Retrofitting your home

September 2022

Cambridge City Council

The importance of home retrofit in Cambridge

We know from public consultation on the Council's Climate Change Strategy that many people in Cambridge are concerned about the climate crisis and rising energy costs, and would like to take make improvements to their home to reduce their energy usage and their carbon footprint. However, many residents are unsure where to start, don't know which measures would suit their particular property, or don't know which measures would be most effective.

We commissioned this retrofitting guide to provide homeowners and landlords in Cambridge with practical information on how to make their homes more energy efficient and lower carbon. The guide sets out a whole-house approach to retrofitting the most common types of property in the city.

The guidance particularly focuses on reducing carbon emissions from homes, as this will make a key contribution to our vision for a net zero carbon city. However, investing in retrofitting your home can also bring a range of other benefits, including reducing your energy consumption and energy bills, making your home warmer and more comfortable in winter, and reducing the cold, draughts and mould that can cause health issues such as respiratory diseases and allergies.

We very much recognise that residents will have different budgets and needs, particularly at a time when the cost of living is increasing rapidly and there is such economic uncertainty. While this guide sets out all the steps that would be needed to retrofit your home to a net zero carbon standard, it outlines a phased approach, so that you can start where you can, with the budget that you have available.

It starts with no cost steps (such as reducing your thermostat, heating only the rooms that you are using, and switching off appliances and chargers rather than leaving them on stand-by) and low cost measures (such as draught proofing, lagging pipes, installing LED light bulbs, fitting radiator controls, reducing air flow in unused chimneys, and sealing cracks in walls or around holes where cables or pipes come in) that can implemented on a limited budget, but will help reduce your energy bills.

For those who are able to afford more extensive improvements, the guide sets out measures costing from a few hundred to a few thousand pounds (such as top-up loft insulation) through to deeper and much more costly retrofit measures (such as insulation to cavity walls, external walls and internal walls, ventilations systems, low carbon heating alternatives such as heat pumps).

As a Council we are providing a range of support for people to retrofit homes, from implementing insulation and energy efficiency programmes using central Government funding such as the Sustainable Warmth scheme, where this is available, to developing a framework contract with approved retrofit contractors which homeowners can use to access reliable installers.

However, the detailed retrofit study that informed this guidance estimated that it would cost an enormous total of £4.65 billion to retrofit all the privately-owned homes in Cambridge to a net zero carbon standard. We therefore call upon Government to commit much greater funding to support retrofit installations in Cambridge and across the country, and also to support the development of the skilled retrofit workforce that is desperately needed to decarbonise our homes.

Councillor Rosy Moore

Executive Councillor for Environment, Climate Change and Biodiversity

Cambridge City Council

How to use this guide

The purpose of this guide is to show how you can retrofit your home to make it more energy efficient.

As well as general information about retrofitting, you can find detailed guidance on how to retrofit the seven different types of houses that are most commonly found in Cambridge.

This means that not all of the information in this guide will be relevent to your home, so there is no need to read it all.

The **Introduction** gives general information about retrofitting – what it is, the benefits of living in a more energy efficient home, and some key concepts to be aware of.

How to retrofit gives an overview of the different kinds of retrofit work you can do, from low-cost and no-cost measures to more extensive work.

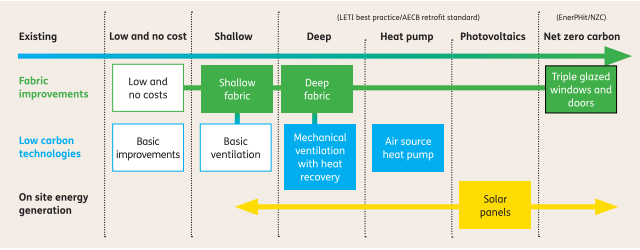
For guidance that is tailored to your home, use the **House-type finder**.

1. What kind of house do you live in?

Skip to the **House-type finder** and select the house that is most similar to your own.

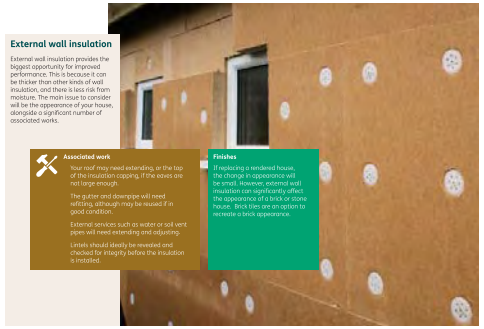
2. Typical measures for your house type

Here you will find detailed information about the types of energy efficiency works that could be suitable for your home, from low cost measures through to net zero carbon.



3. Measures

The section **How to retrofit** contains information about all of the retrofit measures included in this report. To find out more click on the images for detailed information.



Still unsure?

You may need the advice of a retrofit professional. The final section **Next steps** signposts organisations who will be able to support you.

Contents

Introduction

Across the country, millions of households are making changes to their homes to make them more energy efficient, and to reduce their reliance on fossil fuels such as gas for heating and lighting. There are many benefits to retrofitting your home in this way. These include warmer winters, improved health, lower and less volatile energy bills, and reducing your carbon footprint. This guide gives practical advice for homeowners, landlords, and renters on how to retrofit your home, from low and 'no-cost' measures, through to a more fundamental 'deep' retrofit.

This guide begins with general information about retrofitting homes – the benefits of retrofit, the targets you should aim to achieve, and the kinds of improvements you could make to your home.

It then presents the types of homes that are typically found in Cambridge, with detailed guidance on the kinds of retrofit works that are suitable for each one. This includes a comprehensive 'whole house retrofit plan' for each of these seven house types. A whole-house plan is a holistic and phased approach to retrofit that can be adapted to suit your needs, budget and lifestyle. The cost of retrofitting your home can be significant, particularly for a 'deep' retrofit. For this reason, the retrofit measures in this guide include a range of estimated costs at an incremental scale, to enable you to start where you can with the budget that you have. Costs within this section are for a typical house and assume that the retrofit works will be undertaken by a building company. Stated costs can be reduced if the works are undertaken on a 'DIY' basis.

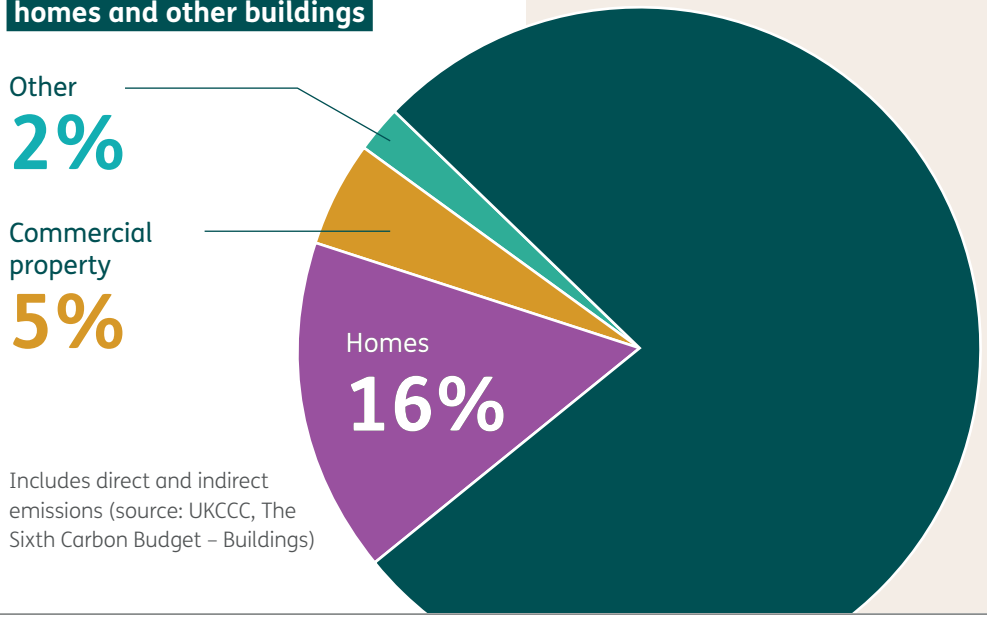
The last section provides links to retrofit advice and resources, and suggests some next steps to begin your retrofit journey.

This guide is not intended to be read in its entirety. Please use the interactive links in the document to navigate. We recommend starting on the House-type finder and then referring to the rest of the document for further information.

What is a retrofit?

A retrofit is works to a home that are designed to reduce its energy use, while making it warmer and more comfortable for the people who live there. To achieve this, retrofit works will make homes more energy efficient, for example by making them better insulated, or will enable them to generate their own renewable energy, for example by installing solar panels. When retrofitting your home, it is important to carry out any necessary property maintenance at the same time. For example, there is little point installing wall insulation if a leaking gutter above is causing issues with damp.

UK CO_2e emissions from homes and other buildings



Includes direct and indirect emissions (source: UKCCC, The Sixth Carbon Budget – Buildings)

The retrofit challenges and opportunities

To prevent catastrophic climate breakdown, most homes and other buildings will need to make significant carbon savings. Emissions from existing homes represent around 15-20% of UK carbon emissions, and 80% of these homes will still be in use by 2050. This means that it is not possible to achieve our climate change targets without retrofitting the homes that we live in now.

Retrofitting homes should not just be viewed from a carbon perspective. The benefits of retrofit include:

- Feeling warm and comfortable in your home,
- Reducing fuel poverty and the cost of living,
- Homes that are less noisy, and free of mould and draughts that can cause allergies and respiratory illnesses,
- Supporting jobs and the local economy.

The International Energy Agency and Organisation for Economic Cooperation and Development states that 75% of the advantages of retrofit are seen in improved health outcomes. Residents have described the effects of retrofitting as 'life changing' from reduced asthma symptoms and other health benefits to lower fuel bills and a sense of warmth and comfort. And work to the outside of your home can often improve and modernise its appearance. Private Landlords will be aware of MEES (Minimum Energy Efficiency Standards), which set a legal minimum energy efficiency rating that a home must achieve before it can be let.

How energy efficient are homes in Cambridge?

On average, homes in Cambridge are less energy efficient than the national average. This is because they tend to be older – around one-third of the city's homes were built before 1914, and one-third were built after 1970, when energy efficiency standards were first included in building regulations.

How far should I retrofit?

What measures do I need for my home, and do I need to reach net zero carbon?

Although ideally we should all aim for net zero, we do not recommend trying to achieve this when retrofitting due to the expense of achieving the final 10-20% of energy savings. Achieving net zero carbon is only possible when the total energy demand of the house is met by renewable energy generated on site (solar panels situated on the roof, for example), but this can often be impossible in cities, where access to sunlight can be restricted by the size and orientation of roofs or overshadowing from neighbouring buildings or trees.

Rebuild or retrofit?

Would it be easier, or cheaper, to rebuild homes rather than to retrofit? We do not advocate this for several reasons. The widespread demolition of homes would be disruptive and would severely harm the character of Cambridge's streets. And in environmental terms, the demolition and rebuilding of homes would emit much more carbon than would be saved. The exception is for poorly performing and badly-built extensions.

Timescales

The proposals in this guide range from low and no cost through to deep retrofit of a building. As a result the time required can also vary greatly. In general the low and no cost measures can be achieved rapidly within days or weeks. The shallow measures a few months whilst a deep retrofit to organise and construct can often take one or two years. A retrofit professional will be able to advise on the specifics of your project.

Jargon busting

Some key terms used in this guide.

Passivhaus

Passivhaus is an energy performance and comfort standard and certification. The standard is defined by the International Passive House Institute. It is primarily defined by strict limits to reduce heat being lost through walls, roofs, floors, windows, and doors. Very high air quality is achieved by stopping draughts and recovering heat usually lost in ventilating a home. EnerPHit is the Passivhaus standard for retrofits.

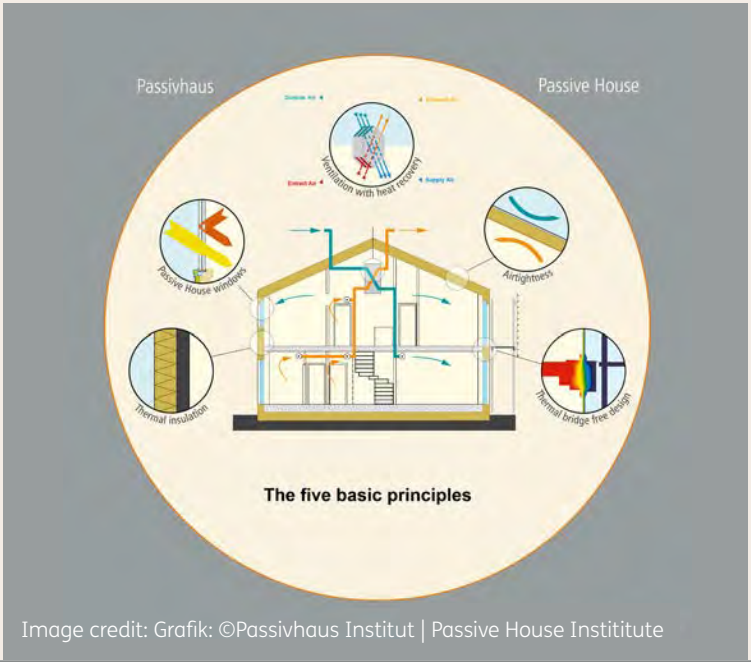
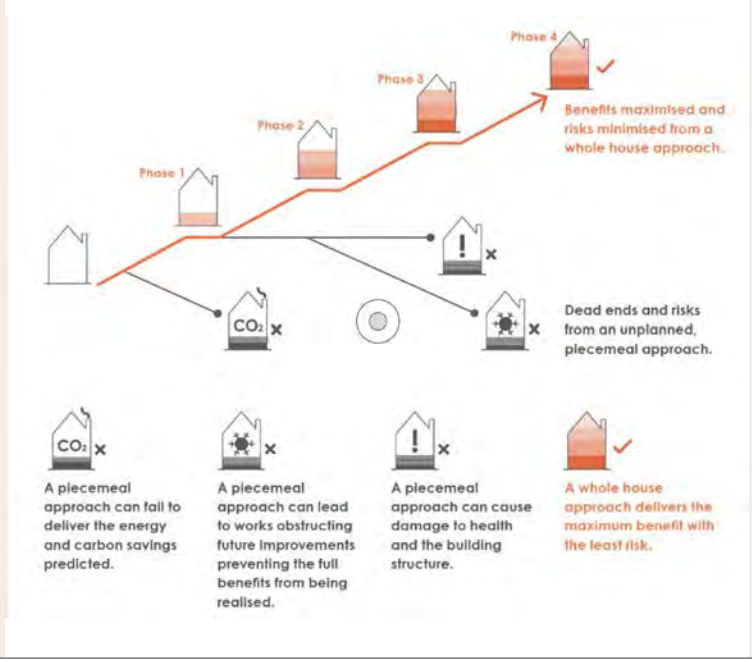


Image credit: Grafik: ©Passivhaus Institut | Passive House Instititute

Whole house plan

Piecemeal retrofits may have unintended consequences that could be detrimental to the performance of a home, and even to the health of its occupants. A 'whole house plan' ensures that retrofit measures are planned so that they can work together. A retrofit designer will be able to assist you in the creation of whole house plan specific for your home.



PAS 2035

PAS 2035 provides a specification for the energy efficiency of home retrofit projects and sets out best practice guidance. When looking for advice on retrofitting, always use a PAS2035 registered professional.

General retrofitting issues

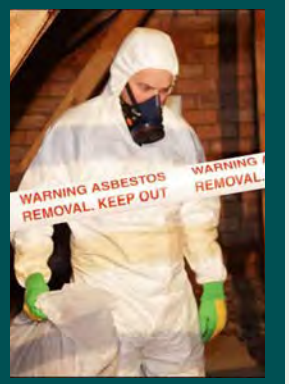
Risks

Poorly designed and executed retrofits can be at best ineffective and at worse damaging to the health of a home and its occupants. A retrofit designer will assess the risks associated with your home and put a plan in place to manage them. This will ensure:

- Pre-existing maintenance issues are not locked in,
- Condensation, damp, and mould issues are remedied,
- Retrofitting works will not cause your home to overheat,
- Good ventilation is maintained,
- Your home will keep the 'breathability' that it needs,
- Heritage features are maintained,
- All works are in line with Planning Regulations, Building Control or Listed Building Consent.

Asbestos risk

For DIY and other works it is essential to commission an asbestos survey for homes built before 2000.



During the build

Retrofitting, like all building works, can be messy so consider your needs during the build phase. For many deep retrofits it is strongly advised to leave your home during the works. If this is undesirable or not possible this needs to be considered in the whole house plan.

Statutory frameworks and permits

Your retrofit professional will help guide you through these requirements. The key statutory requirements are Planning Permission, Listed Building Consent (if your building is heritage listed) and Building Control. A party wall agreement may be required under the Party Wall Act. Skip and scaffolding permits may be required for work directly onto the street.

Greater Cambridge Shared Planning service offers a householder advice service where you can get 15 minutes of free guidance and advise from a planning officer. More information can be found here: Householder and Small Business Planning Advice (greatercambridgeplanning.org). In addition, for listed buildings and buildings in conservation areas, the historic environment team offers bookable free surgery appointments for residents who are looking to undertake energy efficiency works. These can be booked by emailing a request through to historicenvironment@greatercambridgeplanning.org with the subject 'Surgery'.

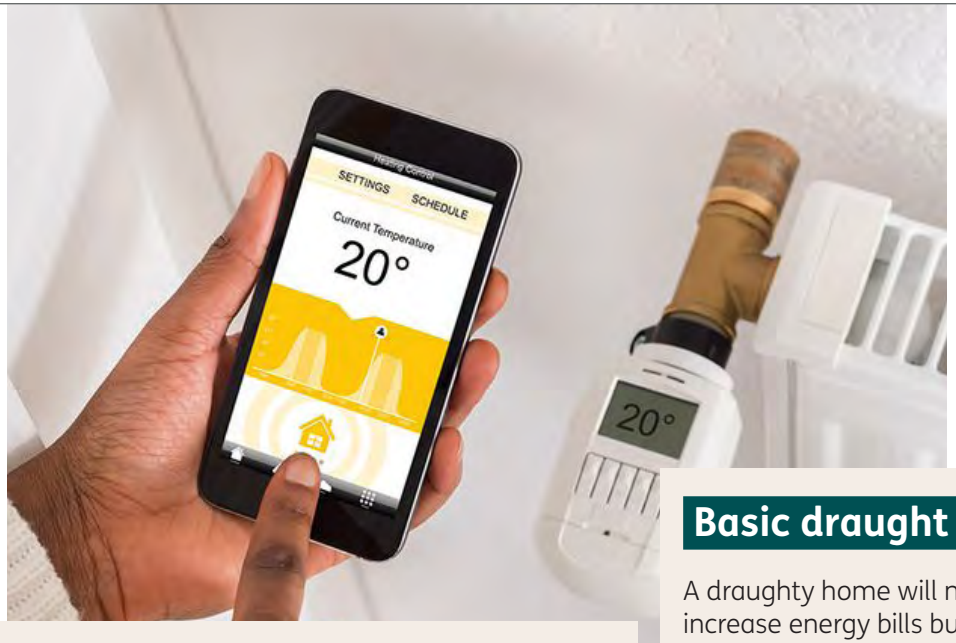
Listed buildings and heritage

This guide coves some general considerations, particularly for homes built before 1914. In these homes, we recommend you use breathable materials (lime plaster, wood fibre insulation, etc) to avoid potential damage to the building fabric. If your home is in a conversation area or is heritage listed, this is a constraint. It's important to note that it is illegal to carry out any works to a listed building without consent. The Sustainable Traditional Buildings Alliance provides specific advice for traditional buildings.

How to retrofit

Low and no-cost measures

The following measures in this section are either free or of low cost (from a few hundreds of pounds to a few thousand). Many are possible with a DIY approach and represent a great way to start retrofitting.



Controls and use

- Reduce your thermostat, but only if your health or wellbeing needs allow.
- Heat only the rooms you are using. You may need to install thermostatic radiator valves (a simple device that controls the temperature of an individual radiator). Smart control can make this even easier but at a higher price point.
- Use conservatories as the Victorians did: enjoy them when the sun shines, and don't heat them. These spaces are often excluded from Building Regulation standards as they are considered outside of the 'heated' home. The high amount of glass and sometimes poor build quality means they often lose a lot of heat. Consider heavy curtains or installing doors if your conservatory makes the adjoining rooms too cold. An infrared heating panel could be used for occasional use, because it responds very quickly when switched on.
- Switch off appliances or chargers at the plug when not in use to eliminate 'phantom loads': appliances, particularly old ones, use considerable energy when in 'stand-by' mode.
- Smart controls can save 10% and upwards from your energy bill.

Basic draught proofing

A draughty home will not only increase energy bills but can be a primary cause of thermal discomfort. It is crucial to differentiate between unwanted draughts and necessary ventilation for indoor air quality, which is covered in the next section.

Open chimney

Open chimneys are a major source of draughts – not surprisingly, as the entire purpose of a chimney is to move air through a home! Several off-the-shelf products are available to reduce the flow of air through the chimney, sometimes called chimney balloons. We recommend a breathable and ideally natural material. An old pillow or ball of insulation in a paper sack is a cheap alternative.

If you have a wood burner, check the seals at the edges of the register plate. A register plate is used when a chimney has no stainless-steel chimney liner. The register plate closes off the chimney at its base, just above a wood burning stove. The register plate acts as a barrier to prevent the smoke and fumes in the chimney from entering the room.

Risk

Chimneys that are not suitably sealed at the top must be allowed to breathe to prevent moisture build up and potential damp issues. Use a breathable seal or, if using a chimney balloon, ensure it is fitted loosely to ensure some air flow. Only reduce the flow of air through your chimney if it is no longer in use.

We recommend fitting a chimney cap if you have safe access to your roof.

Risk

This work is generally safe. However, if your home does not have an up-to-date gas safety or electrical certificate this should be sought first. Do not attempt to move any pipes or cables without appropriate advice.

Holes in outside walls

Whenever a cable or pipe comes from the outside to the inside of your home a hole must be made. These holes are rarely sealed and so often leak air. These are relatively easy to seal using an appropriate sealant for small gaps. Air tightness tape is useful for larger gaps. Foam can also be used but is prone to shrinkage, so look for specific air tightness foam. Try to fill holes first from the outside then from the inside.

Holes in outside walls are typically due to:

- Soil stacks and waste pipes,
- Electricity cables,
- Gas pipes,
- Telephone and internet cables,
- Cable TV, etc.

Cracks and gaps

Cracks and gaps develop in buildings either because they were built poorly or, more likely, because they have simply moved over time. Fixing them is an easy and cheap DIY measure. Internally, use filler where the hole doesn't move (such as a screw hole in plaster board) or decorators' caulk or mastic where the hole might move (such as the gap between skirting boards and walls). Brushes and seals may be needed for windows and doors, while traditional draught excluders are effective on poorly-fitting windows and doors.

- **Caulking or filler internal cracks**
  - Skirtings,
  - Mouldings or covings,
  - Cracks in plasterwork/ plaster board,
  - Screw holes (particularly for dot and dab plaster work).
- **Weather brushes or seals**
  - Doors,
  - Windows,
  - Loft hatches,
  - Storage doors/hatches.

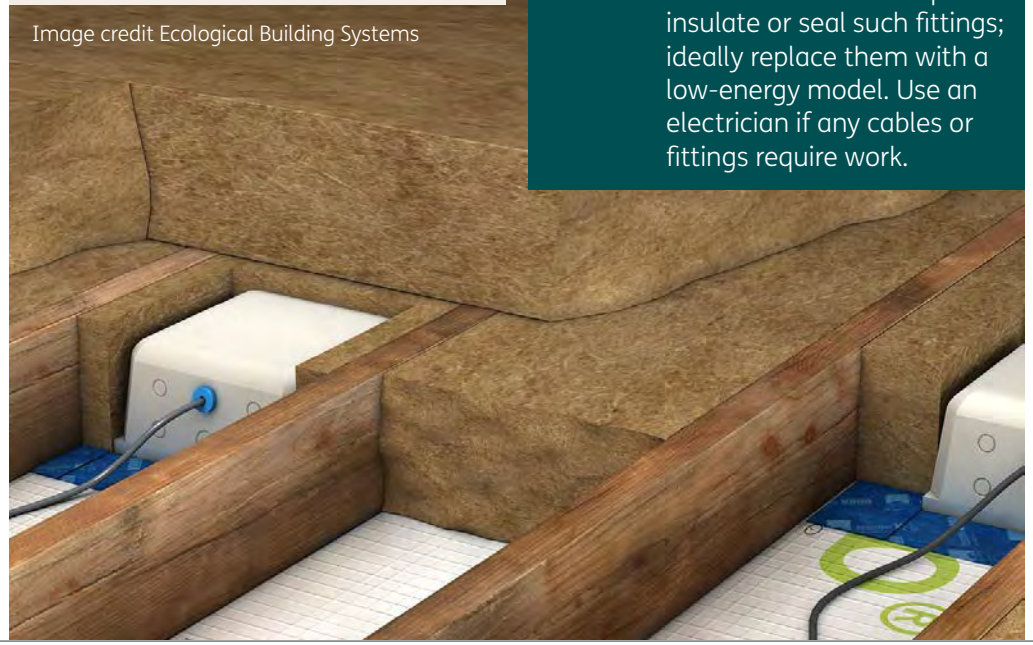
Air tightness is often particularly poor behind bathroom and kitchen fittings. This can be because waste and soil vent pipes have been sealed poorly. Soil vent pipes are often built as a chimney from the ground, where the pipe enters, rising all the way to the roof. Sealing this can prevent significant heat loss, although professional help might be required. Kitchens perform badly as often there is no plaster or plaster board behind the kitchen units. If you are having a kitchen fitted, ensure the air tightness works are done before the units are installed.

Sealing floorboards

Suspended timber floors are designed to be ventilated from below to protect the floor timbers from moisture, but these draughts can be unwelcome in the home.

- If you have exposed timber floors, consider caulking or sealing the gaps.
- A layer of new carpet or an airtight membrane can be laid over floorboards.
- The edges of a room where boards and skirting boards meet can be a source of draughts. This can be remedied with air tightness tape if removing skirtings. If skirtings are retained, then the gaps can be caulked or filled with sealant.

Image credit Ecological Building Systems



Light fittings

Light fittings, particularly downlighters, in the ceilings of pitched roofs or in loft floors often leave holes in the insulation and cause significant draught in the gaps. When decorating, choose surface mounted lights. For lights that have already been installed, an off-the-shelf fitting can create an air-tight seal over the light.

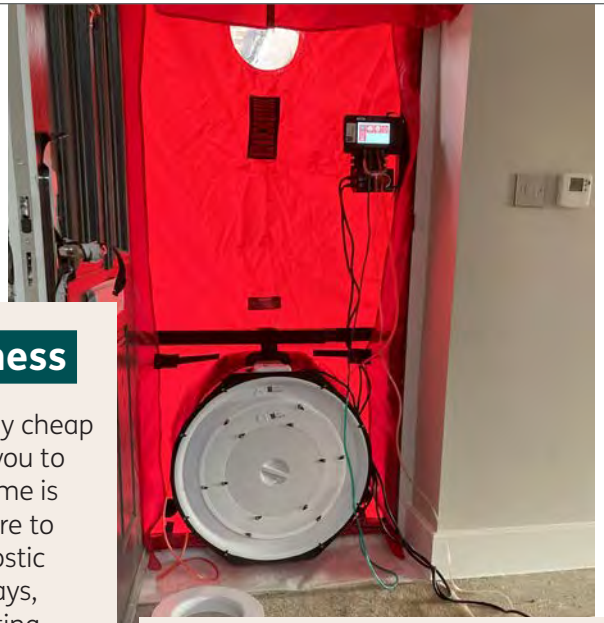
Risk

Old incandescent or halogen lights can become very hot and overheat if insulated or if airflow to them is blocked. Do not attempt to insulate or seal such fittings; ideally replace them with a low-energy model. Use an electrician if any cables or fittings require work.

Test your air tightness

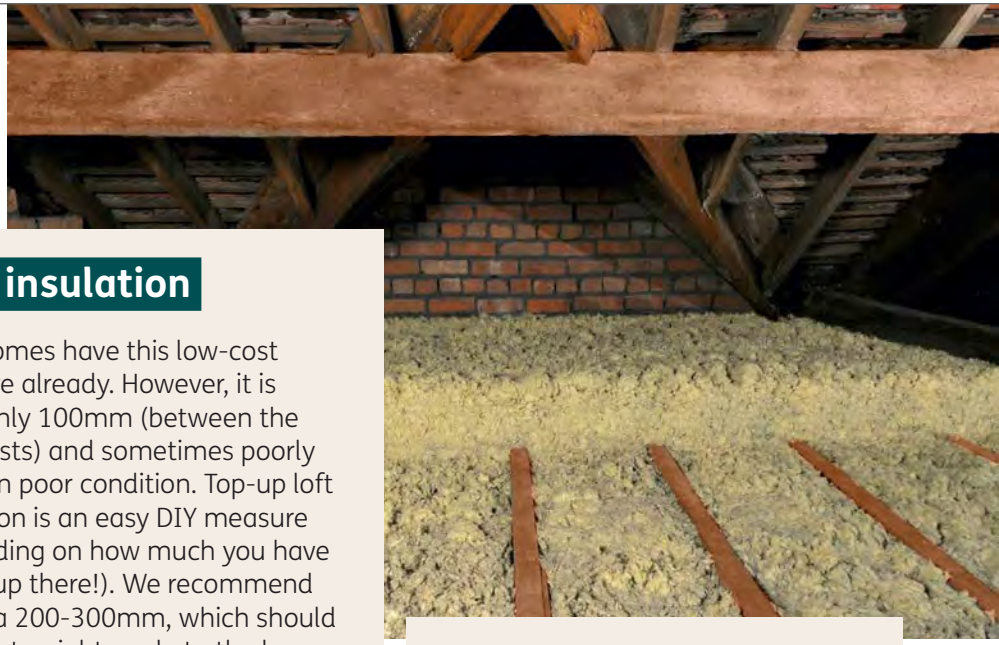
Air tightness tests are relatively cheap (around £200) and will allow you to measure how airtight your home is and to find any leaks. Make sure to ask your air tester for a diagnostic visit to find air leakage pathways, not just for an air tightness rating. The professional body ATTMA (Air Tightness Testing & Measurement Association) is a good place to find accredited testers.

- Attach draught seals to windows and doors.
- Use airtight seals for down lighters (for example, Thermohood).
- Use low-energy light fittings throughout.
- Stick additional insulation to your loft hatch and draught proofing.
- Lag/insulate pipework.
- Fit thermostatic valves to radiators.



Low-cost ventilation

Simple extractor fans should be installed in bathrooms and kitchens (unless you are planning a more extensive retrofit, in which case refer to the section below on air tightness and ventilation). Fans are available that recover the warmth from the extracted air. Bathroom and kitchen doors should have a gap big enough to fit your finger through at the bottom to allow air to enter the rooms while the fan extracts. If your windows have trickle vents, make sure they are open in rooms that are in use.



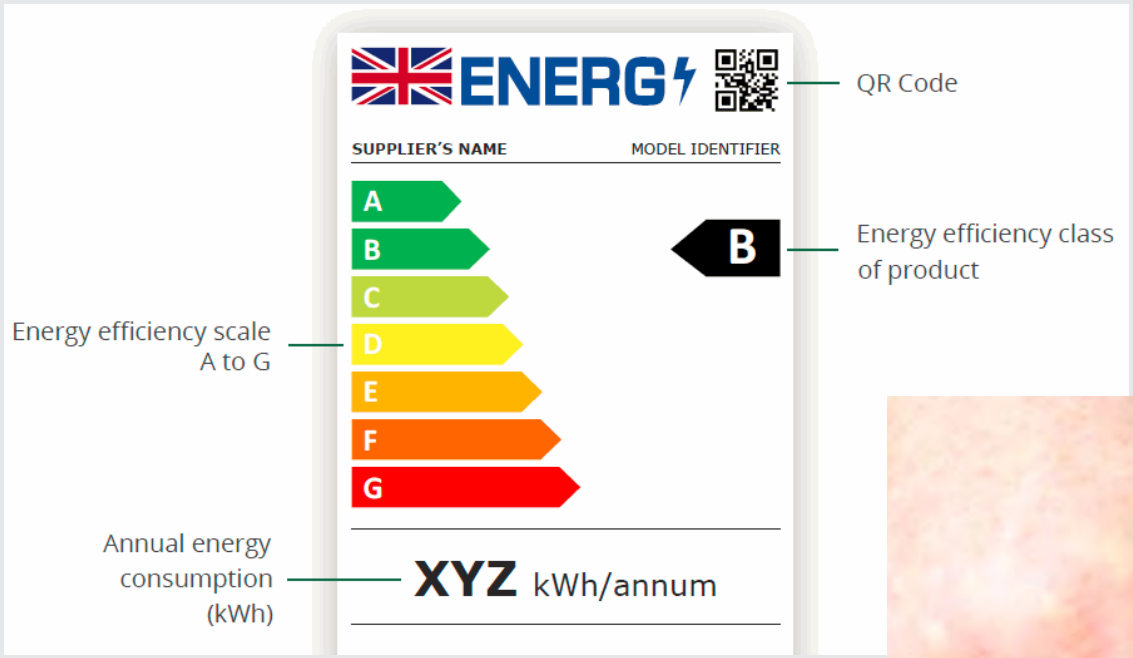
Loft insulation

Most homes have this low-cost measure already. However, it is often only 100mm (between the floor joists) and sometimes poorly laid or in poor condition. Top-up loft insulation is an easy DIY measure (depending on how much you have stored up there!). We recommend an extra 200-300mm, which should be laid at a right angle to the layer of insulation below, to limit gaps forming. You may need a 'loft pack' – essentially chip board flooring on stilts – to create a storage area if required. You should leave a small (20mm) ventilation gap between the chip board and the top of the insulation, just in case any moisture forms. Be careful not to block any eaves ventilation with the new insulation. If you are unsure, check with a retrofit professional.

A slab of ridged insulation and air tightness seals to the loft hatch will complete this potential weak spot.

Lighting

LED light fittings are now widespread, affordable, effective, and reliable. To achieve quick savings, upgrade your incandescent bulbs immediately and replace fluorescent bulbs as they expire.



White goods

Choose white goods that have the highest energy standards that you can afford. Note that under new energy rating guidelines, energy labelling has been changed. Older products go up to A+++, while the maximum energy rating under the new guidelines is an A. Please also note that old A+++ rated-goods are rated much lower under new guidelines, sometimes as low as a D or E rating.

When upgrading your kitchen, consider installing an induction hob, as their high efficiency means any additional upfront cost will be paid back quickly.

Water

Water takes a lot of energy to heat. To reduce the amount of water that you use, low-flow fittings can be fitted on taps, flushes, and shower heads when they need replacing, or when redecorating. The AECB Water Standard is a useful standard to aim for because it is easy to understand and relatively easy to achieve.

Pipe lagging

It is essential to insulate all pipes that run outside of the insulation line of the building, for example through a cold loft space and sub-floor spaces. You should also insulate hot water pipes that run though spaces that don't need heating, such as though a utility cupboard or storage room.

Deeper retrofit measures

Fabric improvement

Your home's 'fabric' is its walls, floors, roofs, windows, and doors. A better building fabric is more comfortable as it loses less heat through it, has fewer draughts, and is less likely to have issues with damp. Retrofitting is often described as a 'fabric first' approach. This means that first you improve the performance of the building's materials and construction before then installing low carbon or energy-efficient technologies.

This section gives an overview of the main measures you can take to improve the fabric of your home. The following section will show you which of these will be most applicable for the type of property that you have.

Wall insulation

Improving the insulation of the walls of your home almost always offers the biggest improvement in energy efficiency performance and the greatest return of benefits for the money you invest.

There are three methods of insulating walls:

1. external wall insulation on the outside of the house,
2. internal wall insulation on the inside external walls, or,
3. cavity wall insulation, which fills the cavity between the inner and outer leaves of the walls, if present.

Homes can have a mix of wall insultation, for example: External Wall Insultation at the rear and Internal Wall Insultation at the front.

Cavity wall insulation

The key advantage of cavity wall insulation is that it is hidden within your walls, meaning the inside and outside of your house will look the same, and most building services will not be affected. For newer homes with wide enough cavities this is a highly appropriate measure.

The work quality of cavity wall insulation can be hard to assess and only thermal imaging can show areas that have been missed or areas where the filling material has settled. For this reason, you should ensure an installer can provide a guarantee from CIGA (Cavity Insulation Guarantee Agency). If they are unable to do so, then they should be avoided.

Internal wall insulation

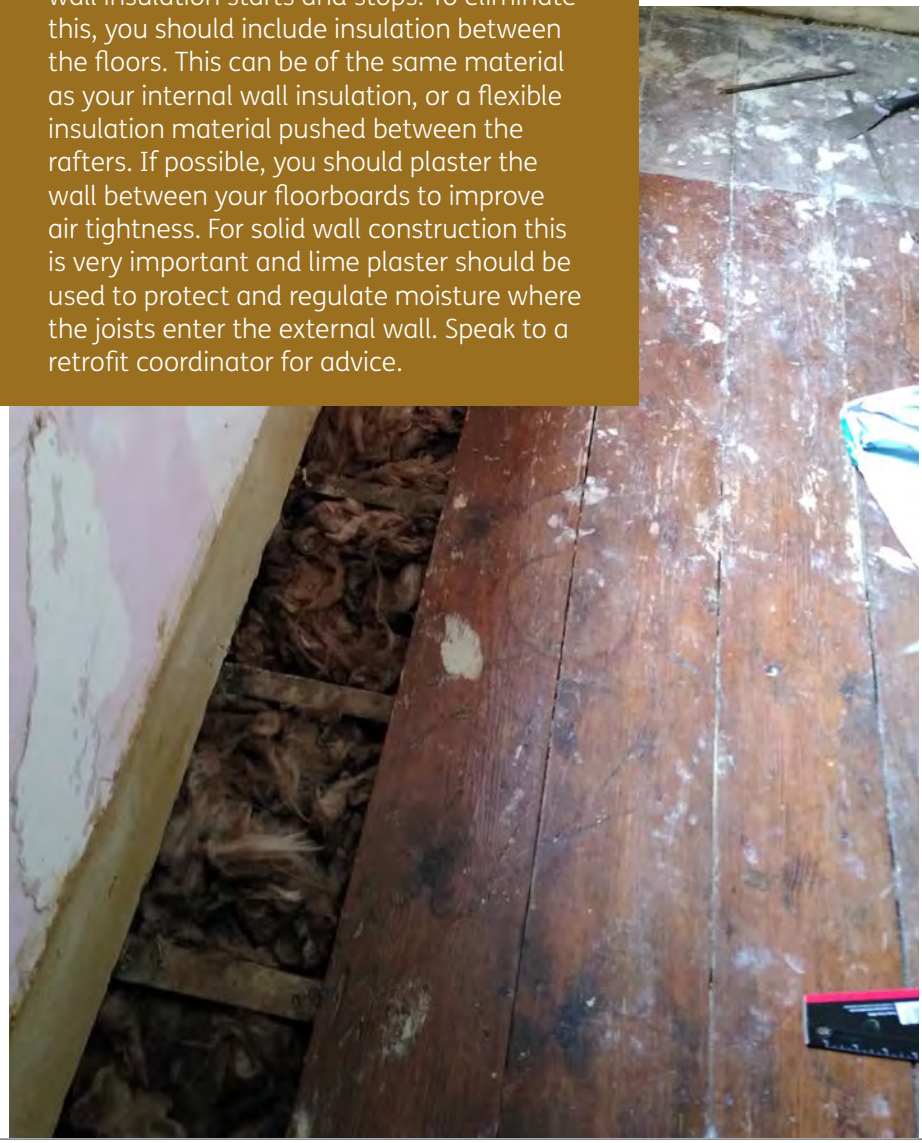
Internal wall insulation is a good choice for solid wall buildings where, for aesthetic or heritage reasons, it is not appropriate to insulate the outside walls. It is also very appropriate for incremental retrofits, doing one room at a time before redecorating.

Risk

Moisture may build up behind internal wall insulation. The use of breathable insulation is highly recommended (for example 100mm wood fibre board). Non-breathable insulation manufactures will recommend a ventilation gap behind the wall to mitigate this risk. However, this significantly reduces the effectiveness of the insulation as warm air is in circulation behind it. A qualified tradesperson should carry out a moisture calculation to assess this risk. Typically, the supplier of the insulation will be able to provide the calculation.

Associated work

Insulate between floor joists. There will be a gap between floors where your internal wall insulation starts and stops. To eliminate this, you should include insulation between the floors. This can be of the same material as your internal wall insulation, or a flexible insulation material pushed between the rafters. If possible, you should plaster the wall between your floorboards to improve air tightness. For solid wall construction this is very important and lime plaster should be used to protect and regulate moisture where the joists enter the external wall. Speak to a retrofit coordinator for advice.



External wall insulation

External wall insulation provides the biggest opportunity for improved performance. This is because it can be thicker than other kinds of wall insulation, and there is less risk from moisture. The main issue to consider will be the appearance of your house, alongside a significant number of associated works.

Therefore it is important to engage fully with the relevant heritage and conservation teams within the council. Please note that any works that alter the character of a listed building require Listed Building consent, a separate process to obtaining planning permission. This would include internal works; re-facing external walls; replacing windows and installing external boiler flues.

Associated work

- Your roof may need extending, or the top of the insulation capping, if the eaves are not large enough.
- The gutter and downpipe will need refitting, although may be reused if in good condition.
- External services such as water or soil vent pipes will need extending and adjusting.
- Lintels should ideally be revealed and checked for integrity before the insulation is installed.

Finishes

If replacing a rendered house, the change in appearance will be small. However, external wall insulation can significantly affect the appearance of a brick or stone house. Brick tiles are an option to recreate a brick appearance.

Roofs and ceilings

Flat roofs

Flat roofs are most easily insulated from above the structure (typically timber joists with a plywood deck) but this is only possible if the roof covering is removed. Therefore, a condition survey is a critical first step before deciding on an approach.

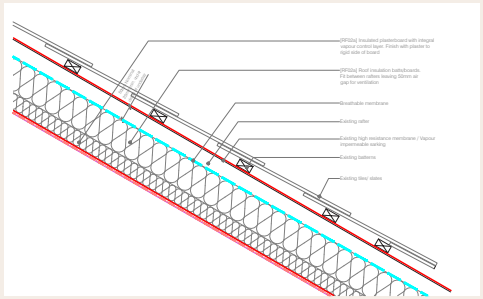
Insulating from below and between is possible and more possible as a DIY approach. There is a condensation risk so any work should be specified by a competent person, ideally with PAS 2035 accreditation.

Pitched roofs

Many homes don't require insulation to pitched roofs. This is because the insulation layer is in the loft floor (between and over the joists). In construction this is referred to as a 'cold roof'. However, if the pitched roof is also the ceiling of a warm room below then this element needs insulation. Typical examples are room-in-the loft extensions or lean-to extensions.

As with a flat roof, a retrofit coordinator or similar person should assess the roof construction before deciding on an approach. Whether tile, slate, or metal, a ventilation space is required behind the covering. Check whether the roofing membrane is vapour permeable - pre-2000 roofs tend to be non-permeable and have a bitumen-like finish. Modern roofs tend to be breathable and have a woven fabric like appearance.

Maintaining ventilation and a path for moisture to escape is essential and needs specifying by a competent person. Care must be taken at the eaves to avoid weak spots in the insulation where heat can escape. At best it is inefficient, at worst these cold areas can result in damp and mould. The Retrofit Pattern Book provides free to download construction detail such as the examples to the right



Skeiling

Skeiling is a construction term that relates to an angled roof, rather than a horizontal ceiling. This is best illustrated in the image above. This may be the whole area of the room or just a small section at the perimeter – this is typical of interwar and post-war construction (see house types C and D, below). They are very often uninsulated and may be an existing area of damp and condensation. This may become worse if the adjacent wall and ceiling are insulated and the skeiling is not. The same approach should be taken to the room in the roof section.

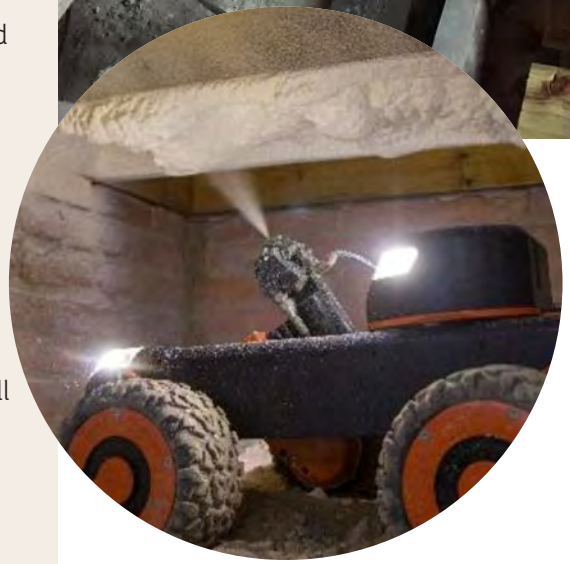
Floors

Suspended timber floor

Typically used until the 1950s, these are timber joists that are lifted above the floor and away from the moist ground. A ventilated space is left below the floor. Clues that you have a suspended floor are the presence of vent bricks and a slightly bouncy feel to the floor. There are broadly two ways to insulate this construction: placing an insulation material between; or spraying from below.

If there is a large void below the floor or the floorboards are being lifted, then insulation can be placed between. Best practice involves draping a breather membrane over the joists; snuggly filling with flexible insulation between; adding an airtight membrane above; then adding a floor finish. Ecological Building Systems provide a good description of this approach.

If the above approach is not desirable or possible (due to a small gap below the floor or because the work would cause excessive disturbance) then an alternative is for a remote-controlled robot to apply insulation from beneath.



Solid concrete floor

Solid concrete floors became popular from the mid-19th century onward, but only towards turn of the millennium were these insulated. These tend to be costly to retrofit. A high performing aerogel insulation can be installed as this can be as thin as 30mm. A lower performing phenolic could also be used, installed between timber battens or directly laid (floated) over the existing concrete.

Beam and block floor

From the 1980s onwards, concrete blocks laid between precast concrete beams became increasingly popular, particularly for mass house builders. If already insulated, then further work is only need if you are aiming for the highest energy efficiency standards. If uninsulated, you can use any of the methods described above.

Air tightness and ventilation

A draughty home can not only be uncomfortable but also lose a lot of energy. Up to a quarter of heat loses can be due to a leaky building. Remedying this could save more energy than fitting new windows, and at a much lower cost.

A draught-free house should not be associated with a bad air quality. Relying on a leaky building for good air quality is extremely expensive, so a ventilation strategy and system is essential to balance air quality and efficiency.

There are a range of ventilation targets with their distinct pros and cons. The below list is not exhaustive but covers the key systems recommend in this guide.

Insulate right and ventilate right

Poorly performing UK homes often have damp issues and knock-on health implications. Retrofitting deals with these issues alongside reducing energy consumption.

Therefore, a key part to a successful retrofit is improving and upgrading ventilation systems.

Building regulations minimum

This is a blend of extractor fans and background ventilation. Mechanical extractor fans are placed in bathrooms and kitchens. The background ventilation occurs through trickle vents (slots or grills) in the window frames. Do not fit these vents if you are planning to install further ventilation measures, as they will not be required.

Single room ventilator with heat recovery (SRV)

This is the same as a typical extractor fan in a kitchen or bathroom, with the key difference that it contains a heat recovery unit. This can collect around 60-80% of the heat from the extracted air. This is an affordable consideration if no extractor fan is currently present. As above, this is not needed if any of the following systems are to be installed.

Mechanical ventilation with heat recovery (MVHR)

Mechanical ventilation with heat recovery is a whole-house system that extracts stale air and supplies fresh air that has been pre-warmed with heat recovered from the extracted air. Air is typically extracted from warm and wet rooms, ie kitchens and bathrooms, and supplied to bedrooms and living spaces. Because 80-90% of heat can be recovered through this system, significantly more fresh air can be delivered while ensuring occupants remain warm. The system requires air ducts to be carefully placed through the house. The unit is about the size of a large suitcase and space equivalent to a fridge freezer is required when the insulated exhaust and intake ducts are included.

Demand control ventilation (DCV)

An alternative whole-house system is demand control ventilation. One or two fan units extract air from kitchens and bathrooms. Air is admitted from the outside via smart grills that automatically open and close dependent on the moisture level in a room. Although it does not recover heat from warmer air, it efficiently only supplies ventilation when and where it is required.

Recirculating cooking hoods

Typical cooker hoods that are ducted to the outside are not compatible with DCV, MVHR and SRV systems. They should be replaced with a recirculating cooker hood. These include charcoal filters to remove moisture and cooking smells.

Windows and doors

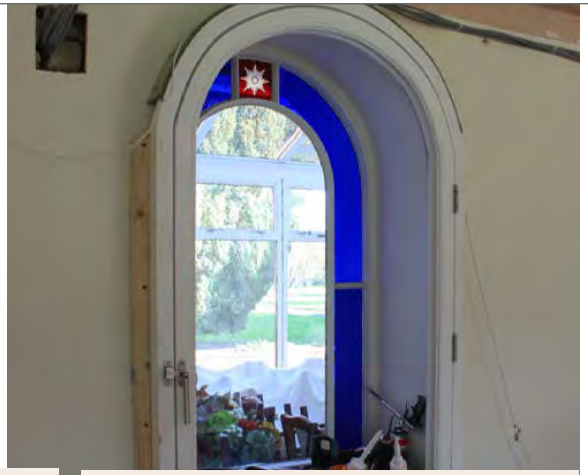
Doors

Not only do old doors have no insulation they also tend to be very draughty. Aim for triple glazing for transparent elements and two layers of draught and weather proofing. A Passivhaus-certified door will achieve the highest of standards.

Windows

Should your building have pre-1990 double-glazing, single glazing, or metal framed windows then then this would be a priority upgrade. However, it is very common to have reasonably well performing double glazing in many homes. Should this be the case, this guide only recommends an upgrade to triple glazing if you are aiming for a very high performing retrofit. This is because the cost is high for the money invested – it will save around half the energy per pound compared to wall insulation, air tightness measures, or ventilation systems.

Nevertheless, high performance windows can increase the value of a home, and significantly increase your comfort, especially in bathrooms.



Secondary glazing

Secondary glazing, as the name suggests, is a second window placed, typically, on the inside face of the wall. This can be highly appropriate for traditional buildings when there is heritage value in retaining the existing glazing, and is very suitable for integration with internal wall insulation. Improved acoustic performance is a further benefit of single glazing.

There are several specialist suppliers on the market. Metal frames are slimmer and have less impact, but timber frames lose less heat. They can be both single or double glazed, with the latter offering better performance but requiring a larger frame.

Loft and storage hatches

An affordable DIY option is shown in the low-cost measures (below). For increased air tightness, a purpose made hatch is a robust option.

Heating upgrades

Heat pumps

A heat pump is essentially a fridge in reverse; instead of cooling it is used for heating. Heat is produced by squeezing heat out of the air or ground using refrigerants and a compressor. For each unit of electricity used, it is possible to produce two-to-five units of useful heat. Ground source heat pumps (GSHP) are more efficient but require greater up-front costs; either horizontal pipes in a large garden or boreholes if land is not available. Air source heat pumps (ASHP) are less efficient but cheaper. Water source heat pumps are also available but can only be used next to a river, lake, or other major body of water.

You may need to increase the size of your existing radiators because the temperature of a heat pump is lower than a gas boiler. An easy way to test if you need upgraded radiators is to reduce your radiators to their lowest settings and leave on for a long time. If you still feel warm on a cold day then your radiators are the correct size.

Heat pumps are typically the size of a tall fridge freezer. Externally, an ASHP is the size of a large suitcase. Poorly designed ASHPs can make some noise and ideally should not be installed under bedroom windows.

A typical ASHP produces 2.5 units of heat for every unit of electricity. In comparison, a gas boiler needs one unit of gas to produce 0.9 of useful heat. Despite this, an ASHP will not necessarily reduce your heating bills (because electricity is around four times the price of gas) unless in conjunction with improvements to insulation and air tightness.

The UK government's boiler upgrade scheme currently provides grants to install heat pumps.

Gas boiler

You should not install new fossil fuel heating systems. Regular servicing of gas boilers can ensure they run as efficiently as possible.

Electric boilers

New electric boilers can be installed as a like-for-like replacement for a gas boiler. At present, no carbon will be saved unless you have a significant number of solar panels to provide zero carbon electricity. However, the carbon content of electricity is falling rapidly as more renewables provide electricity to the grid. Your bills will increase because electricity is more expensive than gas. An electric storage boiler which runs during off peak prices can be cheaper to run.

Infrared heating panels

The principal of 'heat the person not the building' lies behind infrared panels. This technology can be very suitable to heat a localised area in an otherwise low-performing room or building. For example, a home office in a leaky loft conversion.

On-site generation

For most homes, it is only feasible to install photovoltaic/solar panels, if enough suitable roof space is available. Generating power from wind is rarely viable in urban areas and generating hydroelectricity is reliant on access to a water source.

Unlike other retrofit measures, photovoltaics can be installed at any point in the whole house phasing plan (although it is best to look at low-cost and no-cost measures first).

Installing photvoltaics provides a source of renewable electricity that can be used in homes.

Solar PV installations can be considered 'permitted development' and will generally not need planning permission. However, in some cases, such as in Conservation Areas and on Listed Buildings, planning permission may be required. For planning advice please contact the planning department, further information is also available from the Planning Portal online at: Interactive House – Planning Portal.

House-type finder

Large historical townhouse
Age: pre-1914

Victorian terrace/ workers' cottage
Age: pre-1914

Small semi-detached
Age: 1920-1950

Large semi-detached
Age: 1945-1959

Mid-century 'modern'
Age: 1960-1979

End of century mass house builder
Age: 1980-1999

Modern mass house builder
Age: 2000-2015

These photos show the seven most common types of houses in Cambridge. To discover the most appropriate retrofit opportunities for your home, find the house type most similar to yours, and click on the appropriate letter in the navigation bar below.

This should outline the most suitable measures for your home, although you may also need to look at measures from earlier or later eras if the fit is not exact. For example, you might have a 1960s home with a suspended timber floor. Equally your Victorian terrace may have had a solid concrete floor installed as a later addition.

House type A

Large historical townhouse

Energy savings and scope




Age: **pre-1914**
Name: **Large historical townhouse**
Typical size: **72m² (duplex apartment)**

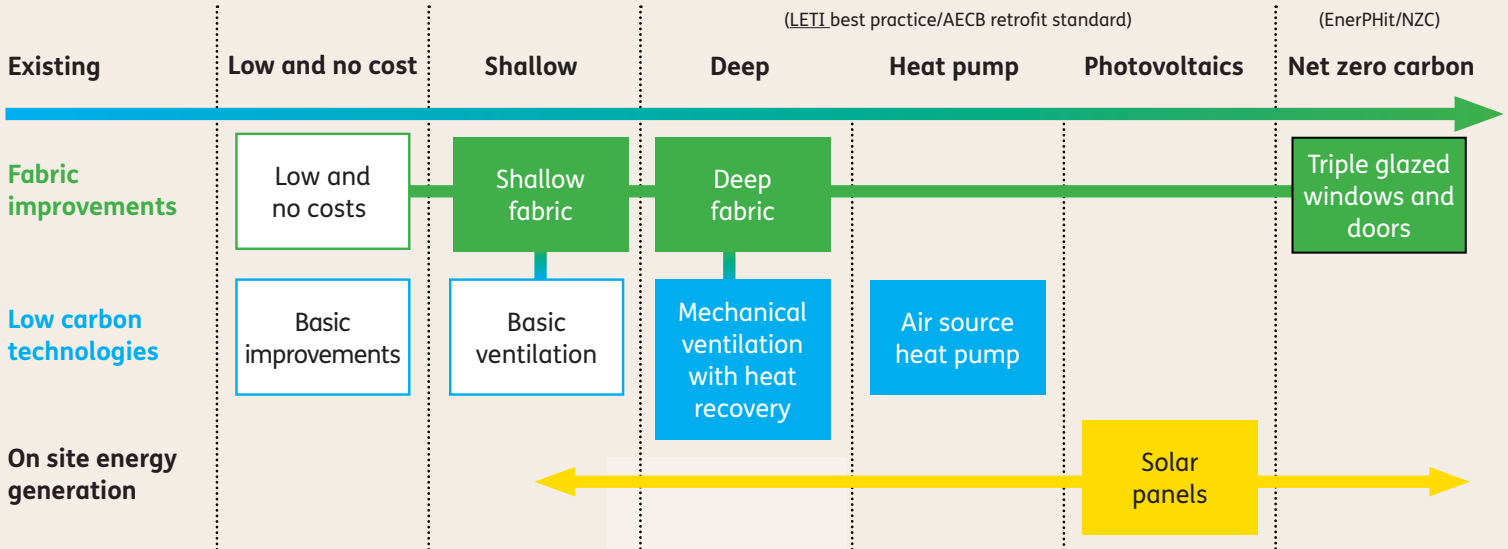
Description

This archetype covers pre-1914 townhouses including those subsequently subdivided into flats. The properties covered in this type are largely constrained due to their historic value.

Typical features

- **Solid masonry walls (generally brick)**
- **Suspended timber floor (uninsulated)**
- **Masonry load-bearing partition walls**
- **Lath and plaster or single brick partition walls**
- **Timber roof with slate or tiles**
- **Loft floor typically insulated between joists**
- **Singe glazed windows**
- **Gas boiler and radiators**
- **Open chimneys with generally unused fireplaces**

Phasing of retrofit work – Type A



Retrofit cost	£0	£3,000	£48,900	£87,600	£103,600	£107,000	£119,600	£ invested
Energy saving	0%	0-10%	17%	73%	85%	89%	93%	Percentage saved
Heating demand	**300**	**280**	**250**	**65**	**65***	**65***	**40**	**kWhr/m²/yr (heating)**
Carbon emissions	10	9	8	2	1	0.7	0.4	Tonnes CO_2/year
Annual bills	£2,000+	£2,000	£1,700	£1,000	£1,200**	£900	£600	£ per year

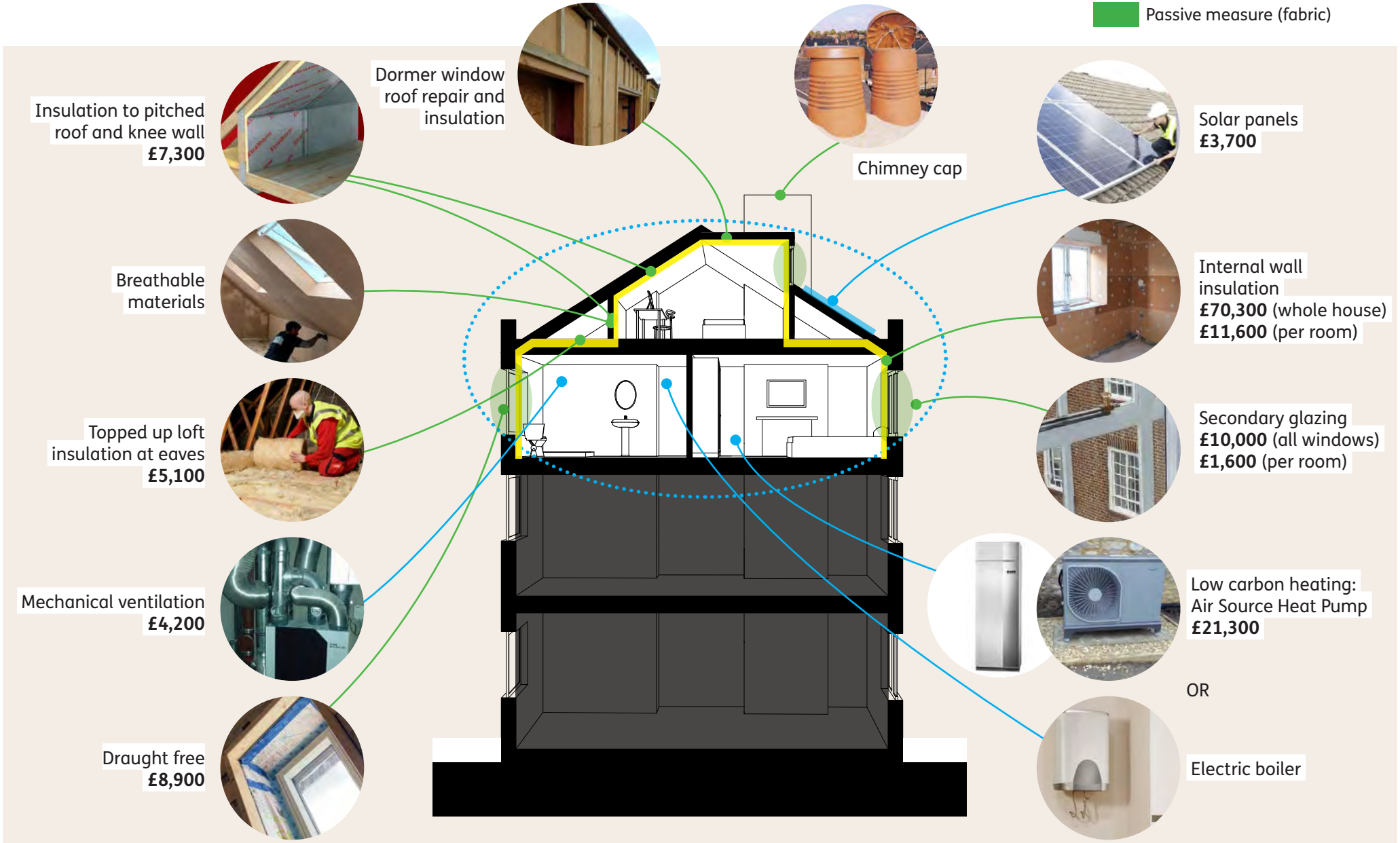
Bill estimates are based on early 2022 prices, so a rise is expected. It assumes homes heated to CBSI recommendations rather than national averages.

*the heating demand is efficiency of the buildings walls, floors, roofs and windows, therefore unaffected by low carbon technology

**bills rise with the switch from gas to more expensive electricity.

Typical measures and approximate costs

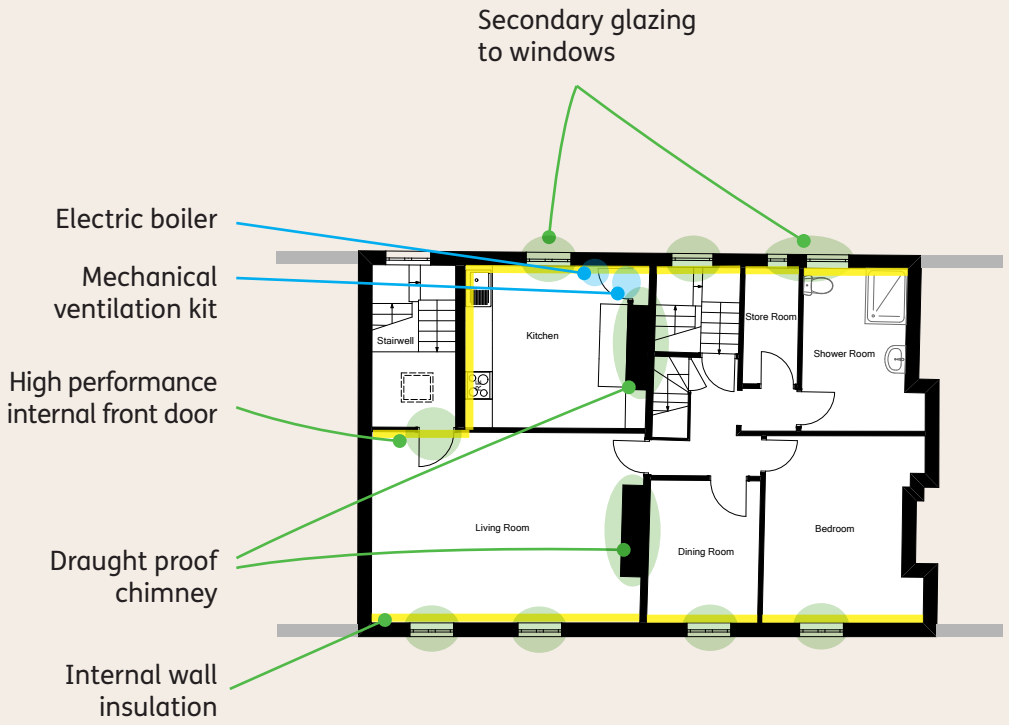
Thermal envelope
Active measure
Passive measure (fabric)



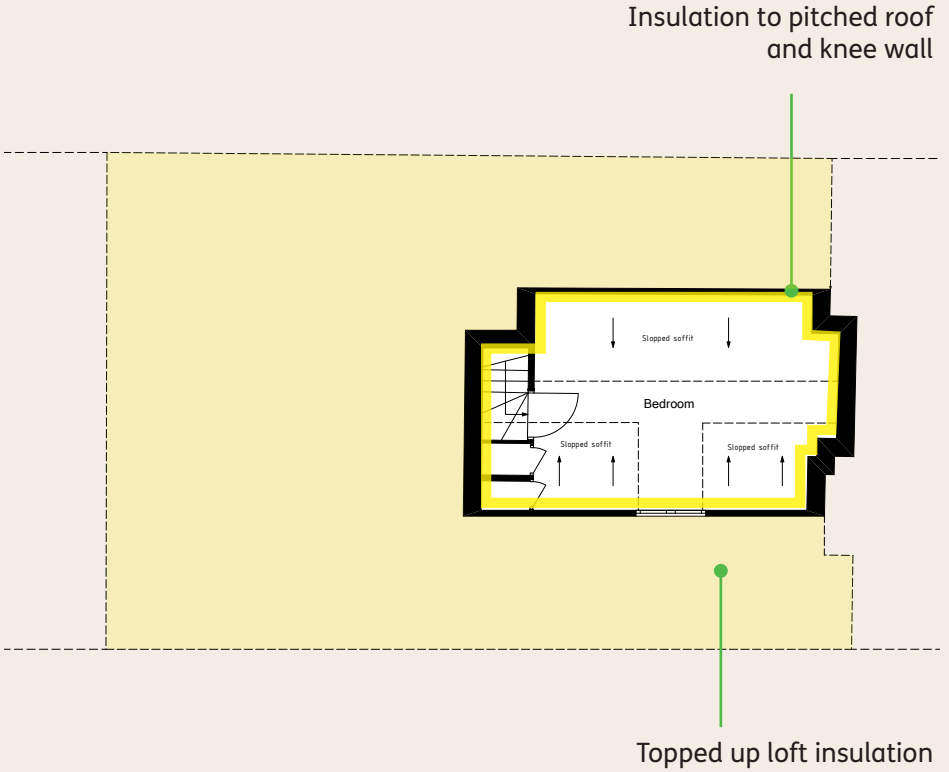
Typical measures

Thermal envelope
Active measure
Passive measure (fabric)

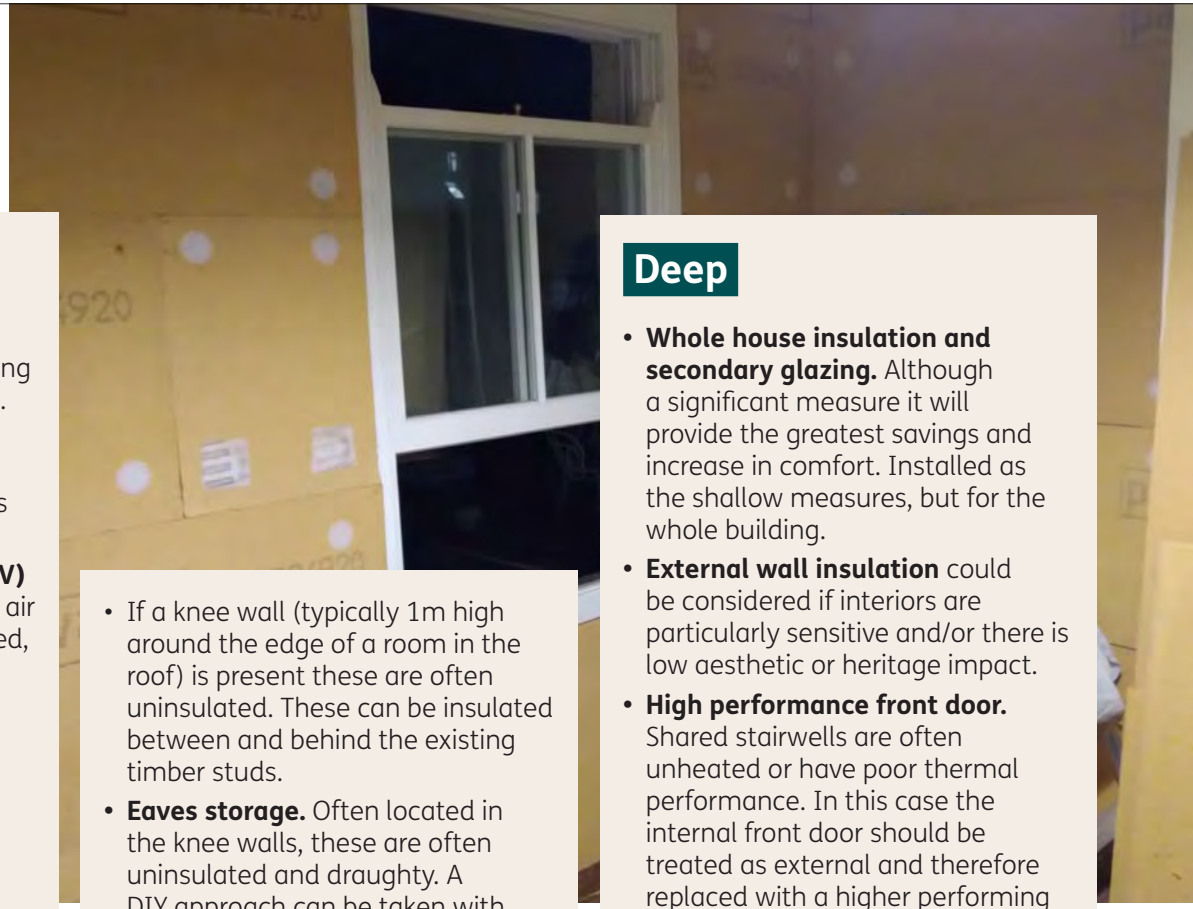
Second floor



Third floor



Retrofit measures



Low-cost measures

- Ensure thermostat is at recommended levels or according to your health needs.
- Fit low energy lighting and appliances.
- Fit draught strips on windows and doors.
- Seal cracks, holes and service penetrations.
- Extractor fans to bathrooms and kitchens.
- Seal gaps around old-fire places.
- Draught-seal chimney fireplaces.
- Install improved heating controls.
- Make DIY improvements to loft and storage hatches.
- Lag pipes.
- Conduct air tightness tests to find leakage pathways.
- Use thermal imaging to find weak spots.

Shallow

- **Top-up loft insulation** with an additional 200mm over the existing 100mm to make 300mm in total.
- **Install mechanical extraction** from kitchens and bathrooms (unless whole house ventilation is planned for later phases).
- **Demand control ventilation (DCV)** can be a viable system as existing air bricks in rooms can be re-purposed, although MVHR (mechanical ventilation with heat recovery) offers higher performance and air quality. You will need Listed Building Consent if you live in a listed building, as the external appearance of inlet and extract vents is often protected.
- **Fit internal wall insulation.** This should be 100mm insulation that in most cases should be breathable. As a shallow measure this can be installed as a room-by-room basis. Care should be taken with any heritage features present (covings, picture rails, skirtings etc). A breathable installation can be spray applied if the walls are particularly uneven.
- If a knee wall (typically 1m high around the edge of a room in the roof) is present these are often uninsulated. These can be insulated between and behind the existing timber studs.
- **Eaves storage.** Often located in the knee walls, these are often uninsulated and draughty. A DIY approach can be taken with draught strips and sticking ridged insulation board to the back. Alternative off-the-shelf products are available.
- **Fit secondary glazing** (a secondary window, typically behind existing windows). This can significantly improve the thermal and acoustic performance of old single glazed windows. It can be installed on a room by room basis. It should be coordinated with the internal wall insulation.

Deep

- **Whole house insulation and secondary glazing.** Although a significant measure it will provide the greatest savings and increase in comfort. Installed as the shallow measures, but for the whole building.
- **External wall insulation** could be considered if interiors are particularly sensitive and/or there is low aesthetic or heritage impact.
- **High performance front door.** Shared stairwells are often unheated or have poor thermal performance. In this case the internal front door should be treated as external and therefore replaced with a higher performing model.
- **Mechanical ventilation with heat recovery.** In homes where duct runs are difficult, demand control ventilation is an alternative option. In conjunction, old passive ventilation measures should be sealed (trickle vents, kitchen, and bathroom extracts, etc). A recirculating extractor over the hob will be necessary to replace any existing direct extract.

Upgraded heating

- **Air source heat pump (ASHP).** You should install this after you have completed improvements to the fabric of the building (insulation and draught proofing). As described above, the radiators or similar may need upgrading. This can be about double the size of a gas boiler (around the size of a fridge freezer); therefore, a suitable location is needed.
- **Electric Boiler.** Electric boilers are designed to directly replace gas boilers. Upgrades to radiators and pipework are not typically needed. This may be practical where space is at a premium or heritage requirements mean the external unit of the ASHP is not permitted. As discussed elsewhere, an increase in fuel bills is likely.

Onsite renewables

- **Photovoltaic panels.** A 2-3kWp array can be installed at any time, but you should try and do this alongside other work that requires scaffolding. You will need access and permission to use shared roof or attic spaces, as well as planning permission, and lawful development certificates.

EnerPHit and Net Zero Carbon

To achieve the Passivhaus retrofit standard EnerPHit you will need the support of a Passivhaus certified designer.

- **Triple glazed windows and doors.** Triple glazing may be hard to install due to the heritage aspects of the building. However, there may be areas where this is possible and therefore recommended for the best performance and comfort.
- **Removal of chimney thermal bridge.** Chimneys will require extra attention to remove the thermal bridge and make fully airtight
- **Fastidious air tightness measures.** A number of extra measures with high quality control is required, eg: air tightness membrane in ceilings and floors; air tightness testing; parge coats (a thin coat of cement mortar) in hidden areas (between floor, behind stairs etc) and repairs to plasterwork; taping at junctions, windows and doors etc. Air changes per hour less than 1 at a pressure of 50 pascals.

House type B

Victorian terrace/ workers' cottage

Energy savings and scope




Age: **pre-1914**
Name: **Victorian terrace/workers' cottage**
Typical Size: **85m²**

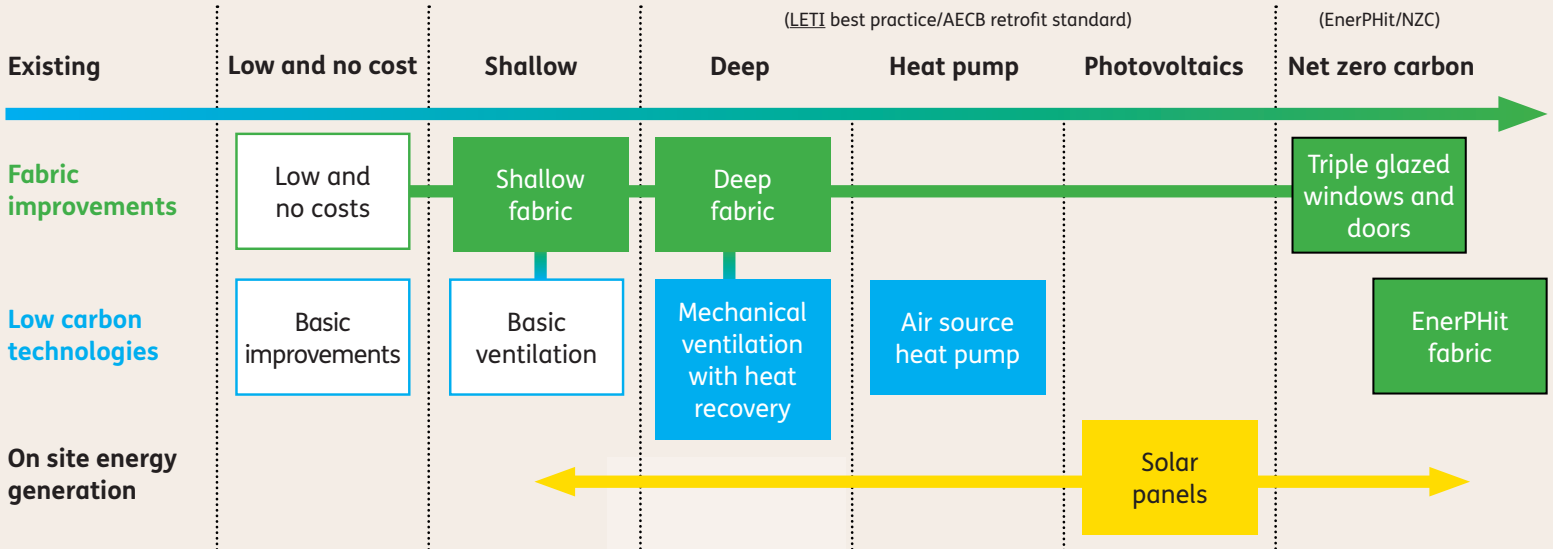
Description

This archetype covers Victorian workers' terraces and cottages.

Typical features

- **Solid masonry walls (generally brick)**
- **Suspended timber floor (uninsulated)**
- **Masonry load-bearing partition walls**
- **Lath and plaster or single brick partition walls**
- **Timber roof**
- **Loft floor typically insulated between joists**
- **Double glazed windows**
- **Gas boiler and radiators**
- **Open chimneys with generally unused fireplaces**

Phasing of retrofit work – Type B



Retrofit cost	£0	£2,500	£42,500	£62,500	£80,000	£91,000	£111,000	£ invested
Energy saving	0%	0-10%	36%	67%	80%	90%	100%	Percentage saved
Heating demand	**300**	**250**	**190**	**88**	**88***	**88***	**22.2**	**kWhr/m²/yr (heating)**
Carbon emissions	11	10	7	2.5	1.4	0.7	0	Tonnes CO_2/year
Annual bills	£2,200+	£2,000	£1,300	£950	£1,200**	£900	£170	£ per year

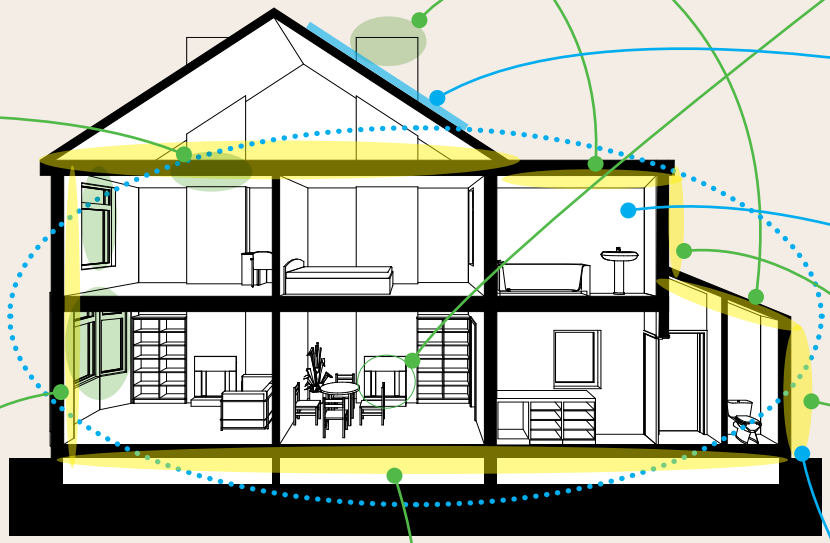
Bill estimates are based on early 2022 prices, so a rise is expected. It assumes homes heated to CBSI recommendations rather than national averages.

*the heating demand is efficiency of the buildings walls, floors, roofs and windows, therefore unaffected by low carbon technology

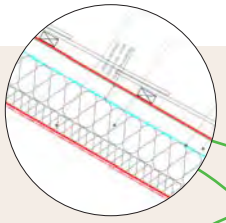
**bills rise with the switch from gas to more expensive electricity.

Typical measures and approximate costs

Thermal envelope
Active measure
Passive measure (fabric)



Topped up loft insulation
£5,400



Pitched roof insulation
£4,000

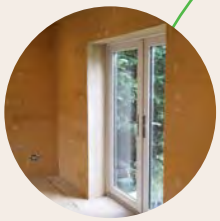
Chimney draught proofing
£800

High performance loft hatch
£1,000

Solar panels
£12,900

Triple glazed windows and external doors
£23,100

Mechanical ventilation
£10,200



Internal wall insulation
£12,200

External wall insulation
£23,500

Draught free
£5,700

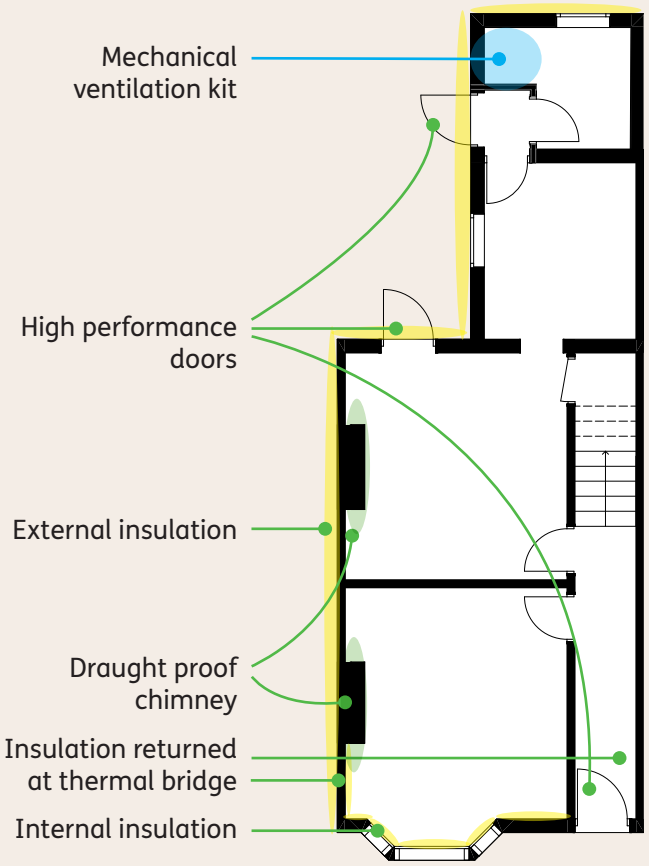
Floor insulation
£6,500

Low carbon heating
£23,900

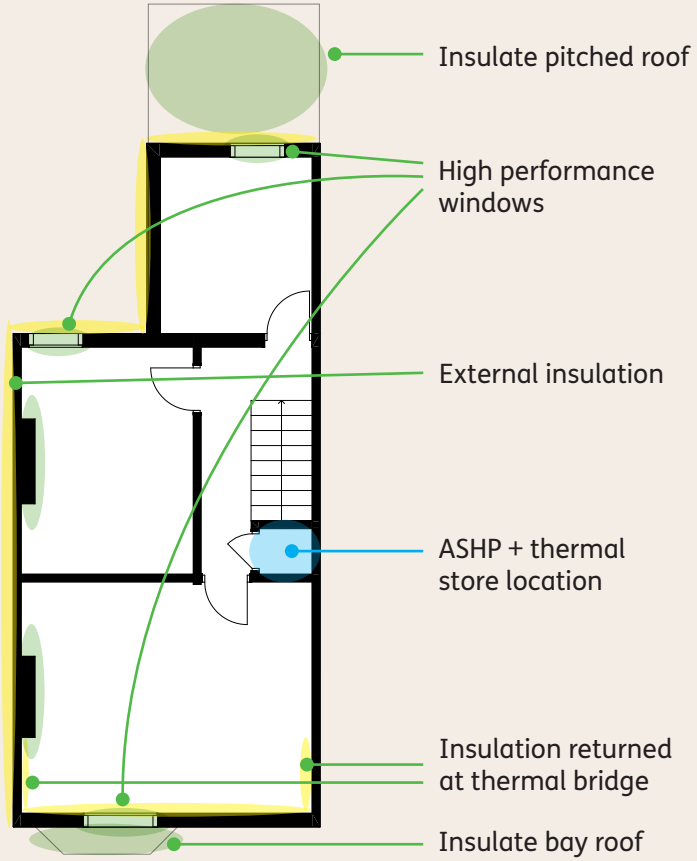
Typical measures

Thermal envelope
Active measure
Passive measure (fabric)

Ground floor



First floor



Retrofit measures

Low-cost measures

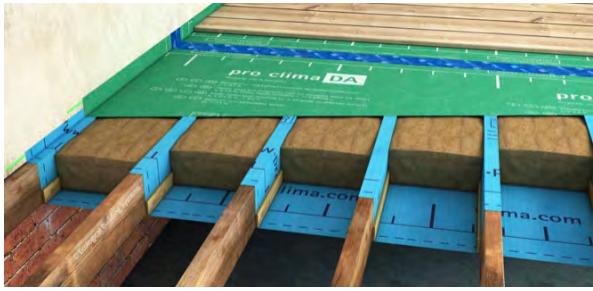
- Ensure thermostat is at recommended levels or according to your health needs.
- Fit low energy lighting and appliances.
- Fit draught strips to windows and doors.
- Seal cracks, holes and service penetrations.
- Extractor fans to bathrooms and kitchens.
- Seal gaps around old-fire places.
- Draught-seal chimney fireplaces.
- Fit improved heating controls.
- Make DIY improvements to loft and storage hatches.
- Lag pipes.
- Test air tightness to find leakage pathways.
- Use thermal imaging to find weak spots.

Shallow

- **Insulate and re-roof your bay window roof** (if present and in poor repair).
- **Top-up loft insulation** with an additional 200mm over the existing 100mm to make 300mm in total.
- **Install mechanical extraction** from kitchens and bathrooms (unless whole house ventilation is planned for later phases).
- **Demand control ventilation (DCV)** can be an affordable option, although MVHR (mechanical ventilation with heat recovery) offers higher performance and air quality. You will need Listed Building Consent if you live in a listed building, as the external appearance of inlet and extract vents is often protected.
- **Fit internal wall insulation**. This should be 100mm insulation that in most cases should be breathable. Care should be taken with any heritage features present (covings, picture rails, skirtings etc).

Deep

- External phenolic insulation and render to rear/side façade (0.1/0.125 W/m²k).
- Provision of whole house mechanical ventilation (mechanical ventilation with heat recovery or demand control ventilation).
- Passivhaus standard loft hatch to roof space.
- Thermal bridge reduction measures.
- Air tightness measures to achieve less than 3 air changes per hour at a pressure of 50 pascals.



Upgraded heating

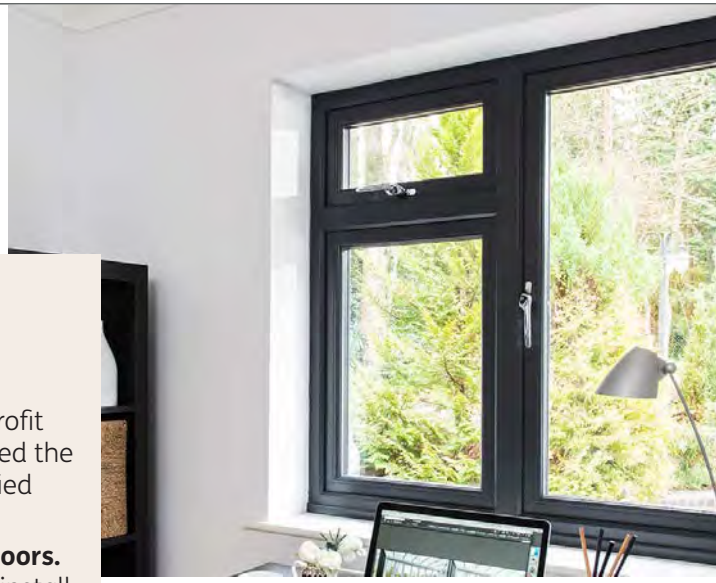
- **Air source heat pump.** You should install this after you have completed improvements to the fabric of the building (insulation and draught proofing). As described above, the radiators or similar may need upgrading. This can be about double the size of a gas boiler (around the size of a fridge freezer) plus an outdoor unit; therefore, suitable locations are needed. As discussed elsewhere, an increase in fuel bills is likely.

Onsite renewables

- **Photovoltaic panels.** A 2.5–5kWp array can be installed at any time, but you should try and do this alongside other work that requires scaffolding. You will need access and permission to use shared roof or attic spaces, as well as planning permission, and lawful development certificates.

EnerPHit and Net Zero Carbon

- To achieve the Passivhaus retrofit standard EnerPHit you will need the support of a Passivhaus certified designer.
- **Triple glazed windows and doors.** Triple glazing may be hard to install due to the heritage aspects of the building. However, there may be areas where this is possible and therefore recommended for the best performance and comfort.
- **Removal of chimney thermal bridge.** Chimneys will require extra attention to remove the thermal bridge and make fully airtight. This is typically done by removing the chimney at the loft insulation line.
- **Fastidious air tightness measures.** A number of extra measures with high quality control is required, eg: air tightness membrane in ceilings and floors; air tightness testing; parge coats (a thin coat of cement mortar) in hidden areas (between floor, behind stairs etc) and repairs to plasterwork; taping at junctions, windows and doors etc. Air changes per hour less than 1 at a pressure of 50 pascals.



House type C

Small semi-detached

Energy savings and scope

Age: **1920-1950**
Name: **Small semi-detached**
Typical Size: **85m²**

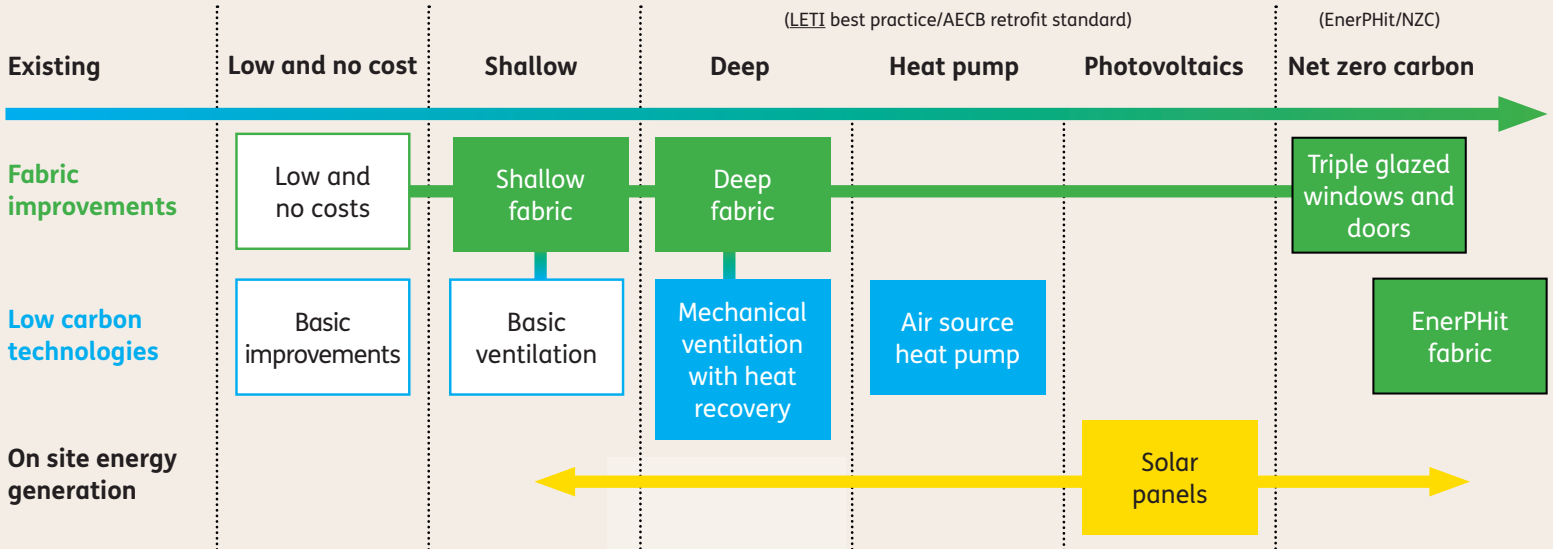
Description

This archetype covers 1930s semi-detached homes

Typical features

- **Solid masonry walls (generally brick)**
- **Suspended timber floor (uninsulated)**
- **Masonry load-bearing partition walls**
- **Timber stud and plasterboard partition walls**
- **Hipped timber roof**
- **Loft floor typically insulated between joists**
- **Air brick ventilation**
- **Gas boiler and central heating**
- **Double glazed windows**
- **Open chimneys with generally unused fireplaces**

Phasing of retrofit work – Type C



Retrofit cost	£0	£3,800	£25,500	£60,500	£78,000	£86,000	£103,000	£ invested
Energy saving	0%	0-4%	10%	74%	85%	90%	95%	Percentage saved
Heating demand	**268**	**259**	**244**	**44**	**44***	**44***	**17**	**kWhr/m²/yr (heating)**
Carbon emissions	9	8.5	8	1.5	0.9	0.6	0.3	Tonnes CO_2/year
Annual bills	£2400+	£2300	£2200	£1200	£1150**	£830	£490	£ per year

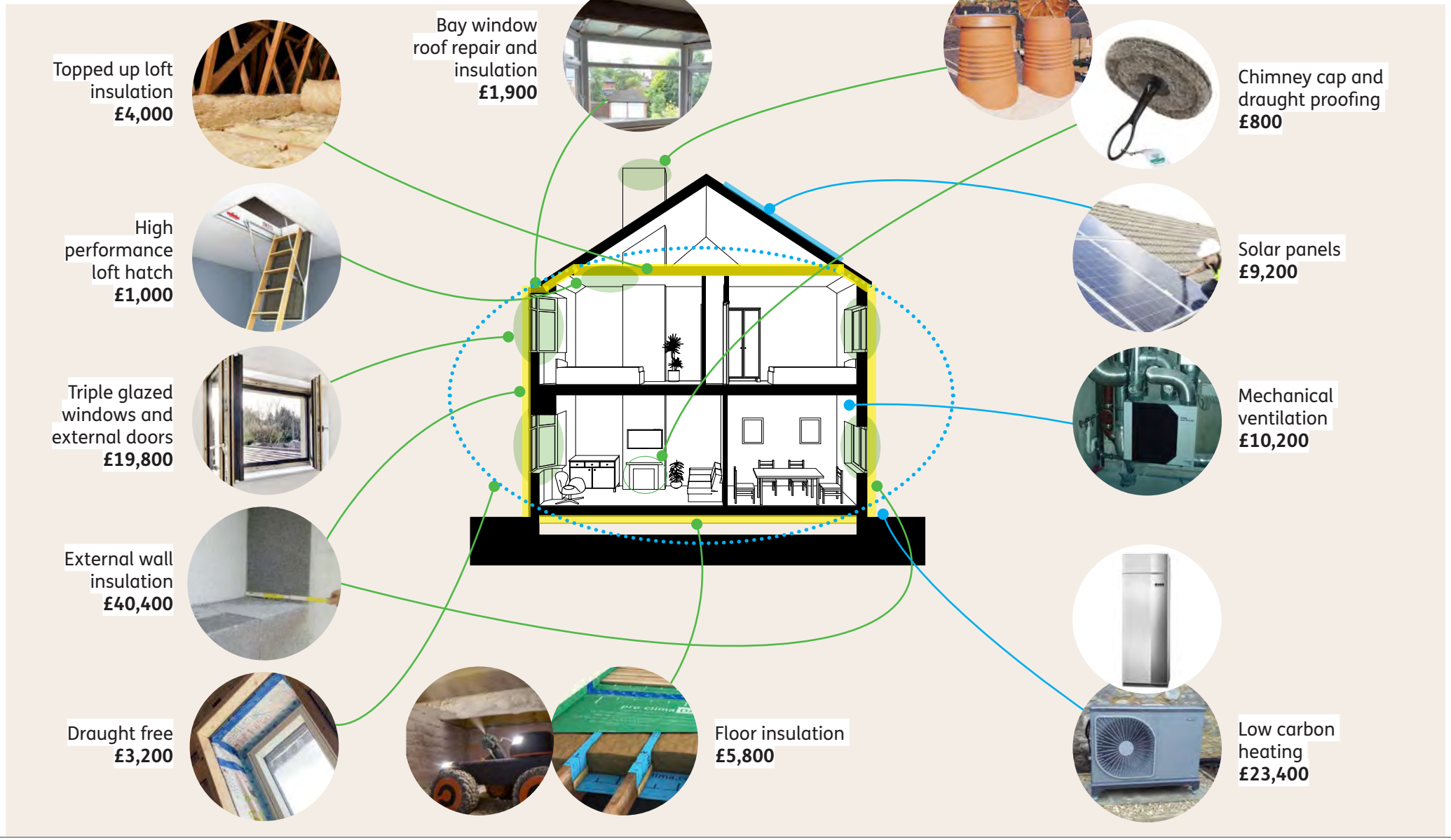
Bill estimates are based on early 2022 prices, so a rise is expected. It assumes homes heated to CBSI recommendations rather than national averages.

*the heating demand is efficiency of the buildings walls, floors, roofs and windows, therefore unaffected by low carbon technology

**bills rise with the switch from gas to more expensive electricity.

Typical measures and approximate costs

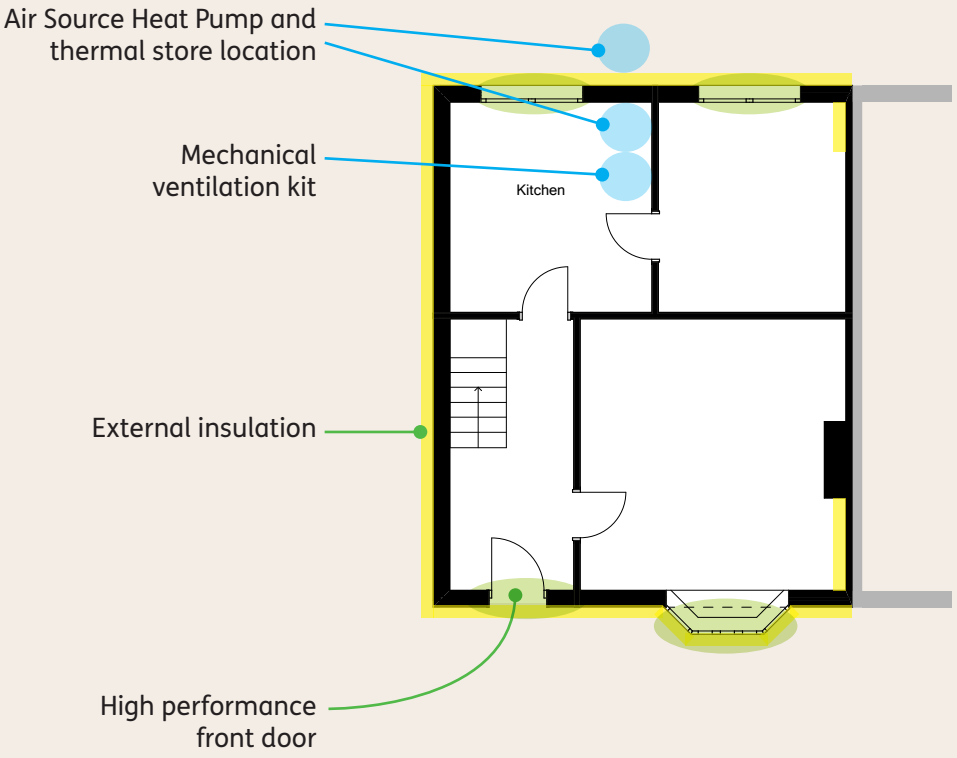
Thermal envelope
Active measure
Passive measure (fabric)



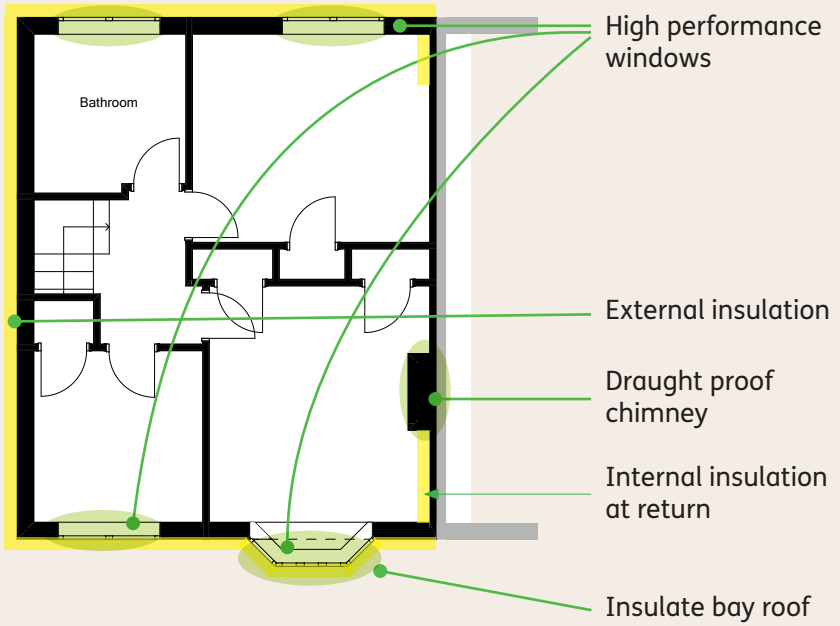
Typical measures

Thermal envelope
Active measure
Passive measure (fabric)

Ground floor



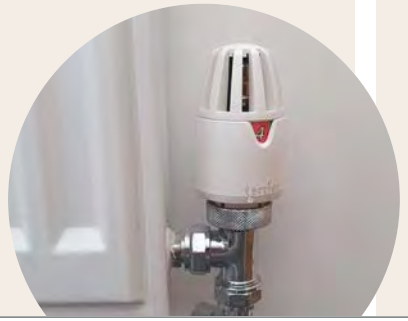
First floor



Retrofit measures

Low-cost measures

- Ensure thermostat is at recommended levels or according to your health needs.
- Fit low energy lighting and appliances.
- Fit draught strips to windows and doors.
- Seal cracks, holes and service penetrations.
- Extractor fans to bathrooms and kitchens.
- Seal gaps around old-fire places.
- Draught-seal chimney fireplaces.
- Fit improved heating controls.
- Make DIY improvements to loft and storage hatches.
- Lag pipes.
- Test air tightness to find leakage pathways.
- Use thermal imaging to find weak spots.

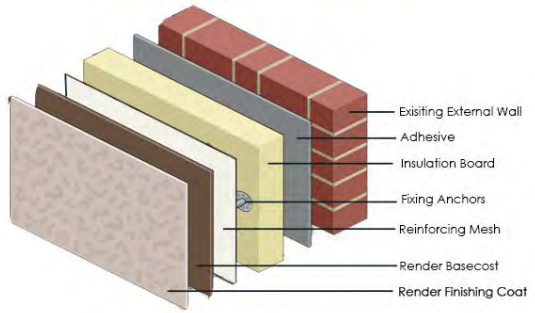


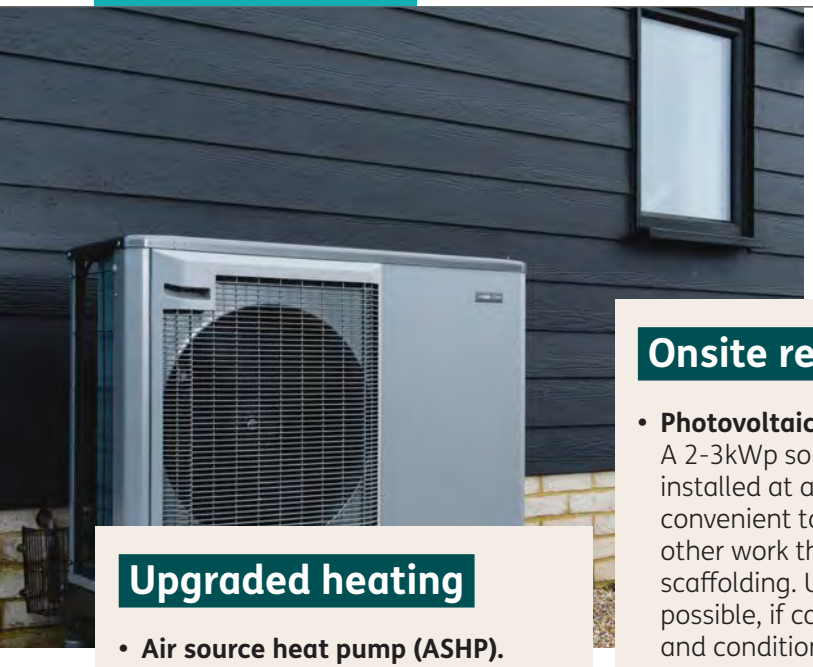
Shallow

- **Robotically sprayed insulation** (125mm) to suspended timber floor insulation.
- **Insulate and re-roof your bay window roof** (if present and in poor repair).
- **Top-up loft insulation.** An additional 200mm over the existing 100mm to make 300mm in total.
- **High performance loft hatch.** This is often a weak spot in a well-insulated loft room. Fit a proprietary high-performance hatch if aiming for a deep retrofit.
- **Mechanical extraction** from kitchens and bathrooms (unless whole house mechanical planned).
- **Demand control ventilation (DCV)** can be a very viable system as existing air bricks in rooms can be re-purposed. This should not be installed and mechanical ventilation with heat recovery installed instead if highest performance and air quality is desired.

Deep

- **200mm external wall insulation.** Although a significant measure, this provides the greatest carbon savings.
- **High performance front door.** Even if double glazing is installed, front doors are often original and can be very poorly performing.
- Installation of mechanical ventilation with heat recovery.





Upgraded heating

- **Air source heat pump (ASHP).** You should install this after you have completed improvements to the fabric of the building (insulation and draught proofing). As described above, the radiators or similar may need upgrading. This can be about double the size of a gas boiler (around the size of a fridge freezer) plus an outdoor unit; therefore, suitable locations are needed. As discussed elsewhere, an increase in fuel bills is likely.

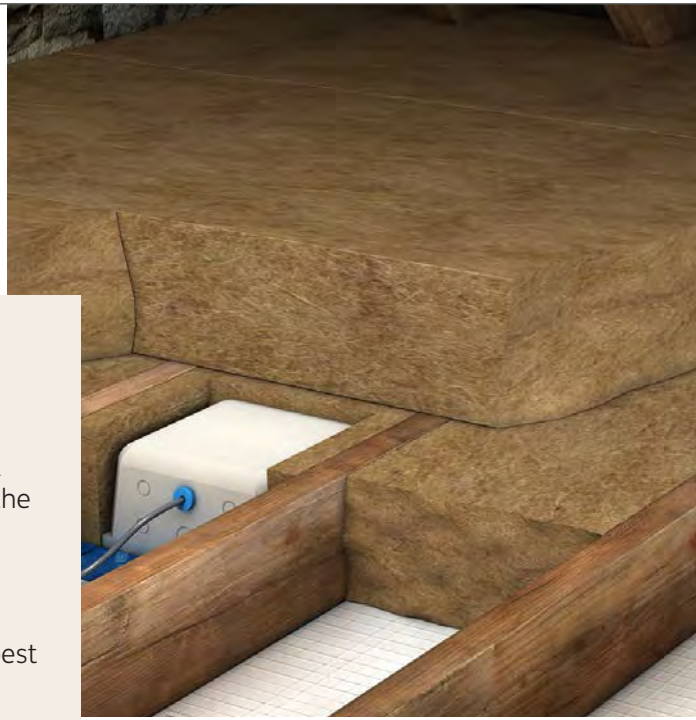
Onsite renewables

- **Photovoltaic panels.** A 2-3kWp solar array can be installed at any time, but is most convenient to install alongside other work that involves scaffolding. Up to 5kWp may be possible, if carefully designed and conditions allow.

EnerPHit and Net Zero Carbon

To achieve the Passivhaus retrofit standard EnerPHit you will need the support of a Passivhaus certified designer.

- **Triple glazed windows and doors.** Recommended for the best performance and comfort.
- **Removal of chimney thermal bridge.** Chimneys will require extra attention to remove the thermal bridge and make fully airtight. This is typically done by removing the chimney at the loft insulation line.
- **Fastidious air tightness measures.** A number of extra measures with high quality control is required, eg: air tightness membrane in ceilings and floors; air tightness testing; parge coats (a thin coat of cement mortar) in hidden areas (between floor, behind stairs etc) and repairs to plasterwork; taping at junctions, windows and doors etc. Air changes per hour less than 1 at a pressure of 50 pascals.



House type D

Large semi-detached

Energy savings and scope




Age:**1945-1959**
Name: **Large semi-detached**
Typical Size: **150m²**

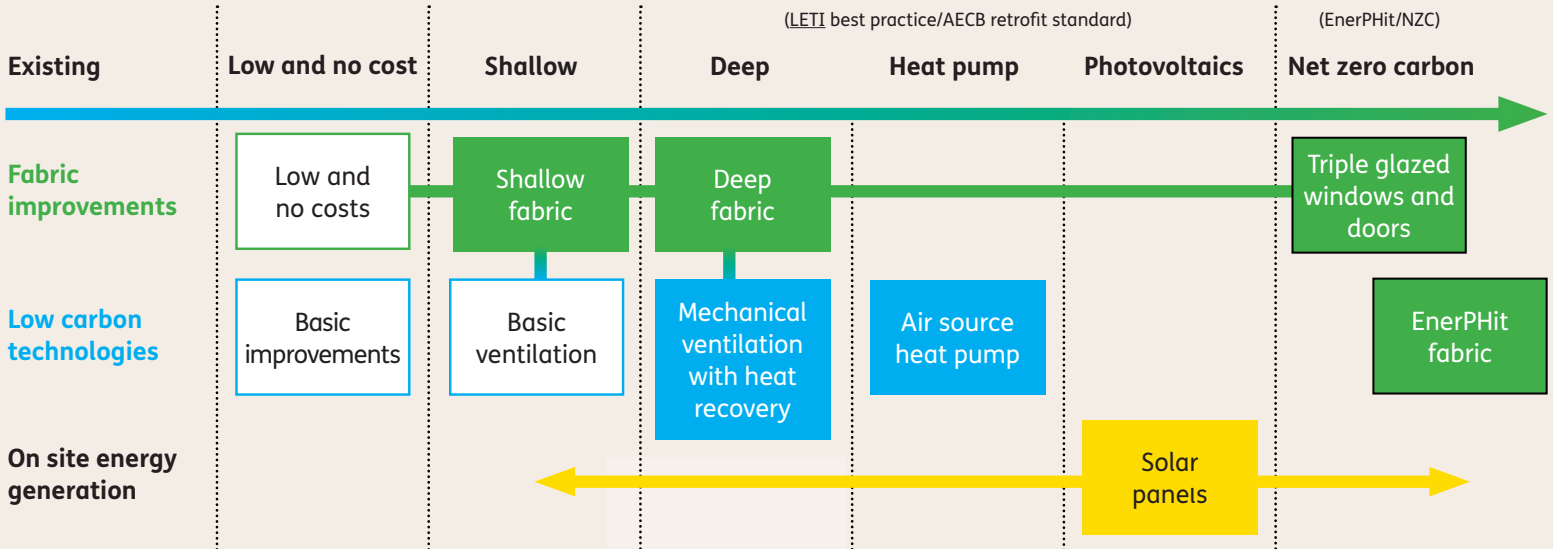
Description

This archetype covers post-WWII low-rise housing. Type C and D differ in size and style. These homes occasionally have arts and craft stylings

Typical features

- **Solid masonry walls or narrow uninsulated cavity (generally brick)**
- **Suspended timber floor (uninsulated)**
- **Masonry load-bearing partition walls**
- **Timber stud and plasterboard partition walls**
- **Hipped timber roof**
- **Loft floor typically insulated between joists**
- **Air brick ventilation**
- **Gas boiler and central heating**
- **Double glazed windows**
- **Open chimneys with generally unused fireplaces**

Phasing of retrofit work – Type D



Retrofit cost***	£0	£5,300	£31,500	£106,000	£124,000	£137,000	£171,000	£ invested
Energy saving	0%	0-8%	50%	77%	86%	92%	99%	Percentage saved
Heating demand	**272**	**260**	**244**	**47**	**47***	**47***	**15**	**kWhr/m²/yr (heating)**
Carbon emissions	15	14	7.7	2.5	1.4	0.7	0	Tonnes CO_2/year
Annual bills	£3200+	£2300	£2200	£1300	£1800**	£950	£250	£ per year

Bill estimates are based on early 2022 prices, so a rise is expected. It assumes homes heated to CBSI recommendations rather than national averages.

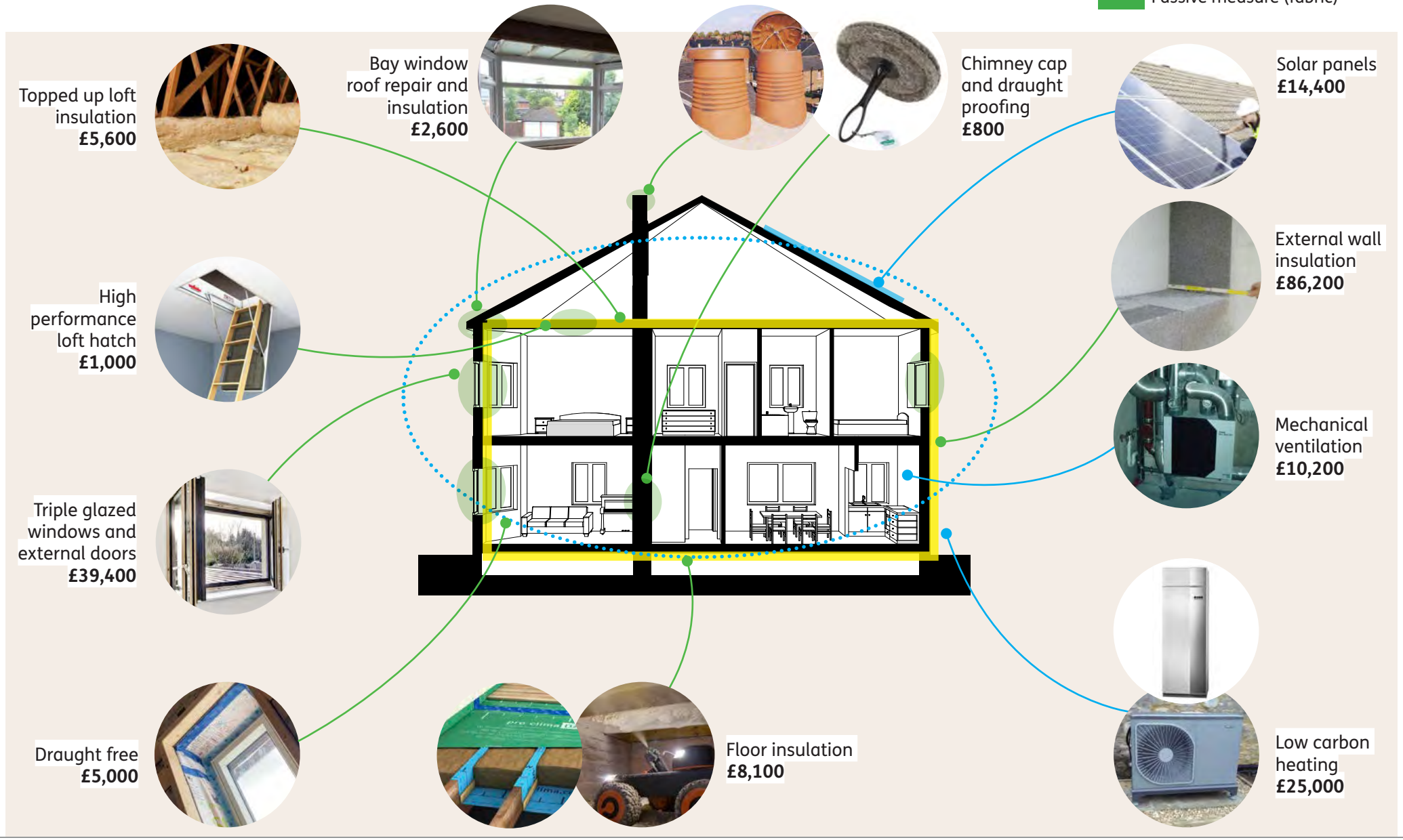
*the heating demand is efficiency of the buildings walls, floors, roofs and windows, therefore unaffected by low carbon technology

**bills rise with the switch from gas to more expensive electricity.

*** the high cost is due to the large size of this archetype. See discussion below for clarification.

Typical measures and approximate costs

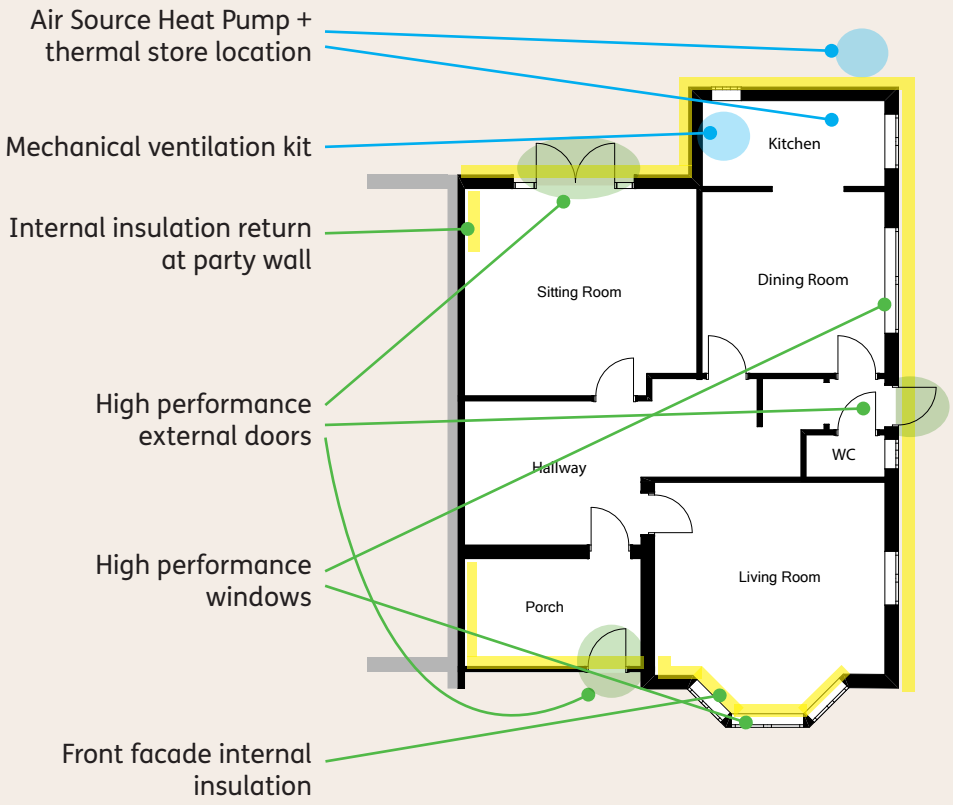
Thermal envelope
Active measure
Passive measure (fabric)



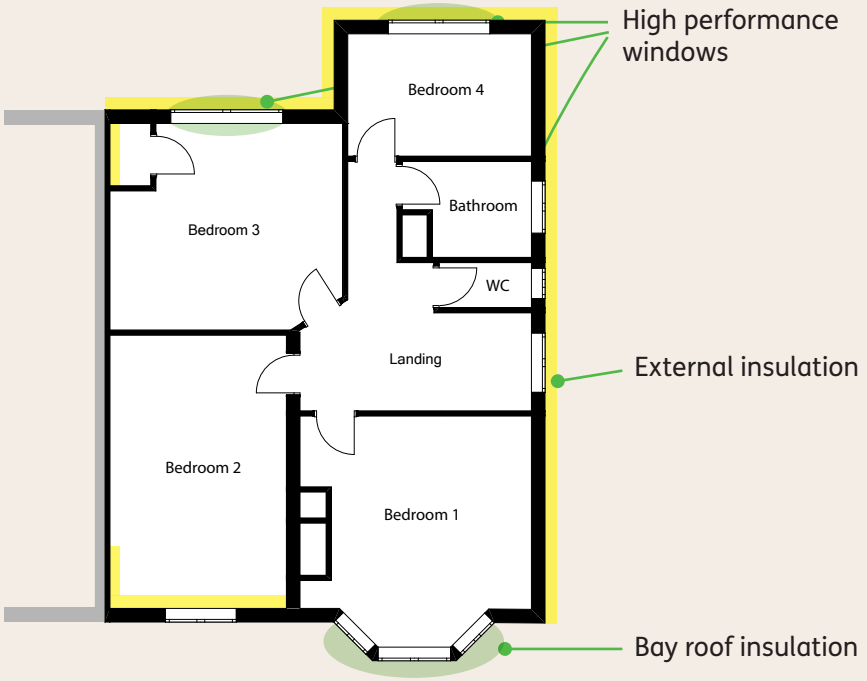
Typical measures

Thermal envelope
Active measure
Passive measure (fabric)

Ground floor



First floor



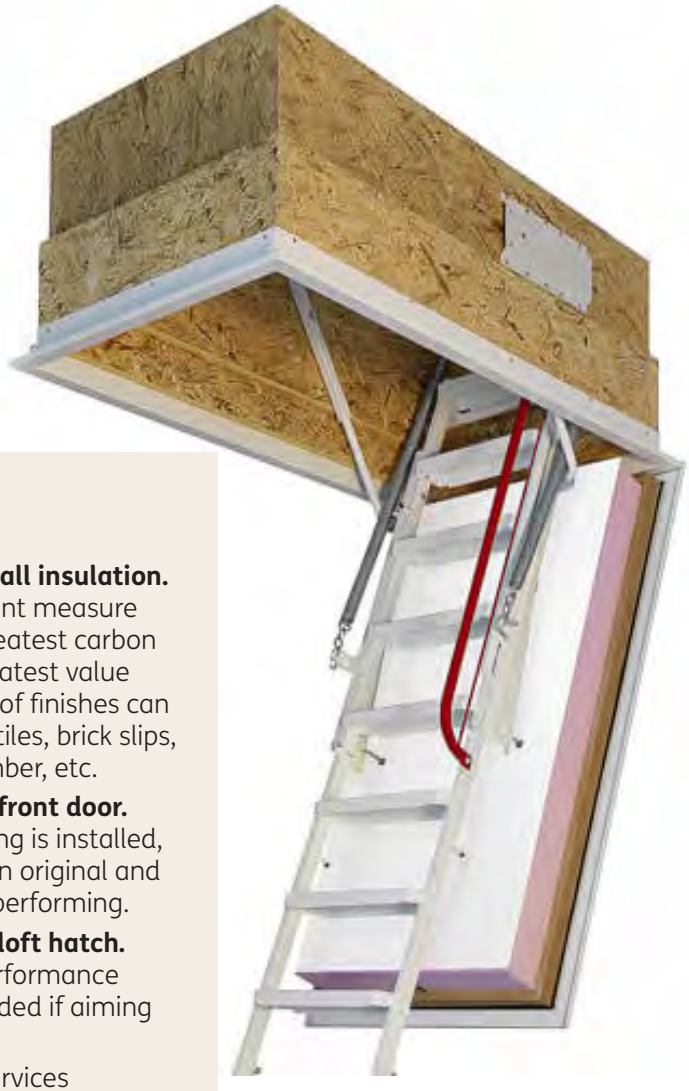
Retrofit measures

Low-cost measures

- Ensure thermostat is at recommended levels or according to your health needs.
- Fit low energy lighting and appliances.
- Fit draught strips to windows and doors.
- Seal cracks, holes and service penetrations.
- Extractor fans to bathrooms and kitchens.
- Seal gaps around old-fire places.
- Draught-seal chimney fireplaces.
- Fit improved heating controls.
- Make DIY improvements to loft and storage hatches.
- Lag pipes.
- Test air tightness to find leakage pathways.
- Use thermal imaging to find weak spots.

Shallow

- **Robotically sprayed insulation.** (125mm) to suspended timber floor insulation.
- **Cavity wall insulation.** Where possible this should be installed as it represents a high value saving.
- **Insulate and re-roof your bay window roof.** (If present and in poor repair) then it should be reroofed and insulated.
- **Top-up loft insulation.** An additional 200mm over the existing 100mm to make 300mm in total.
- **DIY loft hatch.** Often a weak spot in a well-insulated loft room.
- **Mechanical extraction** from kitchens and bathrooms (whole house mechanical ventilation is planned).
- **Demand control ventilation (DCV)** can be a very viable system as existing air bricks in rooms can be re-purposed. This should not be installed and mechanical ventilation with heat recovery installed instead if highest performance and air quality is desired.



Deep

- **200mm external wall insulation.** Although a significant measure this provides the greatest carbon savings and the greatest value for money. A range of finishes can match the existing tiles, brick slips, render, and half-timber, etc.
- **High performance front door.** Even if double glazing is installed, front doors are often original and can be very poorly performing.
- **High performance loft hatch.** A propriety high-performance hatch is recommended if aiming for a deep retrofit.
- **Air tightness.** All services sealed, windows and cracks sealed and taped.
- **Installation of mechanical ventilation** with heat recovery.

Upgraded heating

- **Air source heat pump (ASHP).** You should install this after you have completed improvements to the fabric of the building (insulation and draught proofing). As described above, the radiators or similar may need upgrading. This can be about double the size of a gas boiler (around the size of a fridge freezer) plus an outdoor unit; therefore, suitable locations are needed. As discussed elsewhere, an increase in fuel bills is likely. On large homes like this, three-phase power may be required for a large heat pump.

Onsite renewables

- **Photovoltaic panels.** A 2-4kWp solar array can be installed at any time but you should aim to do this alongside other work that involves scaffolding if possible.
- The relatively large roof size means that up to 8kWp may be possible, if carefully designed and conditions allow.

EnerPHit and Net Zero Carbon

- To achieve the Passivhaus retrofit standard EnerPHit you will need the support of a Passivhaus certified designer.
- **Triple glazed windows and doors.** Recommended for the best performance and comfort.
- **Removal of chimney thermal bridge.** Chimneys will require extra attention to remove the thermal bridge and make fully airtight.
- **Fastidious air tightness measures.** A number of extra measures with high quality control is required, eg: air tightness membrane in ceilings and floors; air tightness testing; parge coats (a thin coat of cement mortar) in hidden areas (between floor, behind stairs etc) and repairs to plasterwork; taping at junctions, windows and doors etc. Air changes per hour less than 1 at a pressure of 50 pascals.

House type E

Mid-century ‘modern’

Energy savings and scope




Age: **1960-1979**
Name: **Mid-century ‘modern’**
Typical Size: **95m²**

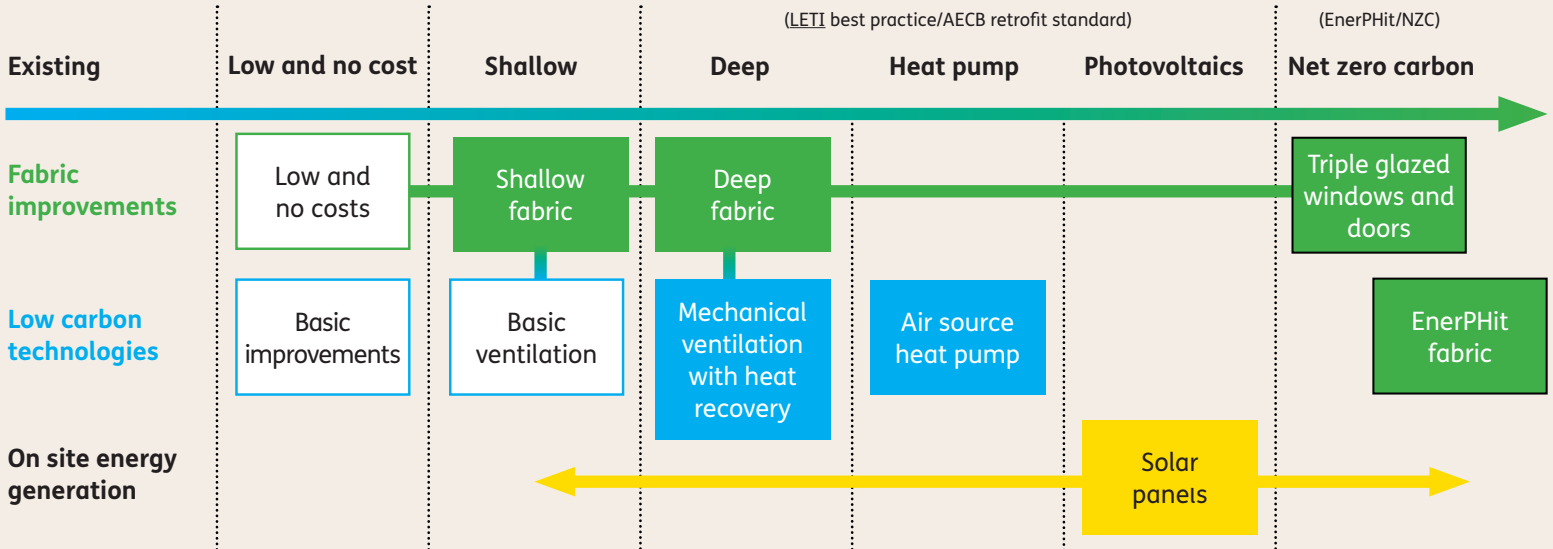
Description

Horizontal windows and banding. Often with timber clad elements. Flat roof elements. Garages often linked to the house. Lower pitched roofs apart from the chalet bungalow.

Typical features

- **Cavity masonry walls with narrow cavity (rendered, fair faced brick or timber panelled) internal leaf typically aerated blockwork**
- **Solid concrete floor (uninsulated)**
- **Masonry load-bearing partition walls**
- **Stud work partitions with plasterboard**
- **Timber truss roof**
- **Loft floor with limited insulation**
- **Open fires largely phased out but some gas fires**
- **Metal, timber, or plastic windows either single or double glazed**

Phasing of retrofit work – Type E



Retrofit cost	£0	£4,750	£42,500	£79,000	£97,500	£105,500	£128,500	£ invested
Energy saving	0%	0-8%	43%	64%	79%	89%	99%	Percentage saved
Heating demand	**230**	**200**	**110**	**59**	**59***	**59***	**18**	**kWhr/m²/yr (heating)**
Carbon emissions	8.5	7.5	4.8	2.0	1.2	0.6	0.01	Tonnes CO_2/year
Annual bills	£2000+	£1800	£1500	£1200	£1500**	£890	£250	£ per year

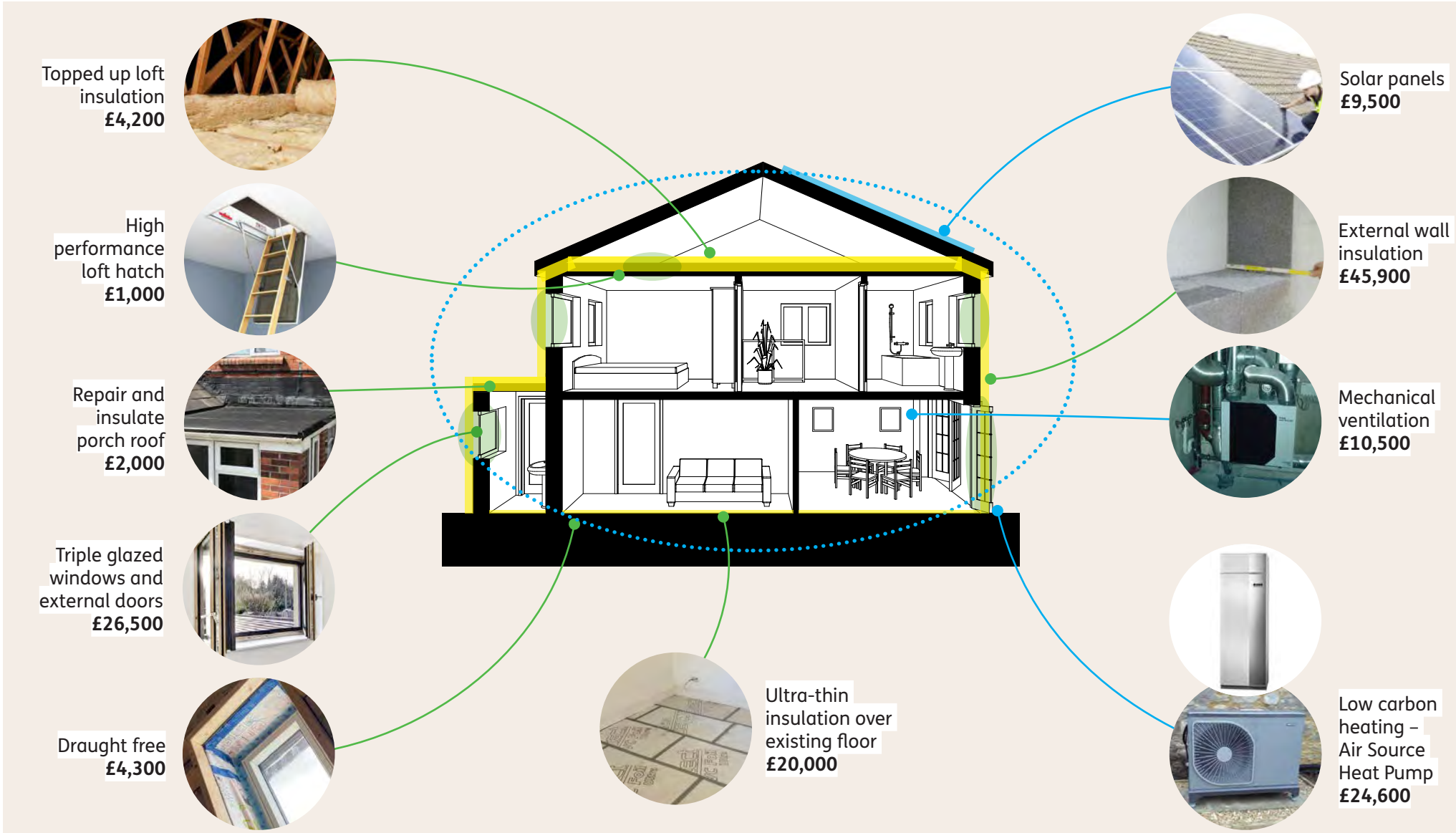
Bill estimates are based on early 2022 prices, so a rise is expected. It assumes homes heated to CBSI recommendations rather than national averages.

*the heating demand is efficiency of the buildings walls, floors, roofs and windows, therefore unaffected by low carbon technology

**bills rise with the switch from gas to more expensive electricity.

Typical measures and approximate costs

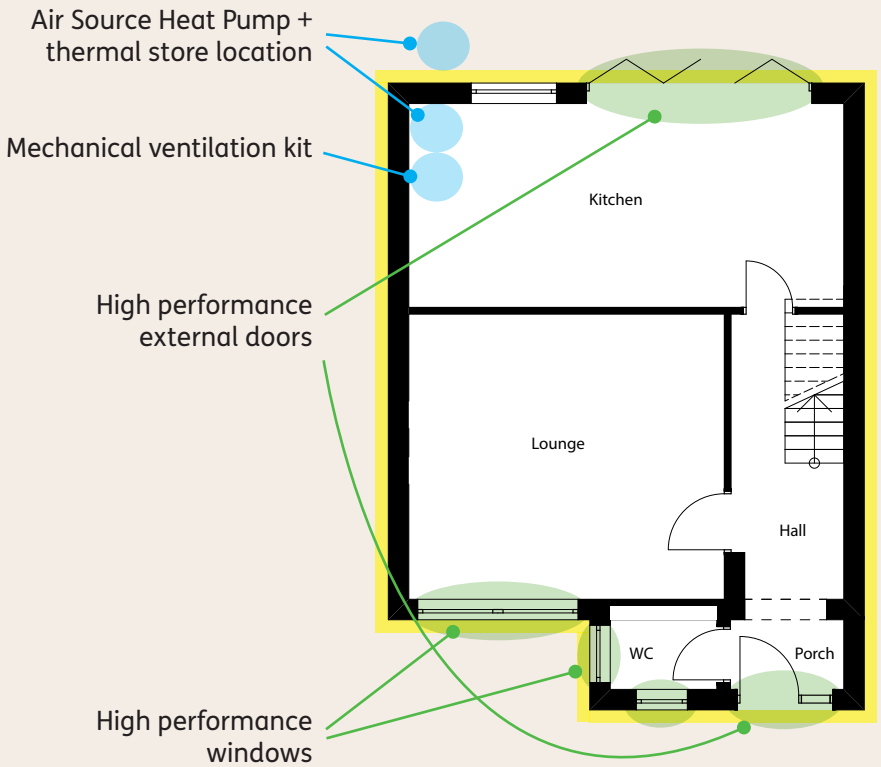
Thermal envelope
Active measure
Passive measure (fabric)



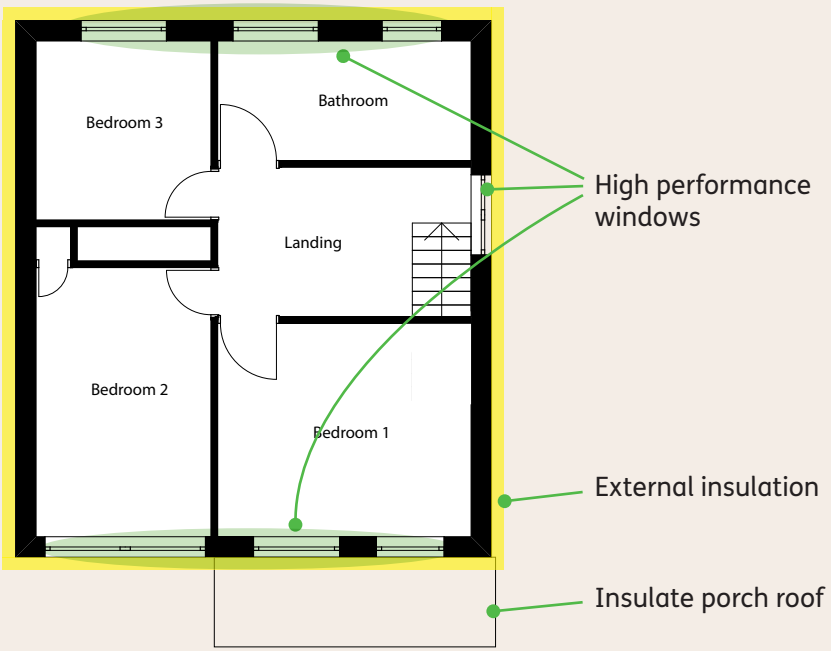
Typical measures

Thermal envelope
Active measure
Passive measure (fabric)

Ground floor



First floor



Retrofit measures

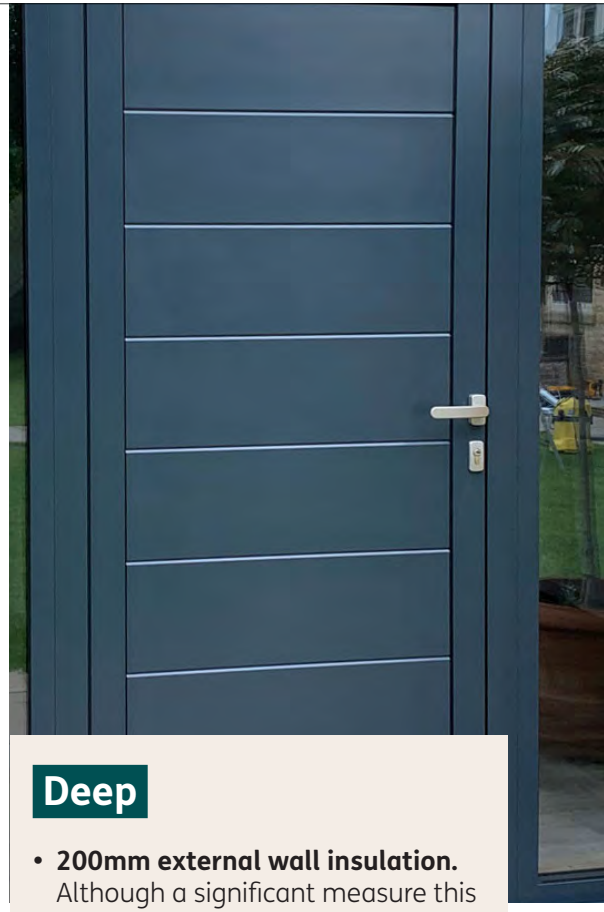
Low-cost measures

- Ensure thermostat is at recommended levels or according to your health needs.
- Fit low energy lighting and appliances.
- Fit draught strips to windows and doors.
- Seal cracks, holes and service penetrations.
- Extractor fans to bathrooms and kitchens.
- Seal gaps around old-fire places – if present.
- Draught-seal chimney fireplaces – if present.
- Fit improved heating controls.
- Make DIY improvements to loft and storage hatches.
- Lag pipes.
- Test air tightness to find leakage pathways.
- Use thermal imaging to find weak spots.

Shallow

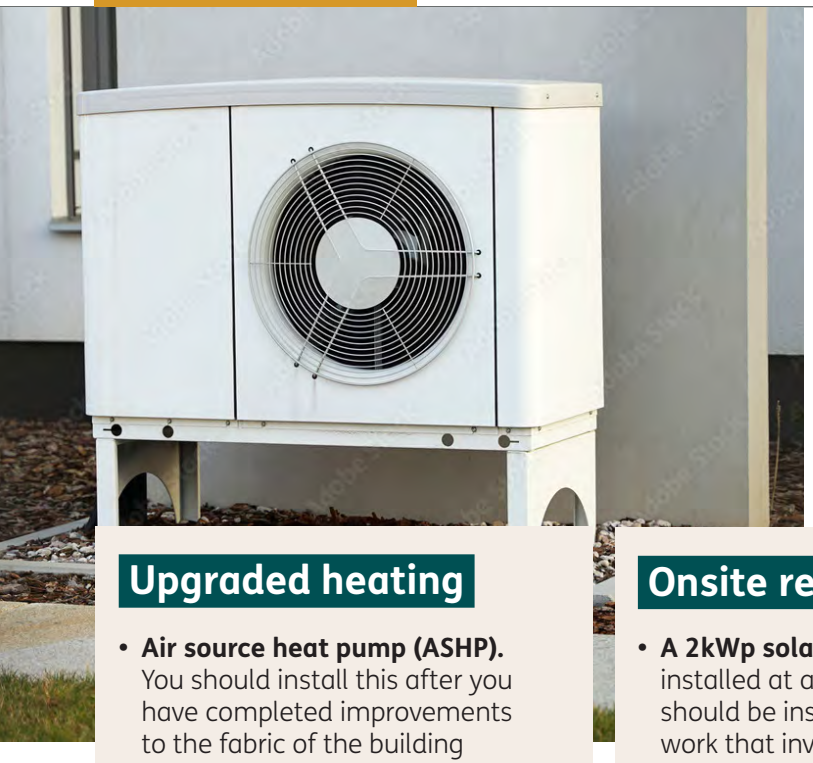
- **Insulated and re-roofed porch roof.** These roofs are often in poor repair so should be reroofed and insulated (100mm). In the event the roof is in sound condition the roof may be insulated from below. Please note, if the porch is not heated and separated by a good quality external door this measure may not be required. See the options outlined earlier in the report.
- **Top-up loft insulation.** An additional 200mm over the existing insulation.
- **High performance loft hatch.** Often a weak spot in a well-insulated loft room.
- **Mechanical extraction** from kitchens and bathrooms (unless whole house mechanical ventilation is planned).
- **Demand control ventilation (DCV)** can be a very viable system as existing air bricks in rooms can be re-purposed. This should not be installed and mechanical ventilation with heat recovery installed instead if highest performance and air quality is desired.

- If the floor is concrete beam and block, then **robotically sprayed insulation** is a low disturbance method providing good insulation and air tightness. The size of the floor void is critical for the viability and a hole(s) will be required for the robot to gain access.
- **Air tightness.** Easy to treat leakage pathways sealed.



Deep

- **200mm external wall insulation.** Although a significant measure this provides the greatest carbon saving. This is typically rendered as a finish but can also be clad in timber, brick slips and other options.
- **High performance front door.** Even if double glazed windows are installed, front doors are often original and can be very poorly performing.
- **Air tightness measures.** All services sealed, windows and cracks sealed and taped.
- **Installation of mechanical ventilation** with heat recovery.



Upgraded heating

- **Air source heat pump (ASHP).** You should install this after you have completed improvements to the fabric of the building (insulation and draught proofing). As described above, the radiators or similar may need upgrading. This can be about double the size of a gas boiler (around the size of a fridge freezer) plus an outdoor unit; therefore, suitable locations are needed. As discussed elsewhere, an increase in fuel bills is likely.

Onsite renewables

- **A 2kWp solar array** can be installed at any time but if possible should be installed alongside other work that involves scaffolding.
- The relatively large roof size means that up to 5kWp may be possible, if carefully designed and conditions allow. Such a large system may be needed to meet or approach zero carbon.

EnerPHit and Net Zero Carbon

To achieve the Passivhaus retrofit standard EnerPHit you will need the support of a Passivhaus certified designer.

- **Triple glazed windows and doors** are recommended for the best performance and comfort.
- **Removal of chimney thermal bridge.** Chimneys will require extra attention to remove the thermal bridge and make fully airtight. This is typically done by removing the chimney at the loft insulation line.
- **Fastidious air tightness measures.** A number of extra measures with high quality control is required, eg: air tightness membrane in ceilings and floors; air tightness testing; parge coats (a thin coat of cement mortar) in hidden areas (between floor, behind stairs etc) and repairs to plasterwork; taping at junctions, windows and doors etc. Air changes per hour less than 1 at a pressure of 50 pascals.

House type F

End of century mass house builder

Energy savings and scope

Age: **1980–1999**

Name: **End of century mass house builder**

Typical Size: **65m²**

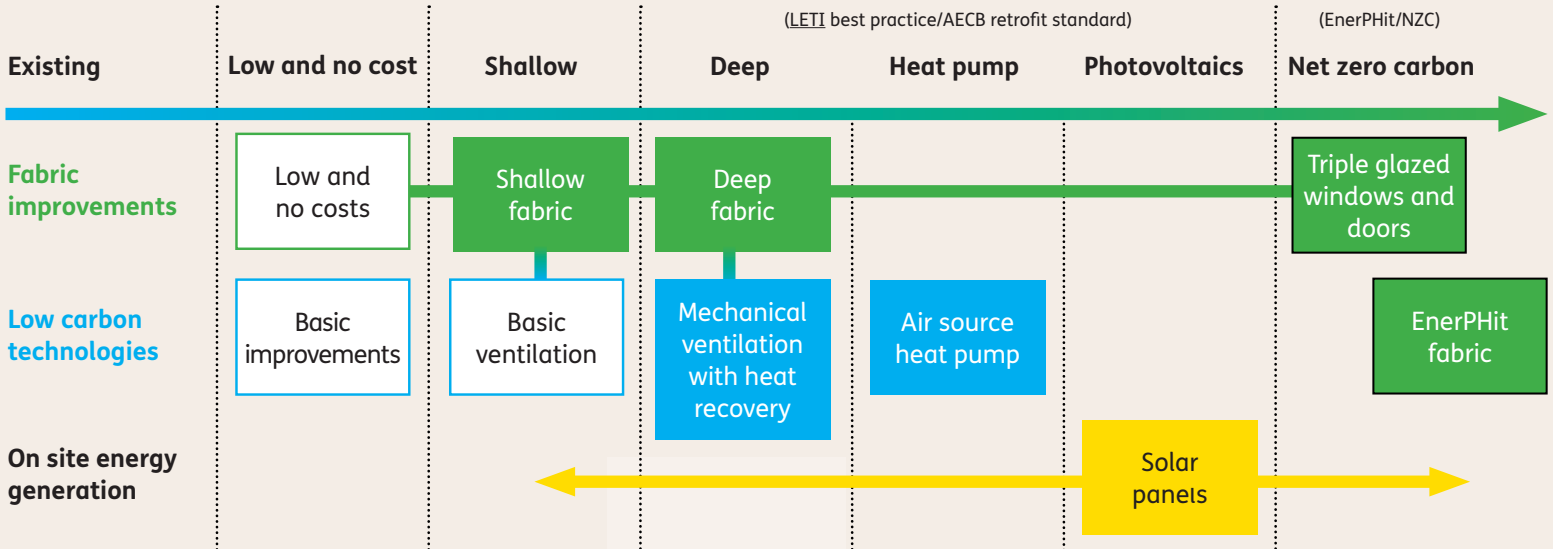
Description

This archetype covers early mass house-builder properties from 1980-2000. Often with dropped eaves. Generally brick with some rendered elements. Some pastiche elements influenced by Poundbury trends.

Typical features

- **Cavity masonry walls cavity either partially filled or unfilled with an inner leaf of aerated concrete block**
- **Dot and dab plaster board**
- **Solid concrete floor or beam and block**
- **Masonry load-bearing partition walls**
- **Studwork partition with plasterboard**
- **Timber truss roof**
- **Loft floor typically insulated**
- **Gas boiler with water tank**
- **Trickle-vents in all windows**
- **Extractor fan in bathrooms and windows**
- **uPVC but also some timber and metal double glazed windows**

Phasing of retrofit work – Type F



Retrofit cost	£0	£3,700	£23,500	£58,500	£77,500	£85,000	£98,500	£ invested
Energy saving	0%	0-10%	21%	55%	75%	96%	105%	Percentage saved
Heating demand	**210**	**200**	**154**	**57**	**57***	**57***	**27**	**kWhr/m²/yr (heating)**
Carbon emissions	5.6	5.1	4.4	1.7	0.9	0.15	-0.2	Tonnes CO_2/year
Annual bills	£1700	£1600	£1400	£1000	£1200**	£350	-£30	£ per year

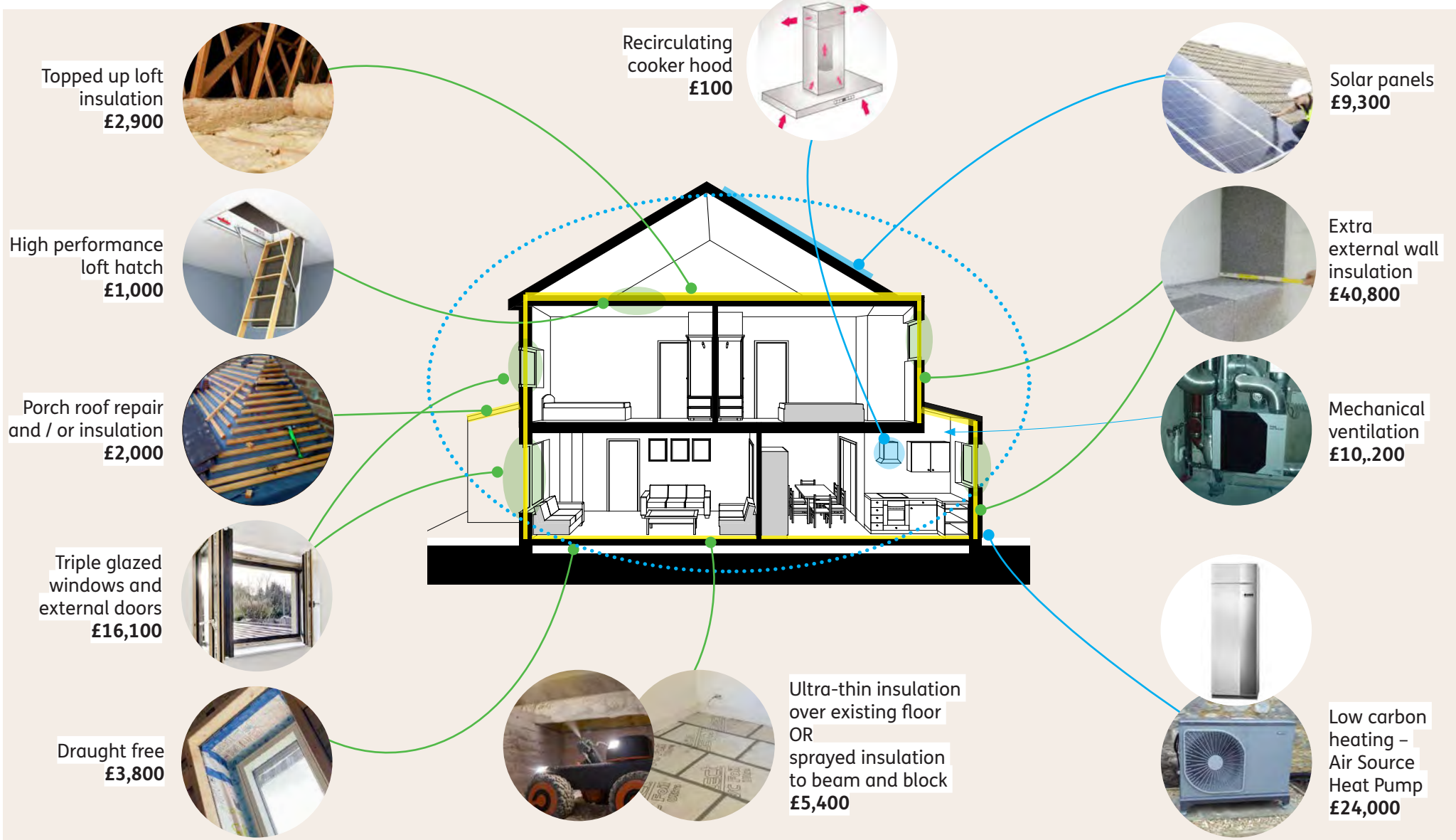
Bill estimates are based on early 2022 prices, so a rise is expected. It assumes homes heated to CBSI recommendations rather than national averages.

*the heating demand is efficiency of the buildings walls, floors, roofs and windows, therefore unaffected by low carbon technology

**bills rise with the switch from gas to more expensive electricity.

Typical measures and approximate costs

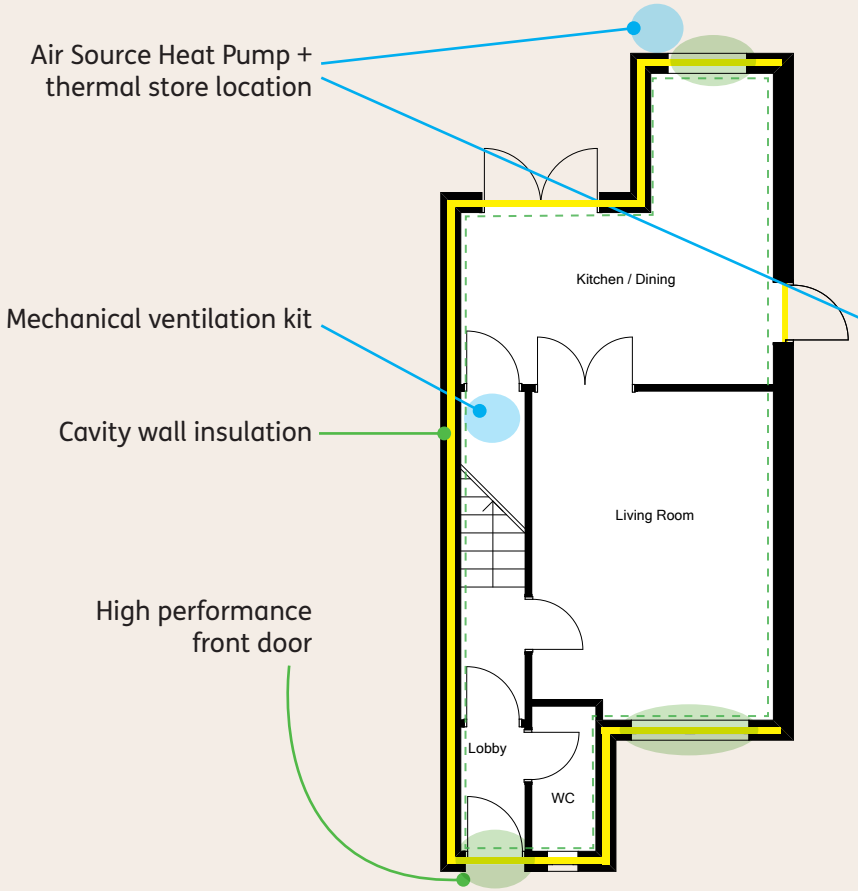
Thermal envelope
Active measure
Passive measure (fabric)



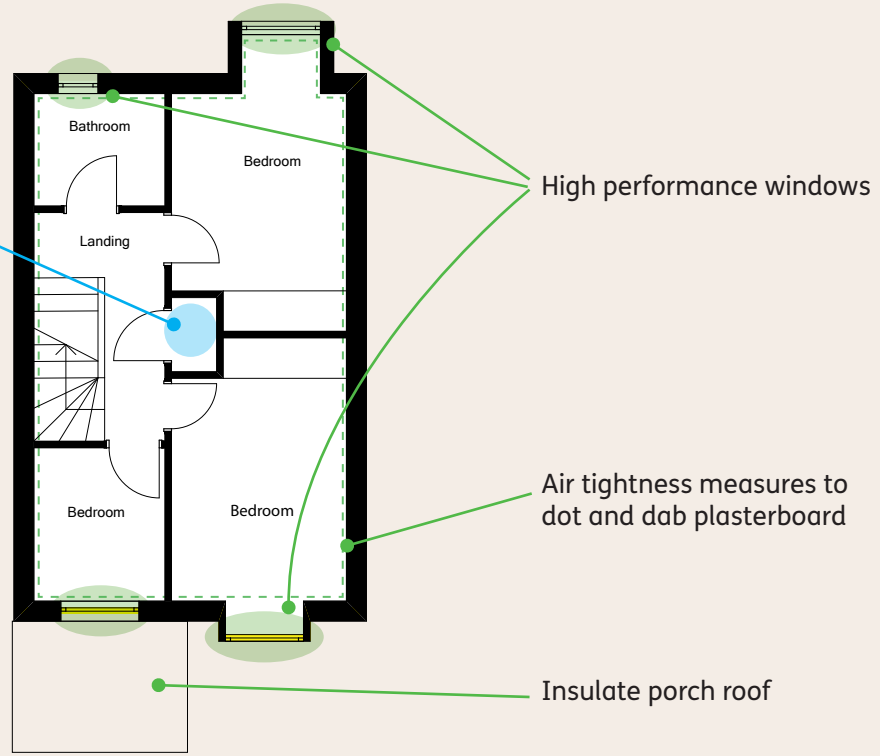
Typical measures

Thermal envelope
Active measure
Passive measure (fabric)

Ground floor



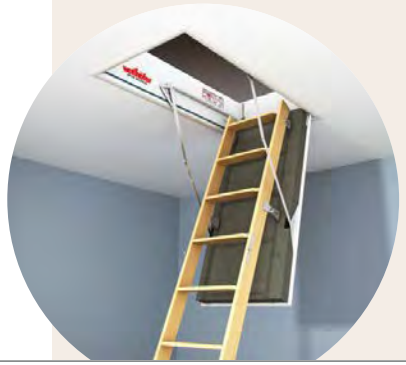
First floor



Retrofit measures

Low-cost measures

- Ensure thermostat is at recommended levels or according to your health needs.
- Fit low energy lighting and appliances.
- Fit draught strips to windows and doors.
- Seal cracks, holes, service penetrations and skirting boards.
- Extractor fans to bathrooms and kitchens.
- Fit improved heating controls.
- Make DIY improvements to loft and storage hatches.
- Lag pipes.
- Test air tightness to find leakage pathways.
- Use thermal imaging to find weak spots.



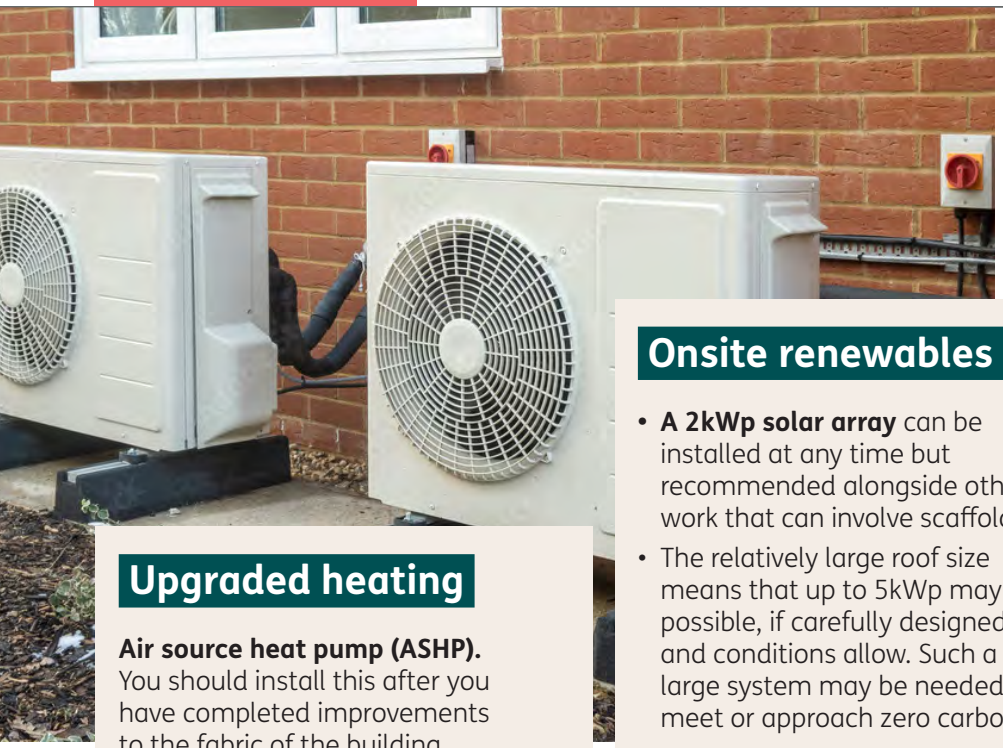
Shallow

The remote install is minimal in disruption and good performance.

- **Insulated and re-roofed porch roof.** These roofs are often in poor repair so recommended for reroofing and insulating (100mm). In the event the roof is in sound condition, the roof may be insulated from below. Please note if the porch is not heated and separated by a good quality external door this measure may not be required. See the options outlined earlier in the report.
- **Top-up loft insulation.** An additional 200mm over the existing.
- **High performance loft hatch.** Often a weak spot in a well-insulated loft room. A propriety high performance hatch is recommended if aiming for a deep retrofit.
- **Mechanical extraction** from kitchens and bathrooms (whole house mechanical ventilation is planned).
- **Demand control ventilation (DCV)** can be a very viable system as existing air bricks in rooms can be re-purposed. This should not be installed and mechanical ventilation with heat recovery installed instead if highest performance and air quality is desired.
- **75mm cavity wall insulation.** In the event the cavity is not filled this is a simple measure.
- If the floor is concrete beam and block, then **robotically sprayed insulation** is a low disturbance method providing good insulation and air tightness. The size of the floor void is critical for the viability and a hole(s) will be required for the robot to gain access.
- **Air tightness measures.** Seal easy to treat leakage pathways.

Deep

- **100mm internal or external wall insulation.** Where the cavity is untreatable or greater performance is required internal or external wall insulation can be considered.
- **High performance front door.** Even if double glazing is installed front doors are often original and can be very poorly performing.
- **Air tightness measures.** All services sealed, windows and cracks sealed and taped. Dot and dab plaster board sealed or removed and replaced with wet plaster.
- **Installation of mechanical ventilation** with heat recovery.



Upgraded heating

Air source heat pump (ASHP). You should install this after you have completed improvements to the fabric of the building (insulation and draught proofing). As described above, the radiators or similar may need upgrading. This can be about double the size of a gas boiler (around the size of a fridge freezer) plus an outdoor unit; therefore, suitable locations are needed. As discussed elsewhere, an increase in fuel bills is likely.

Onsite renewables

- **A 2kWp solar array** can be installed at any time but recommended alongside other work that can involve scaffolding.
- The relatively large roof size means that up to 5kWp may be possible, if carefully designed and conditions allow. Such a large system may be needed to meet or approach zero carbon.

EnerPHit and Net Zero Carbon

To achieve the Passivhaus retrofit standard EnerPHit you will need the support of a Passivhaus certified designer.

- **Triple glazed windows and doors** are recommended for the best performance and comfort.
- **Fastidious air tightness measures.** A number of extra measures with high quality control is required, eg: air tightness membrane in ceilings and floors; air tightness testing; parge coats (a thin coat of cement mortar) in hidden areas (between floor, behind stairs etc) and repairs to plasterwork; taping at junctions, windows and doors etc. Dot and dab plaster board sealed or removed and replaced with wet plaster. Air changes per hour less than 1 at a pressure of 50 pascals.

House type G

Modern mass house builder

Energy savings and scope

Age: **2000-2015**

Name: **Modern mass house builder**

Typical Size: **85m²**

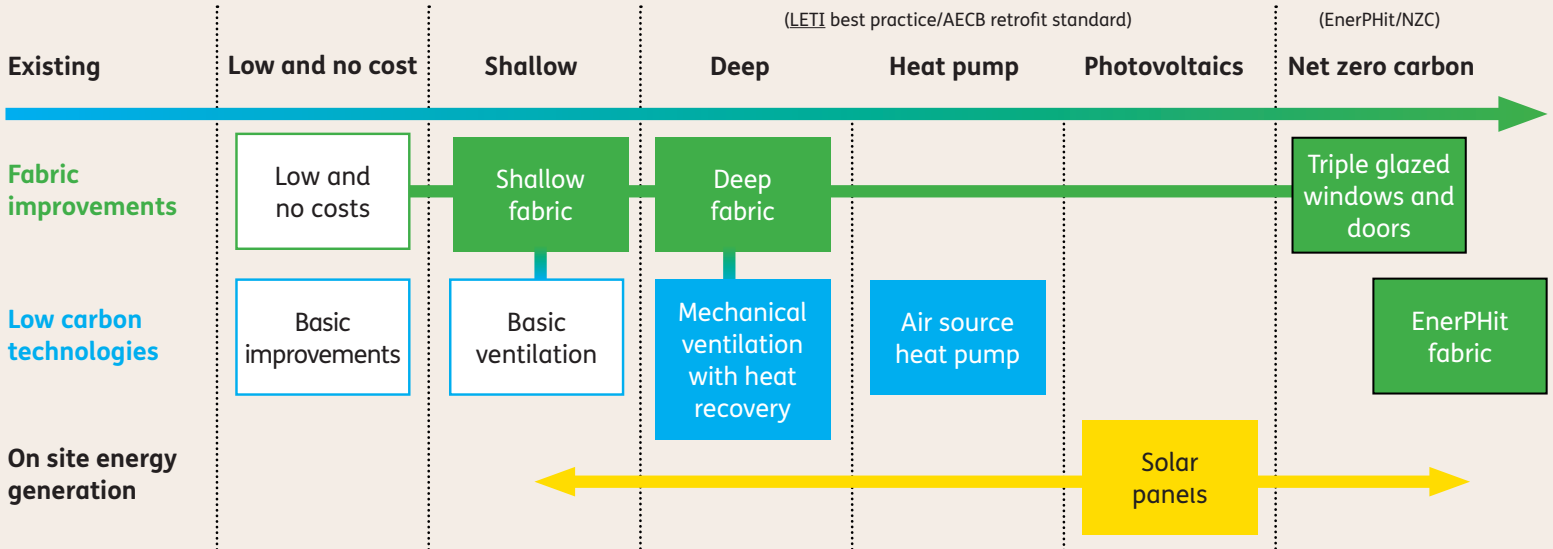
Description

This archetype covers mass house-builder properties from 2000–2015. Typical brick with some render. Pitched interlocking tile roofs. Pastiche embellishments. Occasionally with fake chimneys.

Typical features

- **Walls – filled cavity walls**
- **Dot and dab plasterboard as internal finish**
- **Floors – Insulated concrete beam, or, insulated solid concrete**
- **Masonry load-bearing partition walls**
- **Studwork partition with plasterboard**
- **Timber roof with insulated Skeiling**
- **Loft floor typically insulated**
- **Combi boiler with microbore pipes**
- **Trickle-vents in all windows**
- **Extractor fan in bathrooms and windows.**
- **uPVC windows and doors**
- **Gas boiler and radiators**
- **Open chimneys with generally unused fireplaces**

Phasing of retrofit work – Type G



Retrofit cost	£0	£2,300	£19,000	£56,500	£78,000	£87,500	£118,000	£ invested
Energy saving	0%	0-10%	29%	59%	81%	110%	120%	Percentage saved
Heating demand	**143**	**130**	**100**	**51**	**51***	**51***	**20**	**kWhr/m²/yr (heating)**
Carbon emissions	5.5	5	4.1	1.5	0.7	-0.3	-0.7	Tonnes CO_2/year
Annual bills	£1700	£1600	£1350	£1000	£1300**	-£250	-£600	£ per year

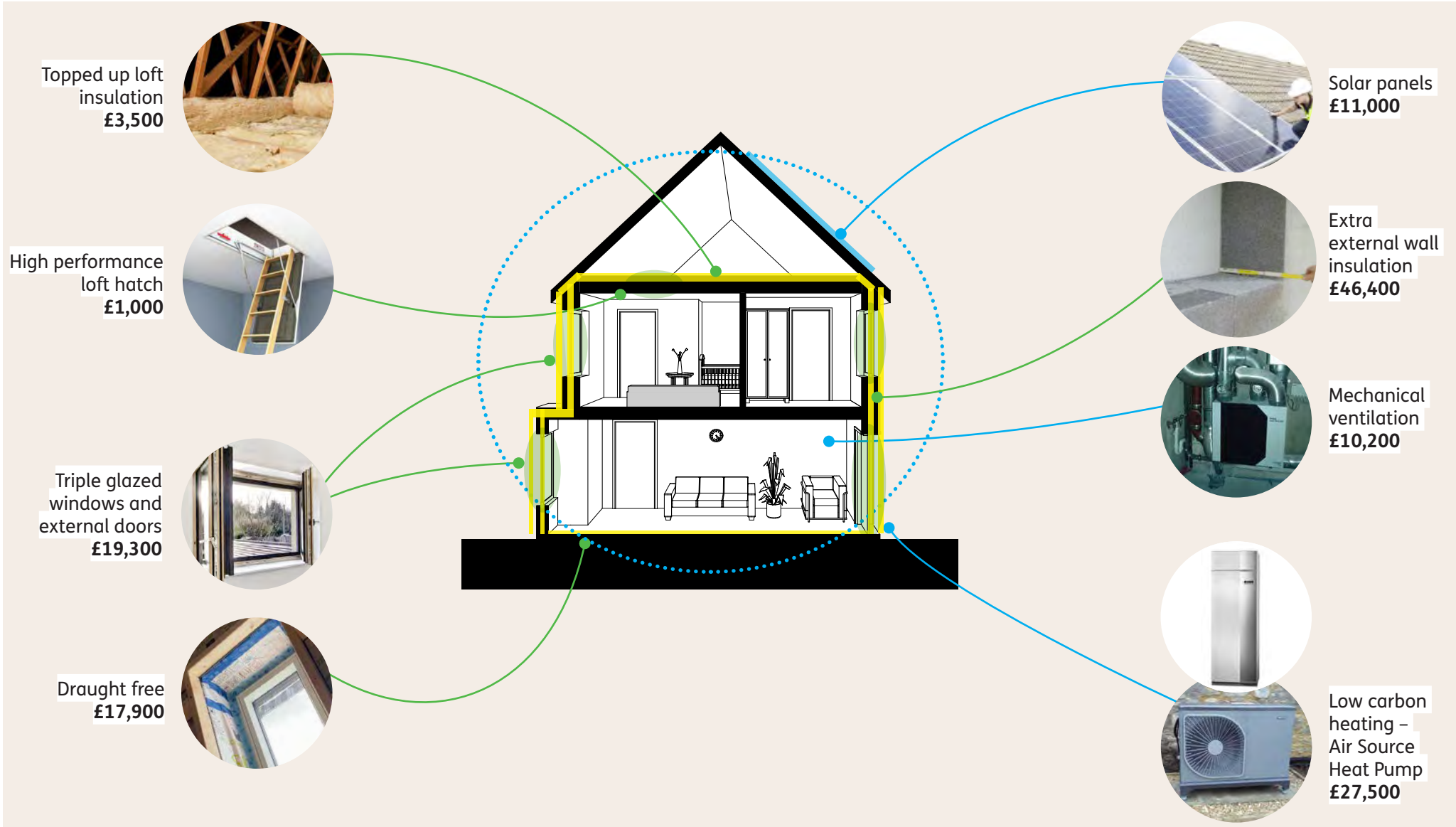
Bill estimates are based on early 2022 prices, so a rise is expected. It assumes homes heated to CBSI recommendations rather than national averages.

*the heating demand is efficiency of the buildings walls, floors, roofs and windows, therefore unaffected by low carbon technology

**bills rise with the switch from gas to more expensive electricity.

Typical measures and approximate costs

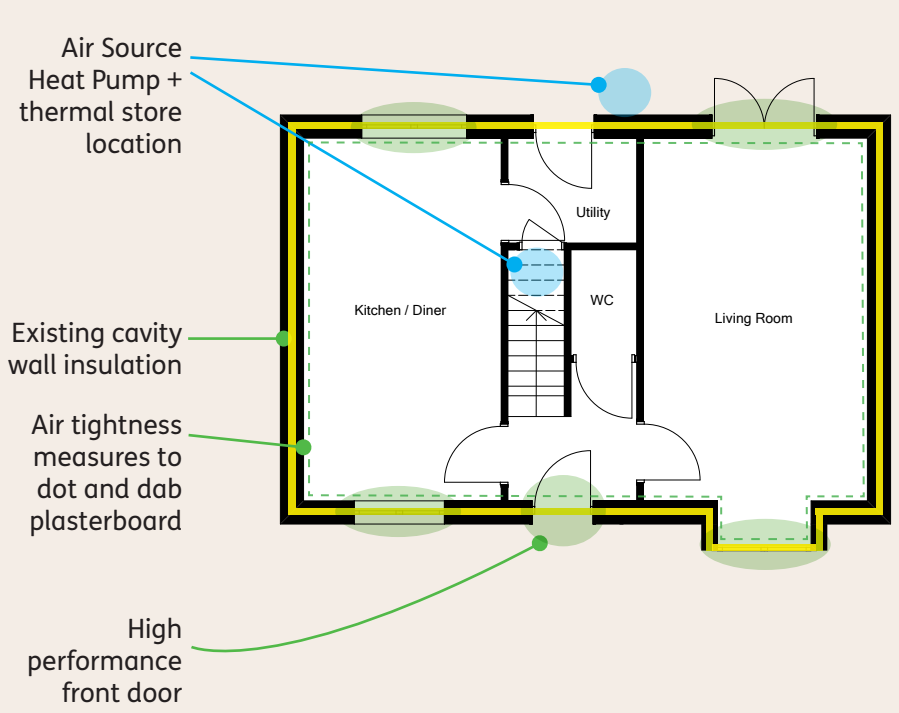
Thermal envelope
Active measure
Passive measure (fabric)



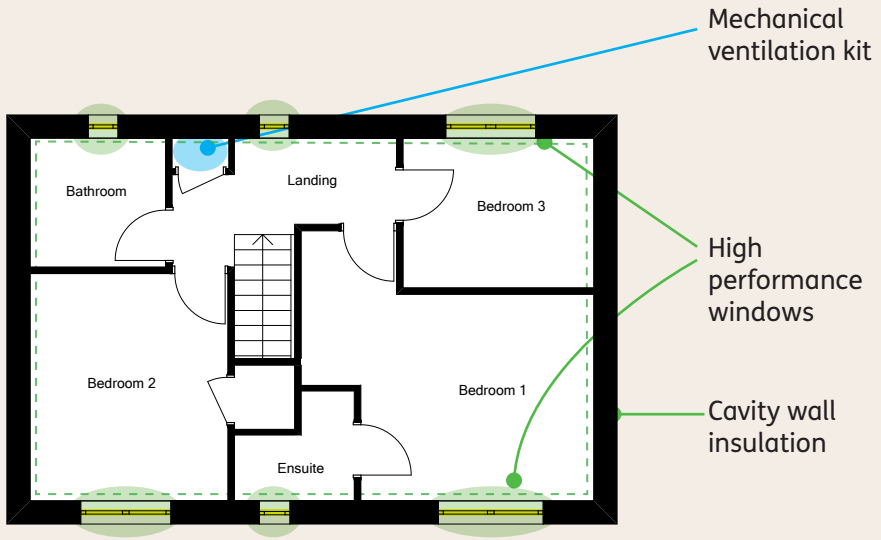
Typical measures

Thermal envelope
Active measure
Passive measure (fabric)

Ground floor



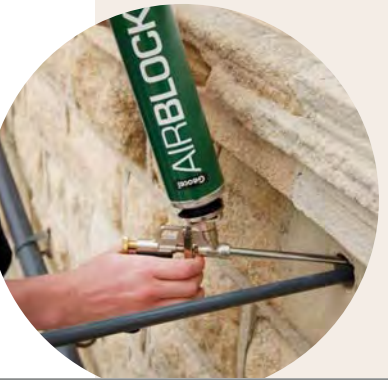
First floor



Retrofit measures

Low-cost measures

- Ensure thermostat is at recommended levels or according to your health needs.
- Fit low energy lighting and appliances.
- Fit draught strips to windows and doors.
- Seal cracks, holes, service penetrations and skirting boards.
- Extractor fans to bathrooms and kitchens.
- Fit improved heating controls.
- Make DIY improvements to loft and storage hatches.
- Lag pipes.
- Test air tightness to find leakage pathways.
- Use thermal imaging to find weak spots.



Shallow

- **Insulated and re-roofed porch roof.**
- **Top-up loft insulation.** An additional 200mm over the existing 100mm to make 300mm in total.
- **High performance loft hatch.** Often a weak spot in a well-insulated loft room. A propriety high performance hatch is recommended if aiming for a deep retrofit
- **Mechanical extraction** from kitchens and bathrooms (whole house mechanical ventilation is planned).
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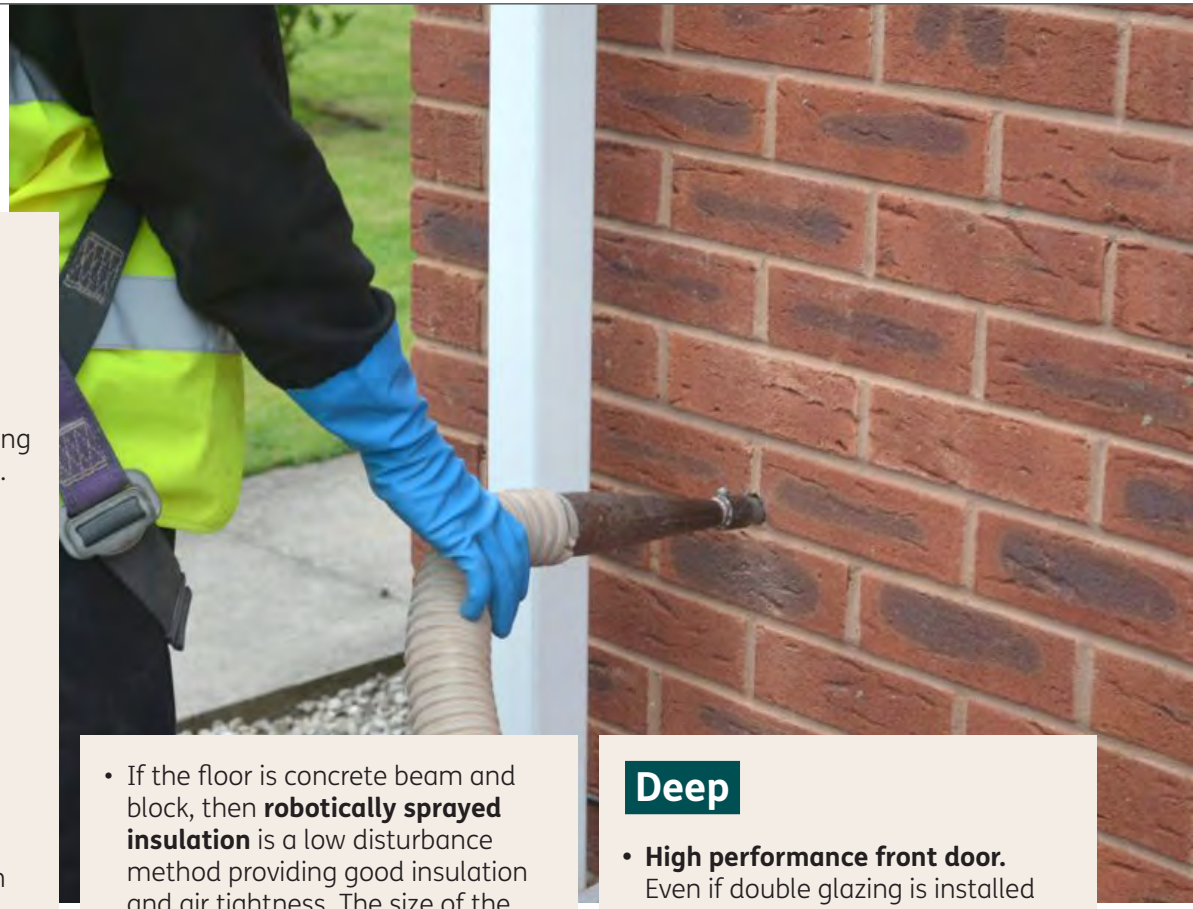

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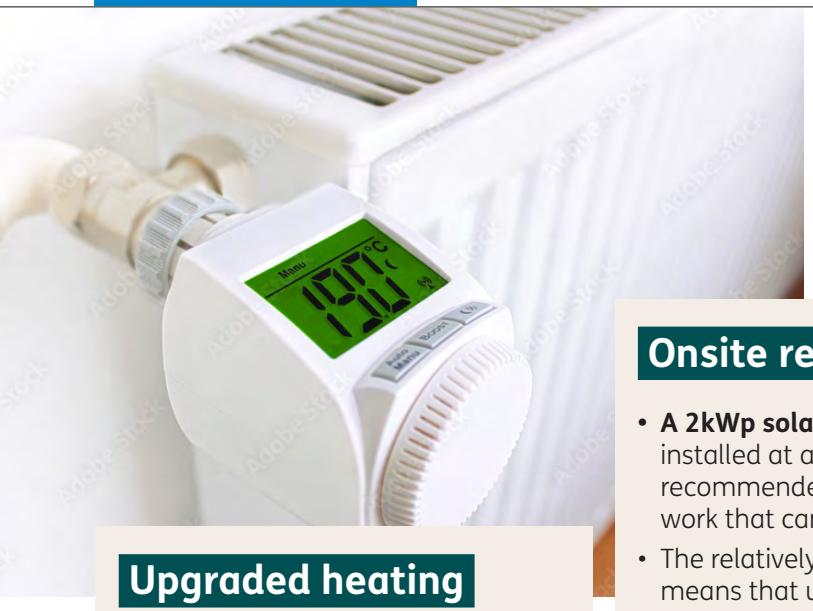

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Next steps

The low and no cost measures represent the first practical steps of your retrofit journey. In order to plan which are the best measures for your home, and in what order, you can commission a retrofit assessment or retrofit feasibility study. This can cost a few hundred pounds for a basic assessment to low thousands for a detailed study and energy modelling.

You should approach a competent retrofit coordinator, architect, or built environment professional to commission a whole-house retrofit plan. You should use professionals with PAS 2035 accreditation/ certification, Passivhaus certification, or equivalent professional accreditation.

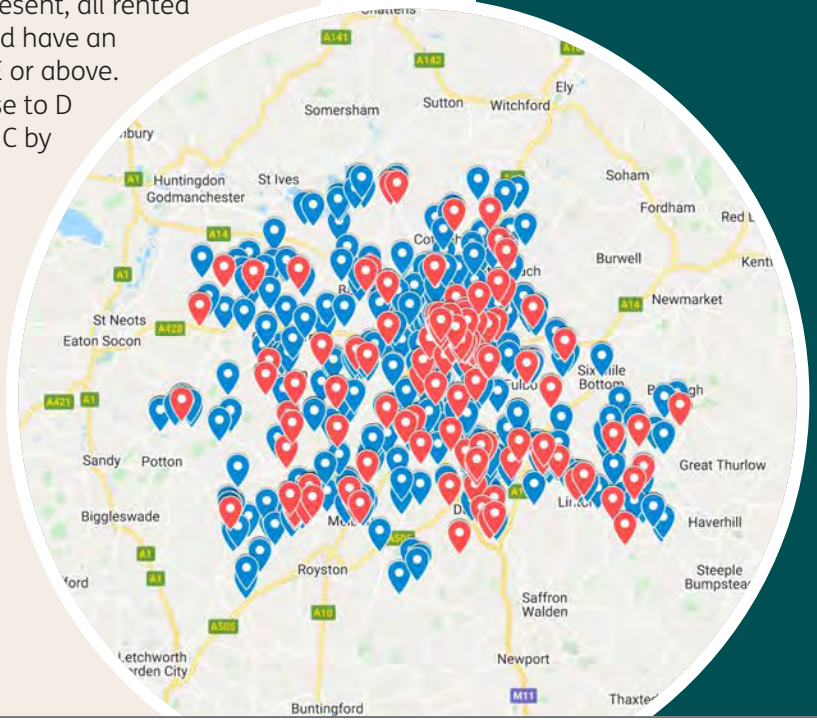
If you are more action oriented, you could begin with the DIY, low and no-cost measures given above. But still seek advice to prevent unintentional consequences or incompatible measures.

The Council has procured a four-year framework relationship with a number of contractors to deliver energy efficiency measures, including insulation. The Council will be using these contractors to deliver home retrofit work for low income households through Government-funded schemes such as the Sustainable Warmth Scheme. If you would like to find contractors to carry out retrofit works on your property and are in a position to pay for this work, you can also use this framework to find contractors. The suppliers within the framework have been assessed and meet current industry standards" rather than "The suppliers within the framework will be vetted and approved by the Council". For more information on which contractors are part of the Council's framework and their contact details, please visit: www.cambridge.gov.uk/home-energy-and-water-use

Renters

If you rent rather than own your home, then it is your landlord who would ultimately decide on whether to go ahead with any energy efficiency work.

However, it is worth being aware of the MEES Minimum Energy Efficiency Scheme , which sets a legal minimum energy efficiency standard for rented homes. At present, all rented homes should have an EPC level of E or above. This may raise to D by 2025 and C by 2030.



Financial support

Unfortunately, there is limited financial support available to help people retrofit their homes.

There are various grant schemes available to increase the energy efficiency of your home in Cambridge. Information can be found here.

- **ECO** Energy Company Obligation – This is a government energy efficiency scheme to help reduce carbon emissions and tackle fuel poverty.
- **SMG** Smart Export Guarantee – Is a scheme for those with small-scale low-carbon generators (renewable energy technologies) to get paid for the electricity they produce and export back to the grid.
- **CHG** Clean Heat Grant (this may be renamed as the Boiler Upgrade Scheme) – This provides financial support for a heat pump.
- **VAT** it is worth noting that retrofit measures are VAT exempt from April 2022.

About this guide

This is the public facing element of a wider study commissioned by Cambridge City Council.

The aim of the study was to establish the technical and cost requirements to achieve net zero carbon. Seven house types from a range of eras that are commonly found in the city were selected, visited and energy modelled. Suitable retrofit measures were assessed and costed at an incremental scale from small interventions, through to net zero. The study recommends an 80% reduction in household carbon emissions in line with LETI best practice as an appropriate target. The route to net zero carbon is shown to be technically possible but the final 20% of savings is disproportionality costly.

The study shows the upfront cost of retrofitting is significant whilst also highlighting wide ranging benefits beyond just carbon savings: improved health; reduction in fuel poverty; creation of retrofitting jobs; and energy sovereignty. Achieving a decarbonised housing stock is going to require a step change in how retrofits are efficiently delivered and supported.

Acknowledgements

This guide and associated study was commissioned by Cambridge City Council and delivered by Bioregional, 3G Construction Consultants and Transition by Design.

Please get in touch via our websites for further information.

Thanks to A1 Air Tightness Testing, Cambridge Carbon Footprint/Open Ecohomes, and Transition Cambridge for linking us with residents for the home visits. Thanks also to the obliging residents in Cambridge for their time and access to their homes.

Design by Steers McGillan Eves.