in confusion, which in turn can lead to the dwelling becoming uncomfortable. In some circumstances, occupants are more likely to achieve thermal comfort if given a minimal degree of control, with the system being largely automated.

4.3.2 MVHR – Air Quality

Dwellings with MVHR generally have significantly lower humidity than homes without.

This can result in low occupant satisfaction, and there are reports of occupants resorting to using wet towels to humidify the air. However, there is evidence that occupants can be satisfied with the humidity in Passivhaus dwellings, and that low humidity is associated with a reduction of house dust mites and improved histamine levels in asthmatic patients. It should be noted that air quality in a Passivhaus dwelling is dependent on the correct use of the MVHR.

4.3.3 MVHR – Maintenance

The filters on a MVHR unit can usually be regularly cleaned or replaced by the occupant, provided access to the filter is easy, and there are no concerns about the possible invalidation of any warranty.

There must be clarity from the outset about whether the responsibility for changing filters rests with the occupant or with the housing provider, in order to avoid any confusion that could result in filters not being changed.

4.4.1 Window Opening – Winter

Opening the external windows of a Passivhaus dwelling during winter months generally causes a decrease in the efficiency of heat recovery, which further causes higher energy inputs to be required.

Occupants' readiness to keep windows shut during the winter is therefore critical to the energy-efficient maintenance of thermal comfort. Evidence indicates, however, that Passivhaus occupants adjust their window-opening practices according to external temperatures, keeping windows shut during winter months.

4.4.2 Window Opening – Summer

Although the use of natural ventilation via window opening is an accepted part of the Passivhaus strategy, there are some nuances to how this should be done in a super-insulated building.

As described above, assuming summer temperatures to be in the range of 15-25°C, the MVHR unit should be switched off or set to bypass mode during the summer so that fresh air does not pass through the heat exchanger (although it should be noted that this switching occurs automatically in some units). If, however, external temperatures rise above 25°C for a significant number of hours in each day, then it is generally best to use the heat exchanger, and to keep the windows closed during the day, opening them only during the night. In this way, warm air can be kept out of the dwelling. Both ventilation strategies also require the minimisation of solar gain (see below).

It can be difficult for some occupants to understand this slightly complex procedure, particularly if they are unused to living in a home that is highly insulated and airtight. Many occupants find they need to pay more attention, than they did in their previous homes, to the opening and closing of doors and windows. In particular, the practice of 'night purging' is often one that needs to be learned, and often occupants' natural instincts are to simply open windows whenever it is hot, rather than at night only. The complexity of these ventilation strategies can lead to apparently contradictory advice being offered to occupants, leaving them confused about how best to ventilate their homes. In addition, concerns about security, proximity to sources of noise such as traffic, and problems with insects can deter occupants from leaving their windows open for any length of time. This might partly explain why some occupants struggle to keep their dwellings cool during the summer.

4.5 Trapped Moisture from Construction

As Passivhaus dwellings are very airtight, moisture from wet trades (such as wet plasterwork, used in the building's construction) can become trapped, leading to mould growth on internal surfaces.

A well-ventilated construction site can help to reduce the build-up of moisture, which in turn will reduce the need to use mechanical ventilation to dry out the home.

4.6 Controlling Solar Gain

Overheating is a problem common in all well-insulated dwellings, including those built to Passivhaus standards.

Occupants who are new to living in a Passivhaus have to learn how to control solar gain, in order to maximise the heat received from the sun in winter and minimise it in winter. A particular problem arises from occupants failing to understand that the primary purpose of external (moveable) blinds is to reduce solar gain, mistakenly believing that the blinds are intended to provide privacy, much as curtains do. This can result, for example, in external blinds being left closed during the day in winter, when opening the blinds each morning would allow more sunlight to enter and warm the dwelling.

4.7 Heat Gains from Appliances

Heat from electrical appliances can affect the temperature within a Passivhaus dwelling, and occupants often have to take this into account in order to maintain thermal comfort.

Passivhaus occupants have reported that having the oven on for long periods, vacuuming, or using a hairdryer significantly increased internal temperatures. Occupants are often obliged learn, through trial and error, how to reorganise bundles of everyday practices (not just individual practices) in order to keep their home at a comfortable temperature. This might include not vacuuming while the oven is on, or changing the time of day when they usually use their washing machine.

4.8 Supplementary Heating System

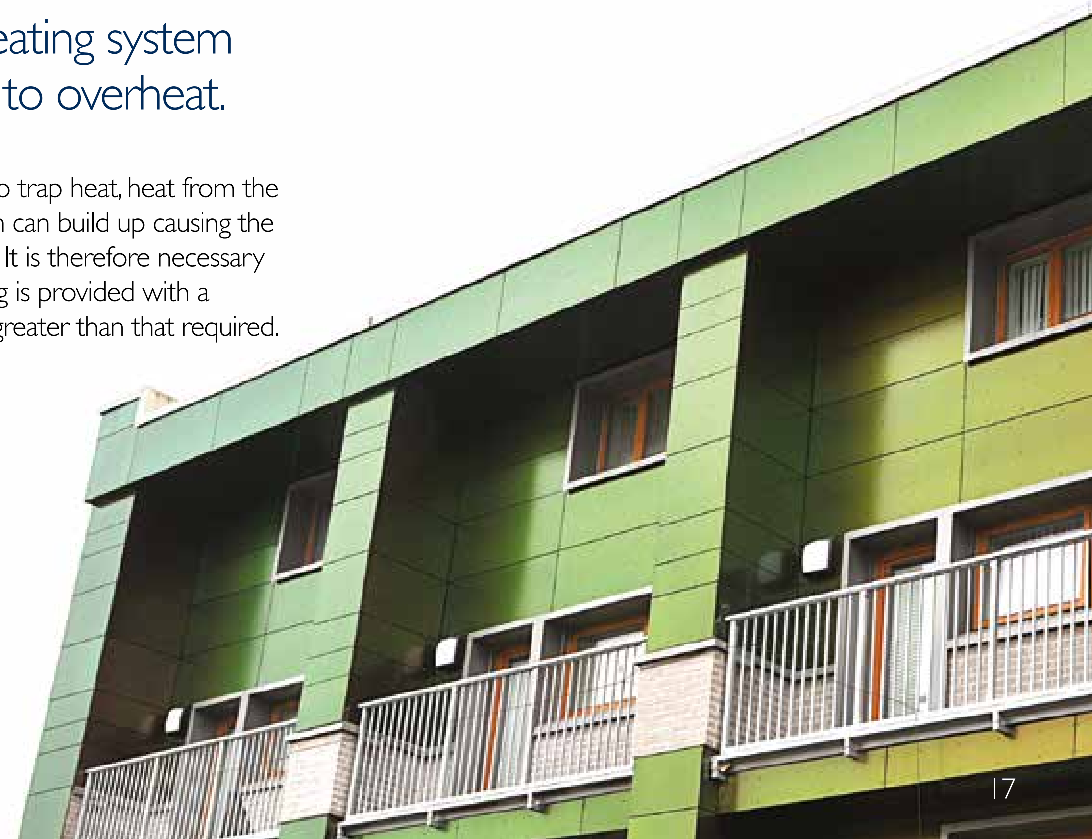
Over-capacity in the heating system can cause the dwelling to overheat.

As Passivhaus dwellings are designed to trap heat, heat from the space heating and/or hot water system can build up causing the dwelling to become excessively warm. It is therefore necessary to ensure that each Passivhaus dwelling is provided with a heating system that has a capacity no greater than that required.

4.9 Temperature Distribution between Rooms

Even where only rooms in the supply zone (i.e. lounges and bedrooms) are actively heated, there is usually an even distribution of heat throughout a Passivhaus dwelling, with all rooms having a similar temperature.

It is difficult to maintain temperature differences between rooms, and there is some recognition that this might be undesirable for some occupants. In particular, some occupants prefer to have living rooms at a higher temperature than bedrooms. Some occupants adapt to the temperatures typically found in Passivhaus dwellings by adapting their everyday practices, such as through not wearing jumpers in the home or using blankets at night, even where this had previously been the norm.



5. Passivhaus Dwellings and Older Occupants

5.1 Challenges Associated with Ageing

There is huge diversity within the older population in terms of health, wealth, physical capacity and cognitive ability.

However, it is possible to identify particular challenges associated with ageing that can cause some older people's needs to differ from those of the younger population, including:

- Physiological changes that reduce the body's capability to maintain a stable core temperature
- Sight loss
- Hearing loss
- Arthritis
- Mobility impairments
- Dementia
- Comparatively low income (and the associated problem of fuel poverty)
- Lack of familiarity with modern technology

It should be emphasised that not all older people will experience these challenges, but it is possible that some of these issues might affect a person's ability to adapt to living in a Passivhaus. To date, little research has been undertaken on what opportunities/challenges are experienced by older people, in adapting to living in Passivhaus dwellings. The observations in this guide are therefore speculative, but based on the available research evidence.

Passivhaus dwellings are possibly unsuitable for people diagnosed with dementia, but otherwise there is no reason why older people should not adapt to living in a Passivhaus as successfully as anyone. Most potential problems can be overcome with suitable design features and adequate guidance.

5.2 MVHR – Design and Use

- Sight loss could lead to difficulties in operating MVHR controls or thermostats. It is recommended that heating controls (including those for MVHR) be placed at eye level in a position where they can be seen face-on by the user (Figure 5).
- Arthritis can make it difficult to manipulate heating controls.
- Ideally, MVHR controls should be simple to comprehend. In particular, research indicates that some menu-based systems can be confusing for some older people. Controls with a binary logic (such as "on/off") might work better for some people (Figure 6), although the selection of such controls is constrained by what is commercially available.
- Hearing loss can cause the sound of fans, such as those associated with the MVHR unit, to be problematic and can lead to occupants switching off mechanical ventilation.
- People diagnosed with dementia might need assistance in setting MVHR controls.
- Some people diagnosed with dementia can be made anxious by the sound of a mechanical fan, if they cannot identify the source of the noise.

5.3 Window Opening

- Even the simple act of opening a window can be made difficult by arthritis, and windows should have easily operated controls fixed more than 750mm and less than 1200mm from floor level (Figure 7).
- Some tilt-and-turn windows can be difficult for some older people to operate, because of the physical strength needed to close them from a tilted position (Figure 8).
- Where dwellings are occupied by people diagnosed with dementia, locks might be needed on windows to prevent them being opened throughout the winter, or to prevent people from climbing out through open windows.

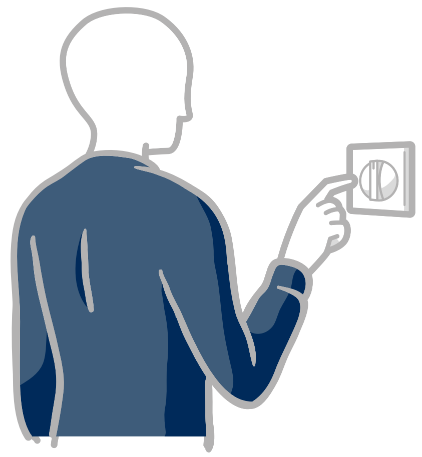


Figure 5. MVHR and heating controls should be placed so that they can be seen face-on by the user.

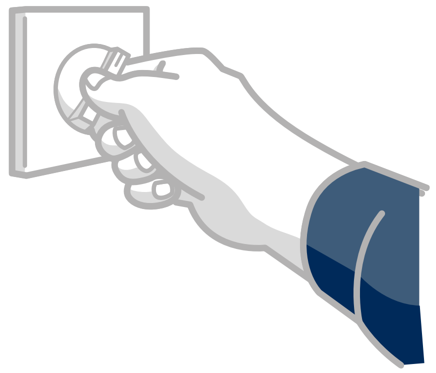


Figure 6. MVHR and heating controls should be simple to comprehend.

Figure 7. Windows should have easily-operated controls between 750mm and 1200mm from floor level.

Figure 8. During Some older people find tilt-and-turn windows difficult to operate because of the physical strength required in closing them.

5.4 Controlling Solar Gain

- People with arthritis, sight loss or mobility impairments can find it difficult to operate awnings, shutters, blinds and curtains, which can be particularly problematic if this is necessary in order to control solar gain (Figure 9).
- People with dementia might also find difficulties if they are obliged to actively manipulate blinds and shutters in order to manage solar gain, as this task (which requires forethought) might be too complex for someone with cognitive impairments.
- Automated blinds can be perceived as threatening by people with dementia and should therefore be avoided.
- Fixed solar shades, such as brise soleil, might be preferential for some occupants.
- Occupants of Passivhaus dwellings are generally advised to keep shutters, blinds and curtains on south, east and west-facing windows drawn back during the day, in winter months, in order to maximise the amount of sunlight that enters the dwelling. Visually impaired occupants who experience problems with glare might find it difficult to keep windows unobstructed in winter.
- It is important for all occupants, but particularly those diagnosed with dementia, to be exposed to an adequate amount of natural light during the daytime to provide a 24-hour cycle of light and dark. This helps to regulate the human body clock, aiding sleeping and wakefulness. Where it is necessary to close blinds or shutters during the day, it is important to ensure that occupants continue to have exposure to bright light during the daytime and to darkness at night.

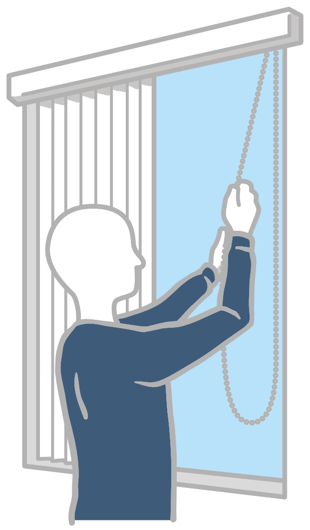


Figure 9. Blinds, curtains, shutters and awnings should be easy to operate, including for people with arthritis, sight loss or for wheelchair users.

5.5 Stable Internal Temperature

- Physiological studies have shown that older people often experience diminished capability in maintaining stable core temperature. The aged body is often less effective at diverting blood away from the skin to prevent heat loss when exposed to cold temperatures. In addition, reduced skeletal muscle mass leads to a lower metabolic rate meaning less heat is generated within the body and the threshold at which shivering is induced is lowered. This means that the body's ability to adjust to changes in temperature is impaired. The stable internal temperatures associated with Passivhaus dwellings should be suitable for those older people who find that they struggle to maintain a stable core-body-temperature.
- Conversely, occupants diagnosed with dementia might struggle to cope with the slow response rate of the MVHR unit, if they need to adjust the temperature. People with dementia often forget that they have adjusted the thermostat, if there is no instant response, and can overcompensate, setting thermostats to very high settings.

5.6 Low Energy Bills

- In the UK there is widespread concern about the adverse effects to health of living in cold environments. It is believed to contribute to the approximate 27,000 excess winter deaths that occur in the UK each year, and older people are regarded as particularly vulnerable, owing to retirees' relatively low income compared to the rest of the population. Housing constructed to Passivhaus standards offers a potential solution, providing warm and dry environments with stable internal temperatures requiring little energy to heat.

6. How to Enable Occupants to Adapt to Living in a Passivhaus

6.1 Occupants' Willingness to Adapt and Learn

Occupants' ability to adapt to living in a Passivhaus, and to gain the maximum benefits available, is partly dependent on their willingness to do so.

Some occupants are initially attracted to a housing development, not by any of the benefits offered by a Passivhaus, but by the prospect of a newly built home, the development's location, and other factors such as the opportunity for low-cost home-ownership. Those occupants who are worried by the unfamiliar technology, or who are more concerned to gain the full benefits on offer, seemingly adapt more quickly to living in a Passivhaus. By contrast, those occupants who are half-hearted in their engagement with the advice offered by the housing provider are often more susceptible to confusion at the point of moving in.

6.2 Written Guidance

Written guidance, on how to maintain thermal comfort in a Passivhaus dwelling, is generally useful for occupants.

Illustrations can also be useful. For example, occupants should be advised to keep the MVHR vents free from obstruction. It can be helpful to occupants to be provided with photographs of the vents, so that they can recognise them. It should be noted, however, that written guidance alone can be insufficient to enable occupants to comprehend how to gain the maximum benefits available from a Passivhaus. In some cases this is because the written guidance is inadequate, while in other cases tenants fail to consult the manuals, or even lose them.

6.3 The Handover Process

A competent person should explain and demonstrate the operation of the MVHR unit as soon as an occupant moves in.

Ideally this should be combined with a more holistic introduction to the dwelling, covering issues such as the location of stopcocks.

6.4 Timing

Seasonality is an important consideration, as the means by which occupants will maintain thermal comfort in a Passivhaus will vary between winter and summer.

In order to counter the risk that occupants will take in only that knowledge they need in the short term, it is advisable to provide occupants with further advice when seasons change. It is also important to consider that occupants might be preoccupied on move-in day, and consequently might not take in the details of any advice with which they are provided. It might therefore be necessary to provide some on-going support during the first 6-12 months of occupation.

6.5 Trust

For a housing provider to be able to offer on-going support to its tenants, it is necessary for staff within the organisation to be well informed regarding Passivhaus principles.

Previous studies indicate that tenants can become distrustful of a housing provider if they receive contradictory advice from different people within the organisation, or advice which contradicts that provided by other support institutions. Distrust can also be engendered in tenants if they ring the housing provider for assistance, only to be told that no one knows what is meant by "Passivhaus." Loss of trust can cause tenants to turn to other, possibly less reliable, sources of advice such as friends, family and neighbours.

6.6 Engaging with All Occupants

Individuals within the same household can have different needs, and can respond to institutionalised knowledge in different ways.

Consequently, different members of the same household might adapt to living in a Passivhaus in different ways. It is therefore inadvisable to provide only one householder with guidance, not least because this individual might struggle to accurately convey this information to others in the household. Where possible, handover tours should be conducted with all occupants of a dwelling.

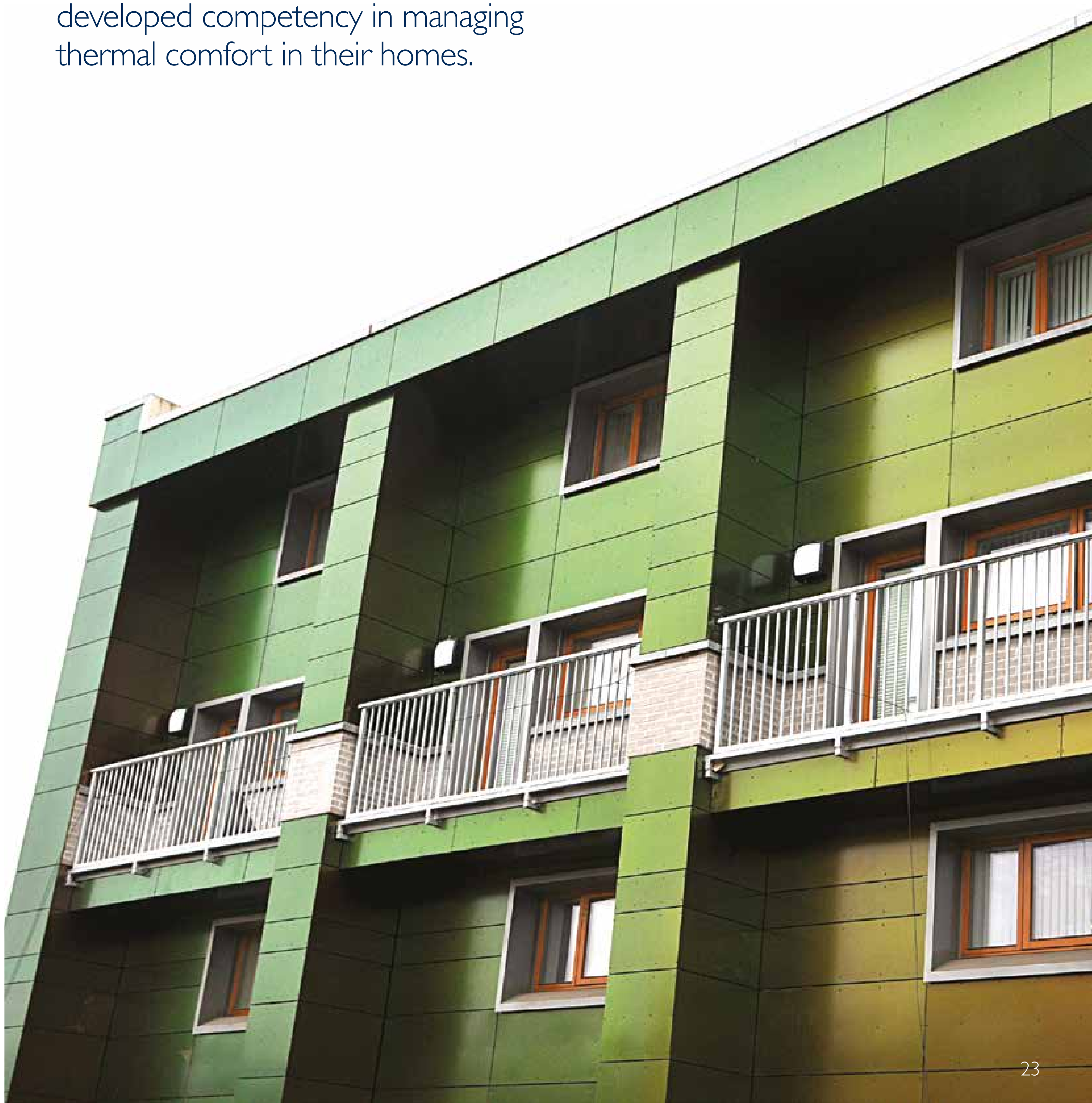
6.7 Hands-On Learning

Ultimately, occupants will adapt to living in a Passivhaus dwelling through hands-on experience, and it should be noted that even occupants who were provided with little or inadequate guidance have developed competency in managing thermal comfort in their homes.

6.8 Feedback

It is advisable to provide occupants with feedback on how much energy they use in their home.

Occupants sometimes want to know how their energy bills compare with their neighbours, and want to know what they can do to further reduce their expenditure on energy. Research evidence indicates that people can be strongly motivated by the desire to bring their energy consumption in line with that of their peers.



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Eastlands Homes is part of the One Manchester group – a partnership between Eastlands Homes and City South Manchester Housing Trust, which provides 12,500 homes across Manchester. One Manchester's aim is to create opportunities, transform communities and change lives by leading , delivering and inspiring greater social innovation across Manchester and the region.

About the Housing LIN

The Housing Learning and Improvement Network (LIN) is the leading 'learning lab' for a growing network of housing, health and social care professionals in England involved in planning, commissioning, designing, funding, building and managing housing, care and support services for older people and vulnerable adults with long term conditions, including dementia. For further information about the Housing LIN's comprehensive list of online resources, including our online 'design hub' with all the latest on designing and planning sustainable housing for older people, visit www.housinglin.org.uk/design/

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