Guidance Toolkit on Building Retrofit

Contents

3. Core Principles of Net Zero Carbon Buildings

3.1 The core principles

Net Zero carbon buildings in operation are supported by three core principles: energy efficiency, low carbon heat and renewable energy.

3.2 Energy efficiency

Buildings use energy for heating, hot water, ventilation, lighting, cooking and appliances. The efficient use of energy reduces running costs and carbon emissions. It also reduces a building's impact on the wider energy supply network, which is also an important consideration. There are different metrics we use to measure the efficiency of a building, including Space Heating Demand and Energy Use Intensity (both measured in kWh/m2/yr).

Heat is lost from a building

Solar photovoltaics and solar thermal are well established and easy to use technologies. It is important that solar arrays are appropriately sized to the energy demand of the building. Solar thermal is generally coupled with hot water storage and electricity generated by solar photovoltaics can be stored in batteries.Excess electricity can be sold back to the Grid however the greater the electricity demand that can be utilised on site, the better the return on investment.

3.5 What is an ultra-low energy home?

An ultra-low energy home is one which has a very low space heating demand. This requires a fabric efficiency and airtightness equivalent to that of a new Passivhaus home.

4. Key Reasons and Benefits of a Low Carbon Retrofit

4.1 Existing buildings are the real challenge

England currently has some 25 million homes. All of those will have to have some form of retrofit by 2050 while, in that time, we will have only built another six million homes. This means that 80% of the homes that will be present in 2050 have already been built. If we are to successfully decarbonise housing, retrofitting is where the real challenge lies; we need to increase their energy efficiency, replace gas or oil heating system for a low carbon heat system (e.g., heat pump) and decarbonise remaining energy demand via renewable energy generation.

4.2 Reducing fuel bills alongside carbon emissions

Whilst decarbonising homes is important to mitigate climate change, it is not the only reason to retrofit. In 2022, central government data showed that 21.8% of Birmingham homes were considered to be in fuel poverty. There is, unsurprisingly, a strong correlation between energy inefficient homes and fuel poverty with 88% of all

5. Energy Targets and Key Performance Indicators for Retrofit

5.1 Setting the right brief and targets is key

To achieve a Net Zero retrofit it is important that the retrofit brief and targets reflect this ambition from the start. A strong brief provides tangible guidance on how targets can be achieved. Best practice Key Performance Indicators (KPI's) for housing retrofit are listed in the adjacent table and all KPI's need to be met for a home to be considered Net Zero carbt tdbtjac92 reW*3 2269nts96JE.02a 595.2 841c0.001 0 0(r)-6(bt)Q62 Tm0

PAS 2035 guidance should be followed on publicly funded retrofit projects.

5.4 Without energy modelling

Energy modelling is recommended, however it is possible to target best practice by setting the right specification and design requirements as part of the project brief. Refer to the ‘How it all comes together’ for retrofit of a terrace house (including the case of a terrace house in a conservation area). The LETI Retrofit Guide can also be used for further guidance (Further guidance on the LETI retrofit guide).

7.3 Where do heat pumps fit?

[1] A heat network would qualify as 'low carbon heat network' for the purpose of this Retrofit Map only if it would have a lower carbon content of heat (per kWh delivered) than direct electric heating. Any system using fossil fuels and/or with high distribution losses is unlikely to qualify.
[2] Could be an individual or building level heat pump with low distribution losses.

8.1.2 The adjacent Retrofit Map could also be used to identify the buildings which should be most urgently retrofitted (in red) as they will be consuming most of the carbon budgets. Other factors (e.g., maintenance schedules, replacement opportunities, resident's appetite) may also influence the prioritisation.

8.2 A long term whole house renovation plan for a phased retrofit

8.2.1 The objective of a retrofit project should be to achieve Net Zero carbon by 2050 (or earlier). This means that:

- The home's energy efficiency is improved
- A low carbon heating system is installed
- Renewable energy is used to provide heat or power; this may be installed on site or provided via a community generation scheme or national grid
- The home is made smart ready

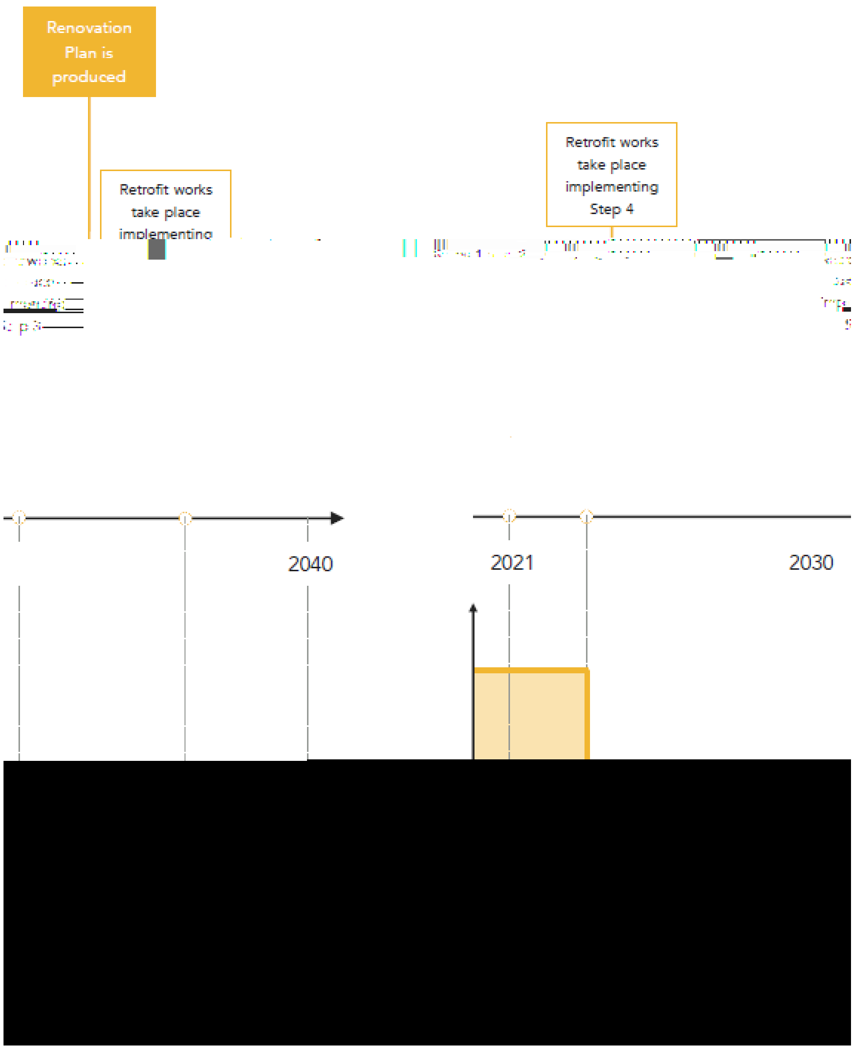
A whole house renovation plan is a useful tool to prepare and provides a pragmatic and coherent way to deliver this ambition.

8.2.2 Phasing improvements as part of coherent whole house plan

It may not be possible to implement all retrofit measures at once, but it is important to plan ahead so that packages of work are coherent and complementary. The preparation of a whole house plan is recommended to help in that planning. The diagram below shows how the measures can form part of a strategy for improvements. It would help landlord and residents to progressively save carbon and energy costs and avoid undertaking measures that conflict with planned future improvements.

8.2.3 A digital logbook

Alongside the whole house renovation plan, a building digital logbook can be developed to gather and retain all relevant information about the building.



9. Retrofit Risks and how to Mitigate Them

9.1 It’s all about moisture…

Our homes need to remain structurally sound, free from damp, mould and rot. Regrettably, many existing homes already suffer from excessive cold, damp, mould and condensation. A poorly planned and executed retrofit could actually make this worse. It is very important to understand this risk to mitigate and avoid it.

It may not be obvious, but our homes are constantly dealing with moisture. They are keeping out the rain and preventing damp rising up from the ground permeating into the building structure. They are also dealing with the significant amounts of moisture that we generate inside the home from cooking, washing and breathing. Finally, if the building fabric does somehow get wet, they are designed to ensure that it will dry out without long-term damage. Negatively impacting any of these mechanisms could end up doing damage to the health of both the building and its occupants.

9.2 Clear principles can address this risk

The risks of retrofit are well understood and can be overcome with sensible design and well-executed construction. Some key rules are:

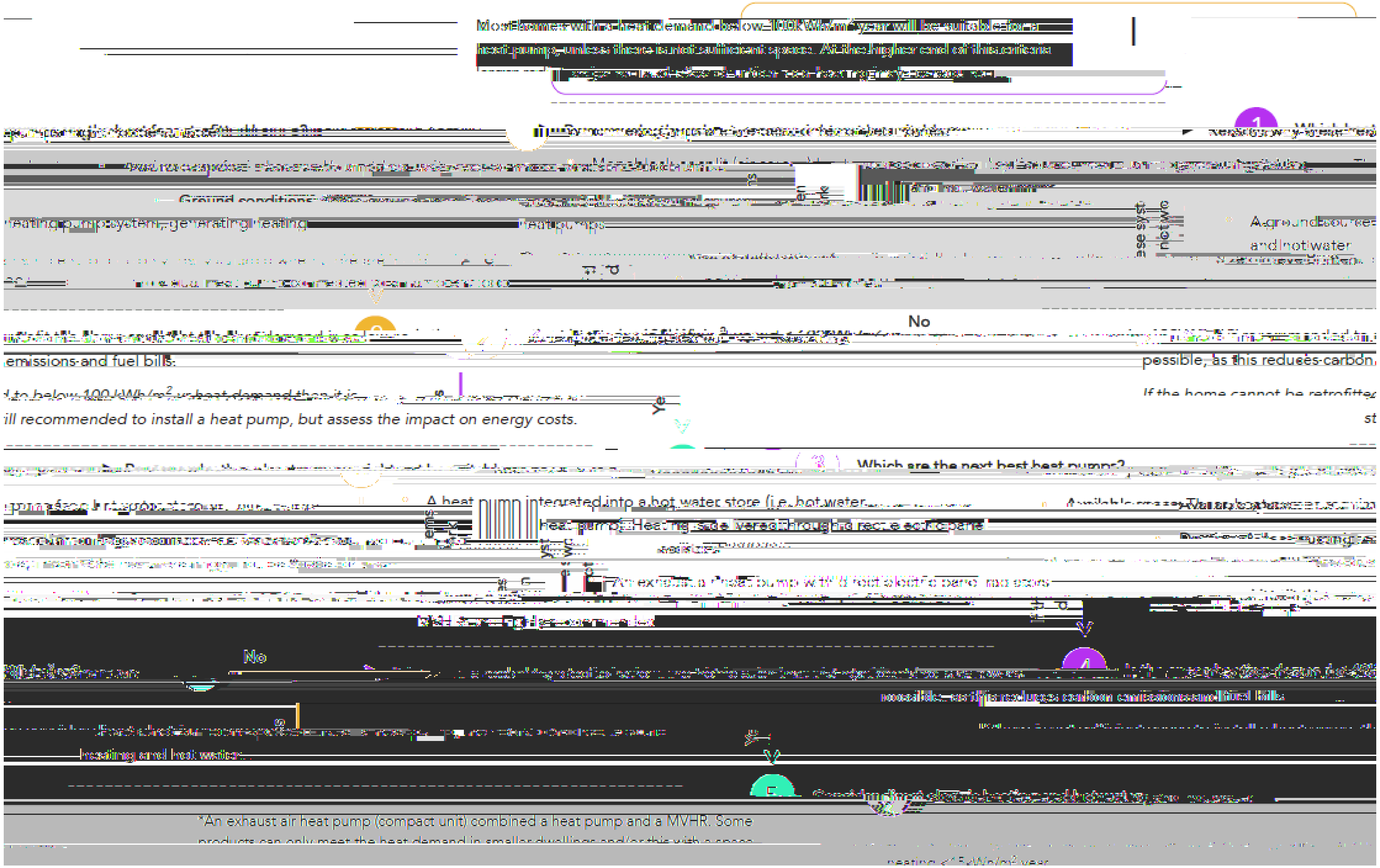
- **No insulation without ventilation**. As you add insulation you are also likely to increase airtightness. This means less air moving through the building. You can counter this with opening windows and extract fans, but ideally by fitting a whole-house ventilation system like Mechanical Ventilation with Heat Recovery (MVHR).

- **External insulation is best.** Internal insulation means your external walls

pumps connected to an ambient loop. Hot water storage is required when using heat pumps to maximise their efficiency.

12.2 Which heat pump is best for me?

There are various types of heat pump options available for retrofit - this page outlines which heat pumps are available and which to choose.



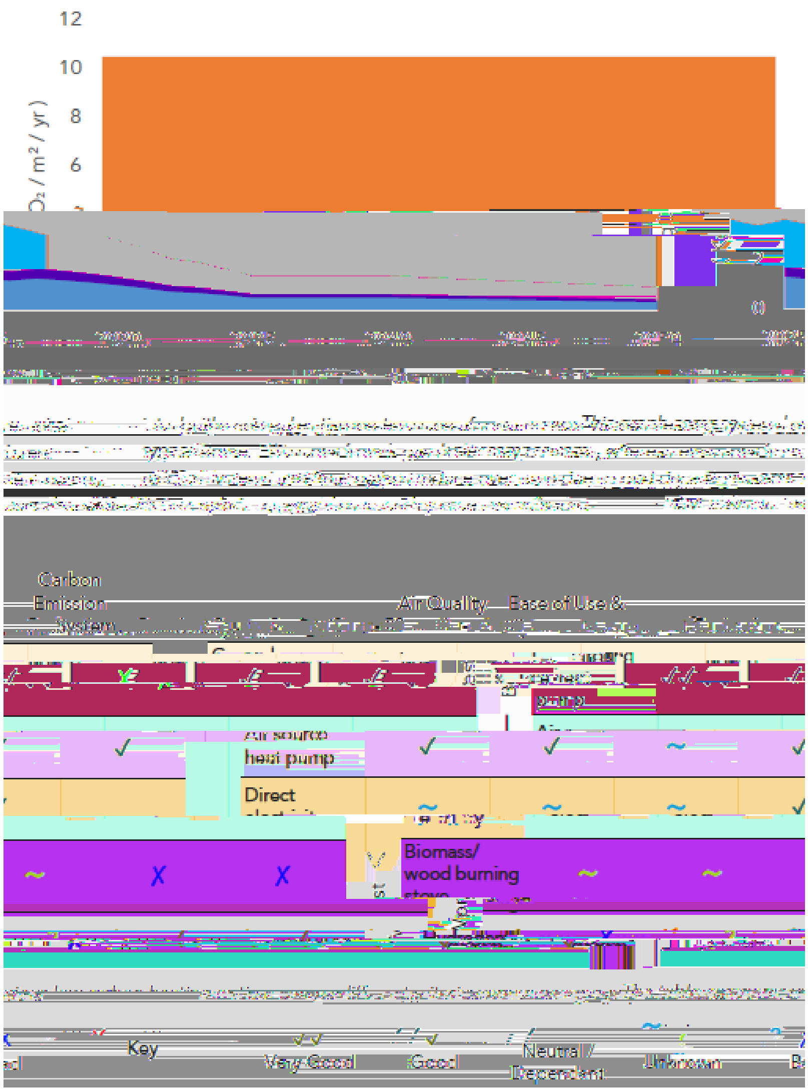
12.3 What other options are available?

Direct electric heating, for example through panel radiators will become low carbon in the future, as the grid continues to decarbonise. However direct electric heating can lead to very high heating bills if not used appropriately. The use of pulsing infra-red heaters or high retention storage heaters can present an affordable alternative for whole house heating.

Hydrogen is unlikely to be a suitable options for many. ‘Green’ hydrogen from renewable power electrolysis is truly zero emissions. However, the UK gas supply industry advocates ‘Blue’ hydrogen manufactured from methane with carbon capture and storage. although this method is yet to be proven at scale and domestic trials of hydrogen heating have so far had mixed results.

The use of woodburning stoves results in the release of particulate matter, a significant contributor to poor air quality and involves burning fossil fuels, which should be avoided.

Heat networks are a UK



13. Window Upgrades

Windows can lose more than ten times more heat compared to a well insulated external wall. Unless the current windows have been installed recently, it is very important to ensure that windows are replaced with high performing triple glazed windows (with a whole unit U-value calculated (U value) of less than 1.0 W/m^2K). When replacing windows it is important to note that since 2002, all replacement glazing has been controlled by building regulations and planning permission may also be required e.g. in listed buildings.

13.1 Detailing the window replacement - Where possible, the window should be replaced in line with the insulation layer of the external wall to continue the thermal line of the dwelling. The connection of the window to the external wall needs to be carefully considered as this is a weak spot thermally. It needs to be designed so that the risk of condensation between the external wall and window is reduced. A specialist consultant who can undertake thermal bridge modelling may need to consulted for project specific guidance. The use of low conductivity cavity closers and products like compacfoam can be a good way to reduce thermal bridging and reduce the risk of condensation.

13.2 **Airtightness** - When installing the windows, care should be given to the junction between the window frame and the airtightness layer of the external wall. High performance airtightness tape should be used to limit infiltration as the connection between windows and external walls can be leaky if not properly installed.

13.3 **Exceptions** - Replacement windows may not always be appropriate in the context of a listed building, or some older buildings in conservation areas, and other methods of improving the energy efficiency of the existing windows may

14.2 External insulation

External wall insulation is a good solution. It is very effective thermally, does not reduce internal space and generally enables residents to stay in the property when insulation is being fitted. The external appearance of a building will be affected, and roof eaves may require extending. Insulation can be easily covered in render but brick slips, pebbledash and cladding are also possible. It is likely that external insulation will require planning permission so you should consult with the Local Planning Authority through their pre-application service prior to financially committing to any measures.

14.3 Internal insulation

Use breathable materials internally e.g. wood fibre insulation, hemp lime insulation. Avoid using non-breathable materials internally e.g. rigid insulation. Even though this can achieve a good thermal performance and is often cheaper, it can increase the condensation risk and make detailing around

When insulating floors or ceilings be sure to check the floor to ceiling height. Insulating floors may require raising the floor level, so ensure you have considered the impacts e.g. steps at the entrances, door heights and consistent staircases levels.

15.2 Extending eaves over external wall insulation

Where external wall insulation meets the roof consider extending eaves to cover the additional wall thickness. Also be sure to maintain or add ventilation at the eaves.

15.3 Insulating roofs

If you have an unheated attic space the simplest approach is to insulate the floor in the loft. Ideally relocate existing water services and tanks in the roof void or insulate them if not possible. If you require a heated and habitable loft, add insulation between rafters and apply insulated sheathing board over the rafters as shown in rafter detail below. Plasterboard can be fixed to the underside of the insulation. Consider fabric improvements in conjunction with any loft reW*nBToss1 08.05 *nBT3(reW*nBT)-3(1hreW*nBT1 66.86 60 g0 G[a)-3eW 84Tc4

16. Thermal Bridging and Junctions

16.1 Thermal bridges

A thermal bridge, or cold bridge, is a piece of material through which heat flows easily, relative to adjacent materials. For example, a concrete lintel that interrupts the wall insulation l in(l inu w-6(o)-3(u)-d5(f)bint)-3(e)-3(dg)(in)-id3(te)-5(r)-3(e)d

16.1.1 Identifying thermal bridges

A good approach to retrofit is to sketch out a cross section drawing of the building. Clearly identify materials that keep heat in, such as insulation, doors, and windows. Ideally, these should all connect together without insulation depth reducing by more than a third. Different materials should be butt jointed, or overlap, ideally for a distance equivalent to the thickness of the insulating element.

16.1.2 Tackling thermal bridges

There are many off-the-shelf products available to avoid thermal bridging. Learn about these and use them where possible. Examples include thermally broken lintels, foam glass blocks, high density EPS foam, and specialist structural thermal br-

16.2 Junctions

16.2.1 Consider junctions carefully

Junctions which pose a weak point for heat loss, i.e. a thermal bridge, should be considered on a case by case basis. Key examples of such junctions are outlined below. Special care should taken to reduce the condensation risk posed at each junction. We strongly recommend engaging an architect or consultant who is able to produce a risk assessment and help design out condensation risk.

16.2.2 Roof eaves with external wall insulation

The space between the external wall insulation and roof insulation is a weak point for heat loss. This can be compensated by providing a strip of internal insulation at ceiling level.

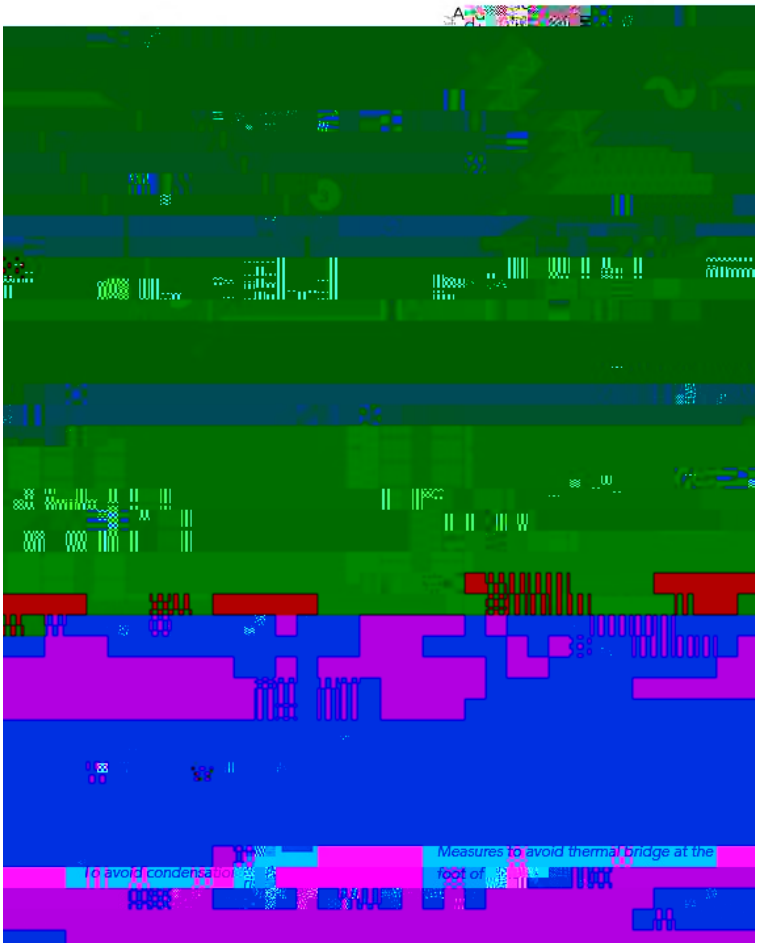
16.2.3 Foot of the façade with external wall insulation

Avoid creating weak points for heat loss at the foot of the façade between external insulation and ground floor. Insulating externally down the wall below ground level as far as possible and provide some internal wall insulation up to counter top level.

16.2.4 Joist ends with internal wall insulation

When applying internal insulation it is important to protect joist ends against thermal bridging and condensation risk:

> The most effective approach is to cut and rehang joists away from the external wall e.g. support them on hangers or by a beam between party walls. This allows for a narrow cavity of insulation to be inserted between the façade and end of joist.
>
> When insulating behind the joists is not possible, consider hanging the joists or wrapping the breather membrane around the end of the joist to prevent the build up of condensation.


To avoid condensa
Measures to avoid thermal bridge at the
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17. Airtightness for Retrofit

17.1 The importance of airtightness

17.1 .1 The importance of airtightness

The airtightness of existing homes varies hugely, however it is recommended that retrofit work targets a value of between 0.5 and $3m^3/h/m^2$, depending on the depth of retrofit and project limitations. Air tightness requires more draughtproofing and needs to consider the gaps between floorboards, skirting boards, pipes to the outside and potentially even cat flaps and key holes, depending on the level or airtightness to be achieved.

17.1.2 Start with a plan, investigate, then update the plan

Building airtight starts with a well thought through airtightness and ventilation strategy. Existing buildings conceal many secrets however, so expect to update the plan once you start stripping out the building. A key consideration in retrofit is managing moisture risk and minimising risk of warm humid indoor air coming into contact with cold surfaces.

17.1.3 Use the right products

Retrofits will use similar products to new build projects. Consider ordering a range of tapes, primers, membranes and parge coats in advance to test on parts of the building. It may be necessary to combine traditional building practices with modern airtightness products. Consider this carefully and contact manufacturers for advice if necessary.

17.1.4 Stick to the plan on site

Retrofit can be a bit chaotic, so ensuring the airtightness strategy is implemented properly is even more important than for new build. Expect setbacks and be ready to adapt your approach as necessary.

17.1.5 Test, then test again

Plan for at least two air tests. The first test should be completed as soon as the building is weathertight and while joints between different components in the airtight layer are still accessible so leaks can be repaired if necessary.

17.2 Retrofitting a ventilation system

17.2.1 Why is it important?

Existing buildings in the UK, particularly those built before Building Regulations required insulation, are generally leaky and naturally ventilated

The MVHR unit should be sized and the system designed according to some specific requirements of the home and to achieve acoustic requirements. It is important to plan the space required for the MVHR unit and the associated ductwork and silencers. Rigid, insulated ductwork should be adopted where necessary. The MVHR unit should preferably be a Passivhaus Certified Unit.

17.2.4 Installing and commissioning the system

Historically the installation and commissioning of MVHR systems has been poor. To ensure the system works as planned, the system must be properly tested to ensure it is balanced, delivers the designed fresh air required and does not generate noise beyond what is expected.

18. Water Efficiency and Domestic Hot Water

Water efficiency is about reducing our use of mains water and the effect our homes have on water resources. In very low energy buildings, the energy required for hot water can exceed the amount of energy required for space heating. Therefore, optimisation of hot water systems is essential to ensure energy use remains low.

What can you do?

- Reduce flow rates - The AECB water standards (below) provide clear guidance on sensible flow rates for showers and taps in low energy buildings.
- Reduce distribution Losses - All pipework must be insulated.
- Install a smart tank which heats just the water required by the household

Refer to the full AECB document for more information.

19. Smart Controls and Demand Response

19.1

Microgrids

Consider being part of a small semi semi-isolated energy network, separate from the national grid.

20. Embodied Carbon

20.1 Embodied carbon is the carbon emissions associated with the extraction and processing of materials, energy use in the factories and transport associated with the products used in the retrofit. It includes emissions associated with disassembly and disposal of these products at end of life as well as the construction of the building and repair, replacement

But don't forget the co-benefits!

Improved comfort, health and lower fuel bills are all valuable and important outcomes of retrofit. Prioritising measures using these different criteria is likely to produce a different order of priority for retrofit. For example, health and wellbeing is probably most improved by a Mechanical Ventilation with Heat Recovery (MVHR) system as this will dramatically improve indoor air quality and comfort.

On the other hand, in most solid-walled dwellings, external wall insulation will offer the greatest net energy savings, and so the most significant reduction in fuel bills, despite being relatively expensive.