Calderdale Retrofit Guide

September 2025

PEOPLE POWERED RETROFIT

Contents

Above and front cover - Illustrations of Calderdale homes clockwise from top left: Through terrace; Back to back; Under and Over dwelling; Weaver's cottage. Credit: A Gardner

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Authors:
Marianne Heaslip, Technical Director, People Powered Retrofit
Mark Crunden-White, Retrofit Surveyor, People Powered Retrofit
Sophia Godfrey, Retrofit Designer, People Powered Retrofit
www.retrofit.coop
Illustrations and photographs:
Andrew Gardner, Director, Above Ground
www.above-ground.co.uk

Introduction

People Powered Retrofit were commissioned by Calderdale Council to produce a retrofit guide for residents in Calderdale. We've considered the building types, construction materials, context and climate, taking five example houses that share common features with many local homes. We have provided outline retrofit strategies for each house that highlight some of the issues that need to be considered and the improvements that might be possible.

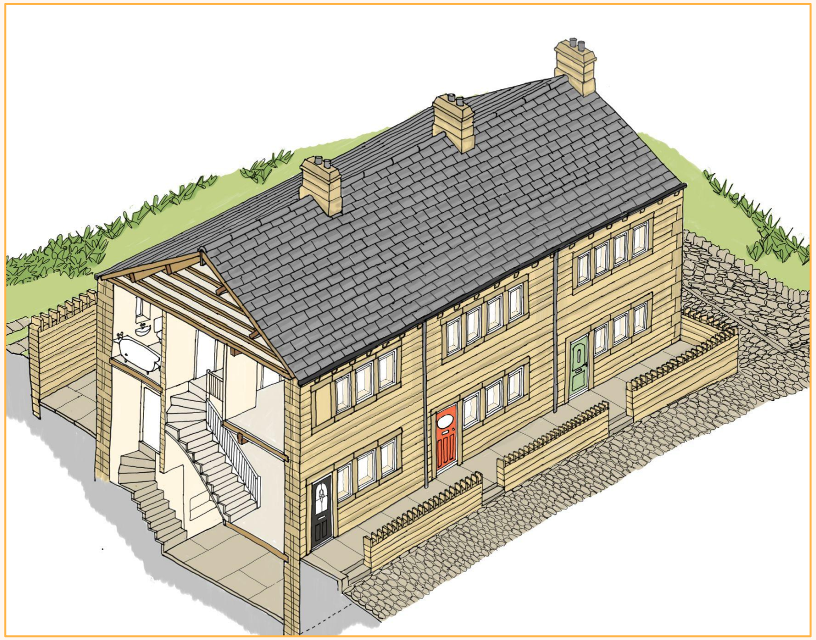


Illustration of weaver's cottages house type. Credit: A Gardner

Background

This guide has been commissioned by Calderdale Council in response to the recommendations from the Calderdale Citizen's Jury on retrofit. Both the jury and this guide were funded by Innovate UK's Net Zero Living Programme which ran from July 2023 to the end of June 2025. The full details of all recommendations are available on the dedicated citizen's jury website.

This guide is specifically responding to Recommendation 4, for guidance to be provided on appropriate retrofit strategies for homes in Calderdale. Guidance is specific to homes of a type most commonly found in Calderdale. It is not exhaustive - rather this guide is a first step in understanding what is possible. Every home will need specific and contextualised support beyond this guide. This should consider the context and condition of the building and the needs of residents. Different homes may need different actions to be prioritised. We have tried to reflect that in this guide, but each retrofit project will be unique, with its own unique context and decisions.

Purpose of this document

This guide is for you if you are starting to think about energy efficiency and heating system improvements in your home. It should give you an idea of what is possible, but also what barriers you might need to overcome - and help you think about your priorities for your home. Some of the things suggested may not work for you and your particular home. You should always carry out a detailed assessment and develop dedicated design before starting a retrofit project. We hope that the information here provides a useful starting point to thinking about your retrofit project - using homes that look like many in Calderdale!

Why retrofit?

To meet the challenges of the 21st Century we need to make changes to all of our homes. We need to reduce carbon emissions by changing how we heat our homes, but we also need to think about running costs, and making sure our homes are healthy. Retrofit is about carbon, energy efficiency and wellbeing. But it's also about sound building maintenance and repair, and adapting our homes to a changing climate.

Before starting any retrofit project, it is important to understand what you are trying to achieve. This is because different retrofit measures will produce different outcomes. So what you choose to do, and what order you do it in, should reflect your priorities.

As a society, and for government, reducing carbon emissions in order to tackle the climate emergency is a key aim. The thing that will make the biggest reduction in any home to this is removing heating systems that burn fuels and replacing them with electrically powered systems, such as heat pumps.

Reducing fuel poverty and energy bills is another key aim. Because electricity is currently more expensive than gas, replacing a heating system might not achieve this. Instead, improvements to the energy efficiency of the building fabric and the addition of energy generation such as solar electric panels may make a bigger reduction in running costs.

Improving health and indoor environments is another key aim for society at large and for individuals. To achieve this it's important to think about improving ventilation systems to improve air quality, and consider fabric improvements that tackle cold spots and raise surface temperatures. Adapting to a changing climate is also part of making healthy homes - for example by minimising the risk of overheating, even in Calderdale!

As an individual in your home you might also have other priorities, such as tackling a particular problem area, refurbishing a kitchen, improving accessibility, or making your heating system easier to manage. Retrofit should not be seen in isolation from this. Considering energy efficiency, ventilation, heating system and energy generation alongside general upgrades and repair works means you are more likely to achieve the outcomes you want for your home.

Responsible retrofit

Retrofit and energy efficiency improvements shouldn't be about just sticking on insulation or new heating and renewable technology. Instead a holistic approach is needed. This needs to understand homes as systems - how the different parts can interact in sometimes unexpected ways. The context of the home also needs to be understood. Appropriate permissions and approvals should be gained.

Illustration of back to back homes. Credit: A Gardner

Healthy retrofit

Retrofit can make big positive improvements to your home, but it needs to be carefully managed. This is to avoid creating new problems or making existing issues worse. For example it is very important that any maintenance or repairs that your home needs is done either alongside or before retrofit work is done. Adding insulation to wet walls is a bad idea. Likewise draught proofing a home that doesn't have proper ventilation can cause problems with damp and mould, and making it unhealthy. It can also inadvertently raise radon levels - which is a serious health risk.

It is also important that work is done safely. This is for the workers carrying it out and for the people living in the home. This includes thinking carefully about things like fire escape and spread, and the risk of falls from height (a particular issue in some very tall Calderdale homes). It also means thinking about materials. Materials that may already be in homes, such as asbestos that will need to be carefully removed by trained and accredited professionals. We should also think about the materials we choose for retrofit, and the impact these can have on building workers and residents.

Planning, heritage and statutory approvals

Responsible retrofit is also about being a good neighbour. This means thinking about the impact of works on the people around you and the social and cultural value of our homes. Works that affect walls and structures between neighbours should be managed as set out in the Party Wall Act. Planning Permission and Building Control approval should always be sought where they apply. Some homes have extra protection, if they are listed or within a conservation area. In decarbonising our homes there are further considerations. For example, given the limited outside space and how close together many homes are, making sure that noise and other factors are considered when specifying an air source heat pump is important.

What’s special about Calderdale?

All homes need retrofit solutions that suit their context and the needs of their residents. The example homes in this guide were chosen as they are particular to Calderdale. They are ‘archetypes’ that are common in the area, and present some common challenges.

Entrances and ground and first floors to ‘under dwellings’ with two storeys of ‘overdwellings’ accessed from the opposite side above. Photo credit: A Gardner

The Calder Valley is in the South Pennines. This is a high exposure zone with significant rainfall and wind driven rain and snow. The altitude of the area means that it is also in a zone of high risk for frost attack. This has an impact on the retrofit measures that can be recommended - especially when it comes to insulating existing walls.

The area also has unusual topography and a high degree of variety for an urban area. Ranging from moorland tops to steep sided wooded valleys. This can create significant differences in temperature and humidity between areas that are in light or are in shade, or the top and bottom of valleys.

Industrialisation created high housing demand in the 19th and early 20th century. This led to the creation of some unique house types in response to the topography of the area. High density arrangements of homes were developed on the steep slopes - such as the ‘under/over dwellings’ and back to backs featured in this guide

Valley bottoms are prone to flooding from runoff down the valleys and from rivers and streams. This risk is increasing with a changing climate. It can be possible to improve the flood resilience of homes as part of a retrofit project - for example by considering how floors and walls are treated. This can help faster to recovery from flood events.

The geology of the region means that radon build up within homes is a concern. This is a naturally occurring gas that increases the risk of cancer. Monitoring this and making sure it is safely vented away should be part of any retrofit strategy in Calderdale.

What's special about Calderdale?

Illustration of sloping through terrace. Credit: A Gardner

What's special about Calderdale homes?

The high demand for homes in the 19th and early 20th centuries and the density of development also affected the form of homes. Houses are often tall and thin, built over 3 or four storeys including a cellar and/or a room in an attic roof space. Many homes are also tightly planned internally, with limited circulation space. Though in some cases there may be a small vestibule, commonly the external entrance door opens straight onto the living space.

The materials that older homes are built from are particular to the Pennine region. Walls are often local stone. In the oldest homes these often have a dressed stone outer and rubblestone inner and fill. Slightly later homes may have a stone outer and brick inner leaf - with some from the around the 1860s onwards even having cavities to help deal with the driving drain. The oldest roofs have large format thick stone slates. With the coming of the railways later in the 19thC these were replaced with standard slates in a smaller format. Gutters were often originally wooden and held in pace by specially designed stone corbels - making maintenance a challenge. Ground floors made from thick flagstones suspended over cellars are common, though more standard timber suspended floors are also a feature in most homes, whether at the ground floor or just on upper levels.

Homes tend to have limited external private space, with many opening straight onto the street. Small yards at the front or rear are a common feature, sometimes built into the slope of the hill and accessed by steep steps. Gardens are rare, so paved impermeable ground surfaces that make rainwater management more difficult are very common.

The five example homes on the following pages show how this special context can influence retrofit and energy efficiency upgrades in Calderdale homes.

Example Homes

On the following pages we have examined five house types that are typical of older housing in Calderdale. This has allowed us to explore some common issues with retrofit in greater depth.

Street of Weaver's Cottages in Heptonstall

None of the houses shown here are meant to be an exact replica of real homes - instead they are archetypes. In suggesting retrofit options and modelling the homes we have made assumptions about the context that should aid understanding, but might not be applicable in any individual home. If you are planning work on your own home, specific and tailored advice that takes into account your needs and the context of your home will always be needed.

The options shown here are focused on energy efficiency and energy systems related work. This should not be treated as a separate issue to good general building upkeep. Repairs and maintenance should always be the first step in any retrofit project. For example, fixing leaking gutters and repairing pointing will help keep walls dry. Dry walls have lower heat loss, so this reduces running costs and improves comfort. It also protects the long term future of the house. This becomes ever more important in a changing climate with increasing heavy rainfall.

The retrofit work for each home is set out in phases - called scenarios here. These are packages of work that it makes sense to do together, usually working from the least to the most disruptive. They are cumulative - so what happens in scenario 3 assumes that the work in scenario 1 and 2 is already done. In your home it might make sense - because of other planned work, building condition, available funds or personal priorities - to do work in a different order. We'd always recommend making a whole house plan that is specific to your home to help you decide what to do and in what order.

1: Through terrace

This stone-walled terrace is set out over three storeys. There is a ground and first floor and a room in the attic roof space. It sits directly at the back of the pavement at the front and side, with a small yard to the rear. This is an end terrace, though many of the issues discussed here apply equally to mid-terrace homes.

Through terrace built on a slope.
Photo credit: A Gardner

Like many homes in Calderdale, this house sits at the back of the pavement. At the rear there is a small yard. In some homes this is part-filled by a more recent extension. The yard provides some space to fit the external unit of an air source heat pump. However, an unimproved end terrace of this type has a peak heat load of around 9kW. With current heat pump models it might be difficult to meet the noise requirements of the heat pump standards. Making some minor improvements to the fabric of the building could get the peak load down below 7kW, meaning a smaller and quieter heat pump could be fitted that is more likely to meet planning requirements. (Each home will vary - which is why assessments are important!).

Adding insulation to the outside face of the wall would require special permission to overhang the pavement, as well as changing the appearance of the house dramatically. Internal wall insulation is likely to be more acceptable to the front and side (gable) walls at least. If the stairs are against the gable wall this limits the depth of insulation internally - but even a thin layer of insulation can make a positive difference, especially on an end terrace with a large gable wall like this.

The roofline slopes with the hillside in a locally common vernacular response to heavy rainfall. This creates some unusual and complex roof geometry, especially at the room in roof. This will need good quality workmanship to insulate well. Overheating can be an issue in attic rooms - using the right materials and taking care with draught-proofing as well as thinking about shading and ventilation can help limit this.

The gable is a 'wet' verge with coping stones. This means the roof slates are held in place with mortar and there is no overhang. A common problem here is water ingress when the stones slip or mortar between slates and stones fails. This will get worse as rainfall increases in a changing climate. Adding leadwork or other blocking to these details may help prevent water ingress. In all cases careful maintenance, detailing and choice of materials is vitally important to avoid problems with damp, mould and rot that can damage the building and occupant health.

1: Through terrace

The retrofit options set out on this and the following page cover both fabric improvements and building systems and services improvements. We have generally assumed that work will be done in phases. These could be aligned with other upgrade, repair and maintenance work. In your home it might vary from the order suggested here, depending on your priorities and the context and condition of the building. It is also possible to do the work all in one go - if you have the budgets and capacity, and can perhaps live somewhere else while some of the work is done.

Photo showing the complex roof geometry in the attic of some terraced homes.

Scenario 1: Ventilation and draught-proofing - Improve draught proofing and upgrade to a continuous ventilation system. These two measures work together to improve comfort and indoor air quality, managing moisture.

Scenario 2: Heating - Fitting an air source heat pump will make an immediate large reduction in carbon emissions from heating by replacing fossil gas use with clean electricity. For an end terrace the peak heat load is about 9kW - so it may be difficult to meet the noise requirements in some cases. In a similar mid-terrace it would be around 6kW, making it more achievable.

Scenario 3: Roof - Tackling the roof will improve insulation and airtightness. It reduces heat loss by around 25% in the modelled case. Where the roof needs repair especially, doing this before fitting a heat pump may make sense - reducing the size of heat pump needed. The opportunity can also be taken to upgrade gutters and detailing to make it more resilient to increased heavy rainfall. Fitting solar panels at the same time using the same scaffold makes sense if it's possible. Head height can limit insulation depth - but even thinner insulation with very good airtightness is worthwhile.

Scenario 4: Windows and doors - This is relatively expensive and will generally have a lower impact on heat loss compared to walls - though it depends on the window type and condition. Rotten single glazing should be replaced as soon as possible, while modern double glazing can be replaced at the end of life.

Scenario 5: Walls and floors - The wall and ground floor insulation are left until last, because it is disruptive and expensive - though can makes a big difference to the gable wall especially. The junction with the roof should be detailed to minimise gaps in insulation and maximise airtightness.

1: Through terrace

Through terrace retrofit. Credit: A Gardner

1: Improving air tightness and insulation in the room in roof will reduce heat loss and, if insulation with high thermal mass and decrement delay is used like woodfibre, it will also reduce overheating in summer. It's also important to make sure this insulation connects to any wall insulation - maximising airtightness and minimising thermal bridging. This is often easier if insulation is all at rafter level as shown at the rear of the house here - with care, insulating at the stud walls and ceiling is also possible as at the front.

2: Aiming for a heat pump that is less than 7kW should mean a smaller unit and noise requirements can be met

3: Careful detailing is needed where external wall insulation meets the ground - to minimise thermal bridging and protect it from moisture damage.

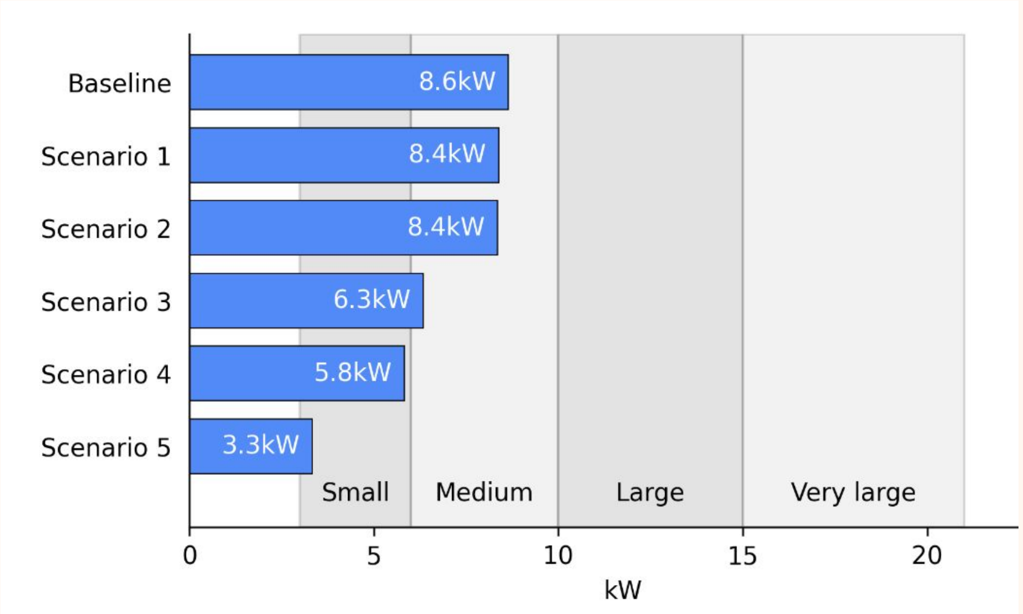
4: Sub-floors must be dry and well ventilated to minimise the risk of damp problems when insulating. If the home is in a flood zone, replacing with a solid floor is an option.

5: Adding external shading to windows can help minimise overheating risk.

6: To add solar panels the roof should be in good condition - so this is a good time to undertake any roof level repairs if they are needed.

7: Rooflights should be upgraded with the roof - maximising airtightness and minimising thermal bridging. .

Through terrace: Peak heat load

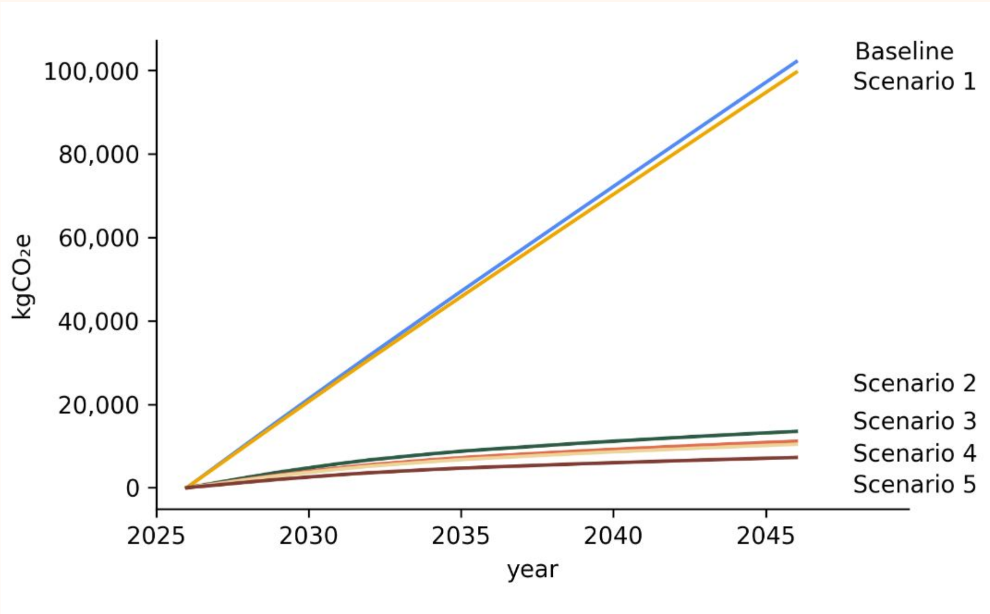


This graph shows the output needed from the heating system to keep the home warm on the coldest day of the year. It provides an approximate indication of the size of heating system that would be required.

In all of the scenarios modelled, it would be possible for a heat pump to meet this requirement. In scenario 3, where the roof has been improved, the reduction in heat loss means a smaller heat pump is needed that is more likely to be able to meet the noise requirements associated with planning approval or permitted development and the Microgeneration Certification Scheme.

In scenario 5 the peak heat load is estimated to be very low. Care should be taken here with design and planning the order of works - as any heat pump fitted to meet a higher demand might struggle to run efficiently at this much reduced demand.

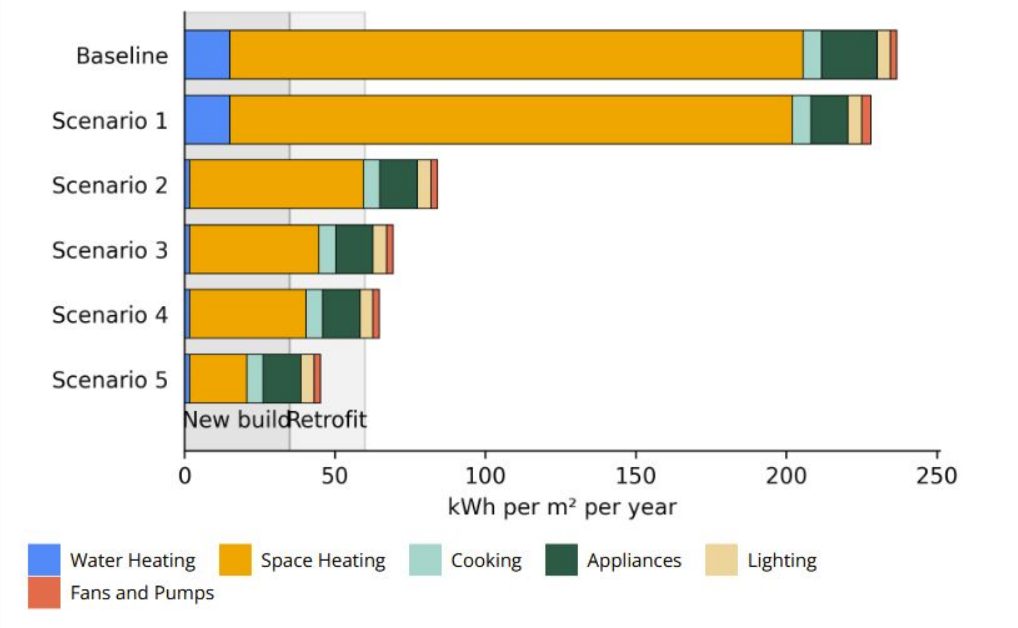
Through terrace: Cumulative carbon emissions



This graph shows the carbon emissions over time associated with running all of the systems that use energy in the home. This includes heating, ventilation and lighting - but also an estimate of the energy used for cooking and appliances.

Scenario 2, where the heat pump is fitted, is where the biggest drop in carbon emissions occurs. This is consistent with the finding in many other homes that changing your heating system from fossil gas to an efficient electrically powered system is one of the biggest things you can do to reduce carbon emissions from homes.

Through terrace: Energy use intensity

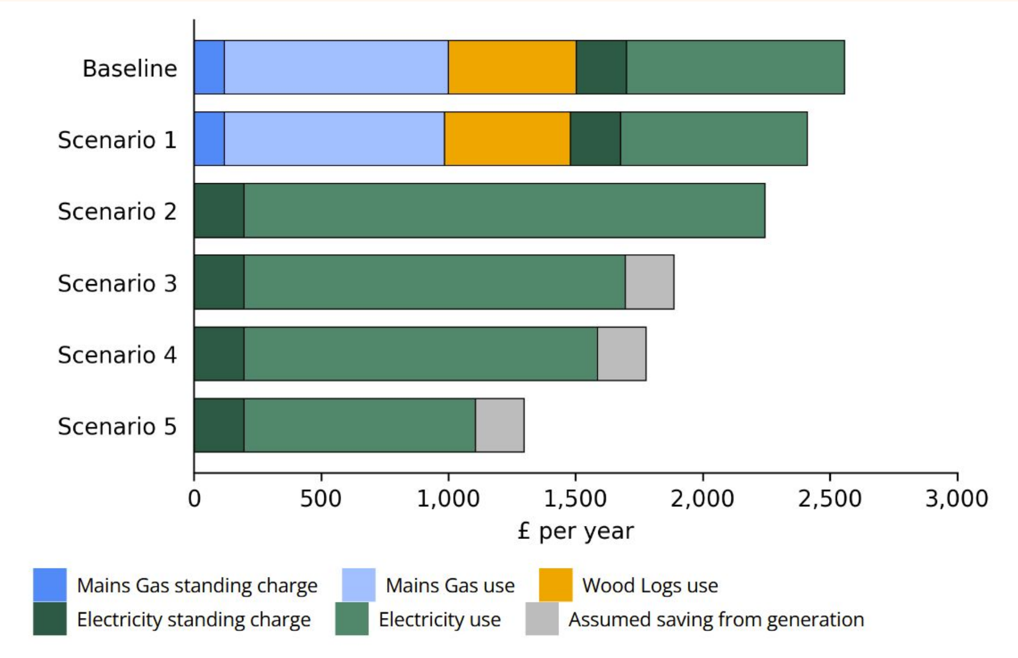


This graph shows the total energy use in the home per square metre of floor area per year. This is a useful metric for comparing homes against each other. The grey area to the left hand side of the graph are the targets for new build and retrofit developed by LETI.

Adding a heat pump again makes a big difference here. This is because for every unit of energy it uses in electricity, around 3.5 units of heat are generated.

Improvements to the fabric, especially tackling the roof and the walls, also make significant reductions in total energy use.

Through terrace: Energy costs



This graph shows the estimated running costs of the home for each of the retrofit phases. You can see that the improvements in ventilation and draught proofing in scenario 1 can make a modest improvement in running costs. The heatpump makes a similar fairly marginal improvement in running costs - though beware this will depends a lot on how well the system is designed and installed. Here we have assumed an efficiency of around 350% is achieved. This is very possible, but needs care and attention to detail.

We have assumed that once the heat pump is installed, the woodburner is no longer used, and cooking is switched away from gas. This saves more money because it means the gas meter could be capped off and the gas standing charge stopped.

Improvements to the building fabric make some of the biggest differences to running costs. While the grey area on the graph represents the money saved by using electricity from solar panels within the home.

2: Back to back

This mid-terrace house type only has one external elevation and very limited or no private external space. There are neighbours to either side but also to the rear. There is usually a single roof pitch sloping from the back to the front. This is mirrored on the property to the rear.

Back to back terrace.

This is a relatively common type of housing in West Yorkshire and the Pennines, though it is rare in the rest of the UK. It presents some unique challenges for retrofit. The orientation of the single exposed elevation on these houses can have a big influence on what they are like to live in, affecting temperature and humidity. If the house faces south and is relatively unshaded it will be light and benefit from solar gain in the winter, contributing to space heating. But it may also be prone to overheating, especially as there are few opportunities for cross-ventilation. If it faces north or is very shaded it will be darker and the walls will take longer to dry out after rain - making the home colder and more prone to damp.

The main issue for decarbonising heating systems in these homes is the very limited outdoor space. There is no backyard - because that's where another house sits - and many homes open directly onto the pavement. This means there is no space for an external unit for an air source heat pump. Luckily many of these homes are relatively small and because they only have one exposed wall they have a low heat losses. Even in an unimproved condition the peak heat load is likely to be around 4-5kW. Targeting insulation and draught proofing works will reduce this further. This means it may be possible to swap out fossil gas boilers for a mix of wholly internal heat pumps and direct electric heating for space heating and hot water. To make this more affordable to run, greater fabric improvements are likely to be worthwhile.

The other option is a communal heating system - such as a low temperature ground source heat pump loop. This takes greater coordination and planning - all the houses in a street or area would need to take part to make this worthwhile. The infrastructure costs are also generally high - with the need to build and manage shared central equipment and pipework. In some areas finding space for the central plant may be challenging - with little open ground. Internal space is often limited in these homes. The front door generally opens straight into the living space and there are few cupboards. This may mean attic or loft space needs to be used for equipment for any heating system. With limited roof space - that may be north facing - these houses also might not be able to benefit fully from individual solar panel systems.

2: Back to back

The retrofit options set out on this and the following page cover both fabric improvements and building systems and services improvements. We have generally assumed that work will be done in phases. These could be spread out over several years and aligned with other upgrade, repair and maintenance work to help manage budgets and disruption. In your home it might vary from the order suggested here, depending on your priorities and the context and condition of the building. It is also possible to do the work all in one go if you have the budget and capacity.

Roofs on back to back homes are shared with neighbours on either side and also to the rear. This can add complexity to retrofit projects - especially where roofs feature dormers and rooflights.

Scenario 1: Airtightness and ventilation - There is little opportunity for cross-ventilation, so installing a well planned ventilation system here is even more important. Whilst more disruptive and expensive, a balanced mechanical ventilation system with heat recovery may be worthwhile - we've modelled this in the final scenario below here (scenario 5).

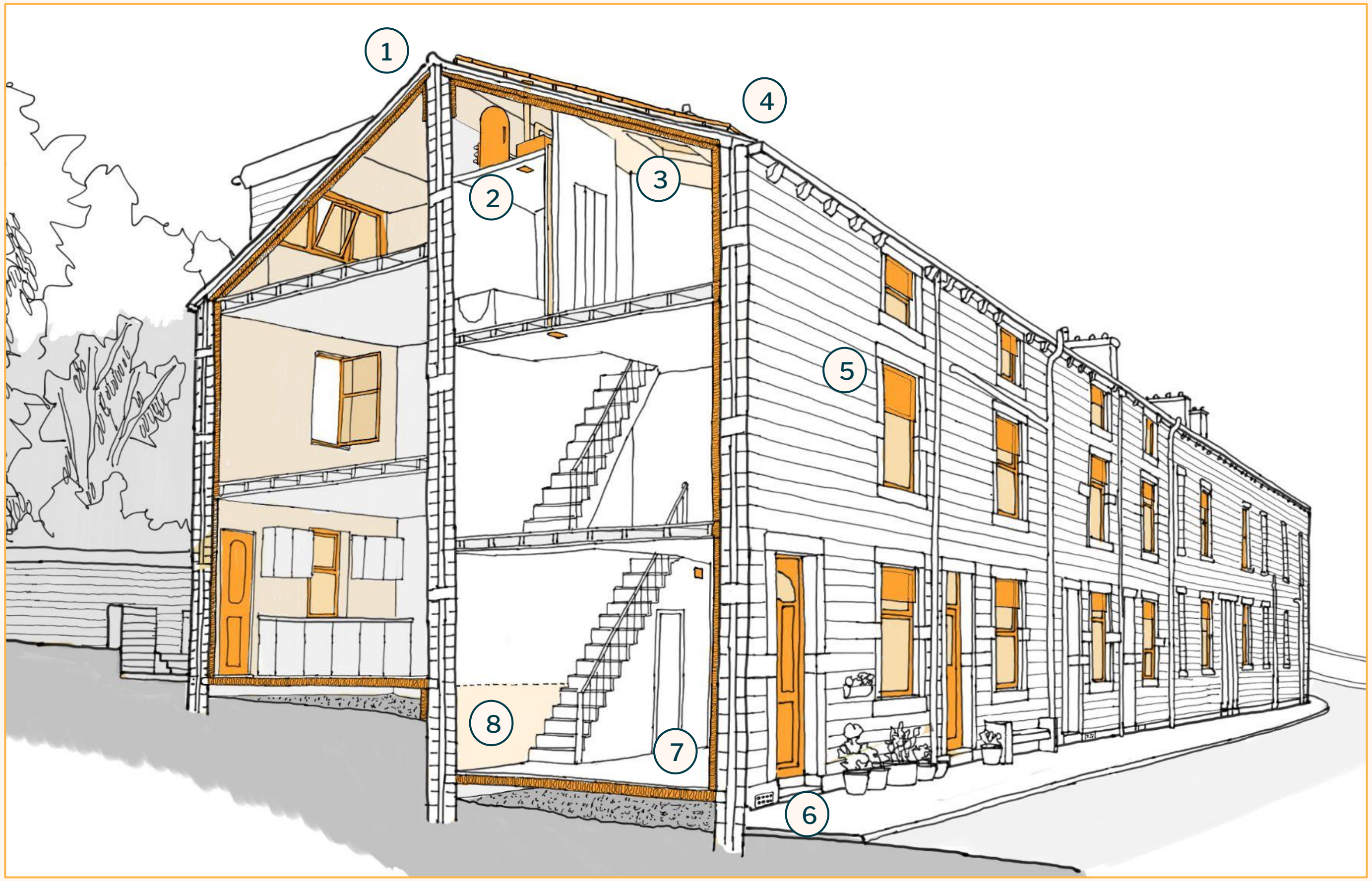
Scenario 2: Windows and doors - While there are not many windows and doors in this home, they make up a significant proportion of the external wall area. Upgrading helps to reduce heat loss, especially if they are installed to be airtight. In south facing homes, upgrading to triple glazing - and potentially also including external shading - also helps limit overheating risk.

Scenario 3: Roof - This is a big area of heat loss, but can be tricky. There are sloping ceilings, attic rooms and dormers, so standard loft insulation isn't often possible. We've assumed that the roof is insulated at the rafters, with any rooflights upgraded at the same time. If the right type of insulation is used this will help tackle overheating too. Adding solar panels to the roof will reduce bill costs - but north-facing and shaded homes may not be able to benefit.

Scenario 4: Heating - With no external space, a standard individual air source heat pump is not possible here. Instead we have suggested an internal ducted heat pump that just covers hot water, with direct electric heating for space heating. An alternative would be a shared ground source ambient loop. These are cheaper to run - using around a third less energy for space heating - but more complex and expensive to build.

Scenario 5: Walls and floors - We've suggested leaving wall and floor insulation til last because it is so disruptive. But if direct electric heating is used, this would reduce running costs.

2: Back to back



Back to back retrofit. Credit: A Gardner

1: Roofs are often complicated. Basic loft insulation is often either not possible or very limited in area. Upgrading at the rafter level to insulation like woodfibre with high thermal mass and decrement delay will ensure less heat loss and summer overheating. Careful detailing will be needed at the ridge, party walls and around dormers - where fire separation from neighbours is also a concern. Treating the whole roof in one helps to reduce the risk of cold spots and so condensation and mould risks.

2: Insulation at rafter level is helpful because it brings any loft space into the heated area of the home - making this a good place to fit equipment for heating and ventilation systems like hot water cylinders, heat interface units, and central fan units - given the very limited space.

3: Rooflights can help with cooling - with secure night-time ventilation driven by the stack effect of hot air rising.

4: Solar panels help keep bills down - but are not always sensible on roofs that are heavily shaded or face north.

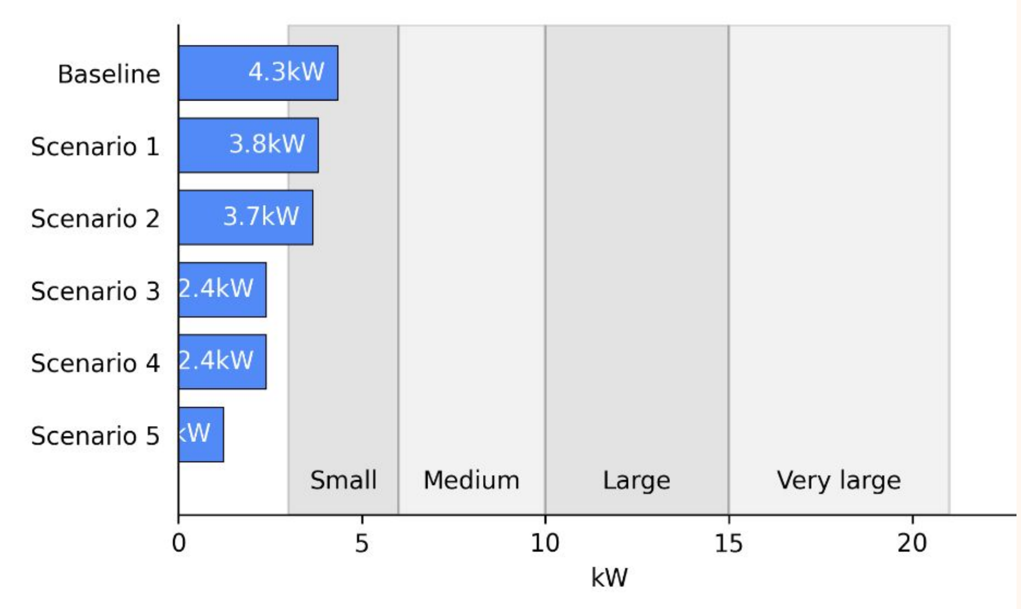
5: Upgrading windows will cut down on heat loss but is also an opportunity to limit overheating in summer through shading and glazing specification.

6: Replacing entrance doors will have a limited impact on overall heat loss, but will make a difference to comfort as most entrances open straight into living space.

7: Wall and floor insulation should further improve comfort. In areas with greater flood risk, switching to a solid floor may be sensible.

8: Insulation to walls against ground should not be forgotten, but this requires specialist advice.

Back to back: Peak heat load

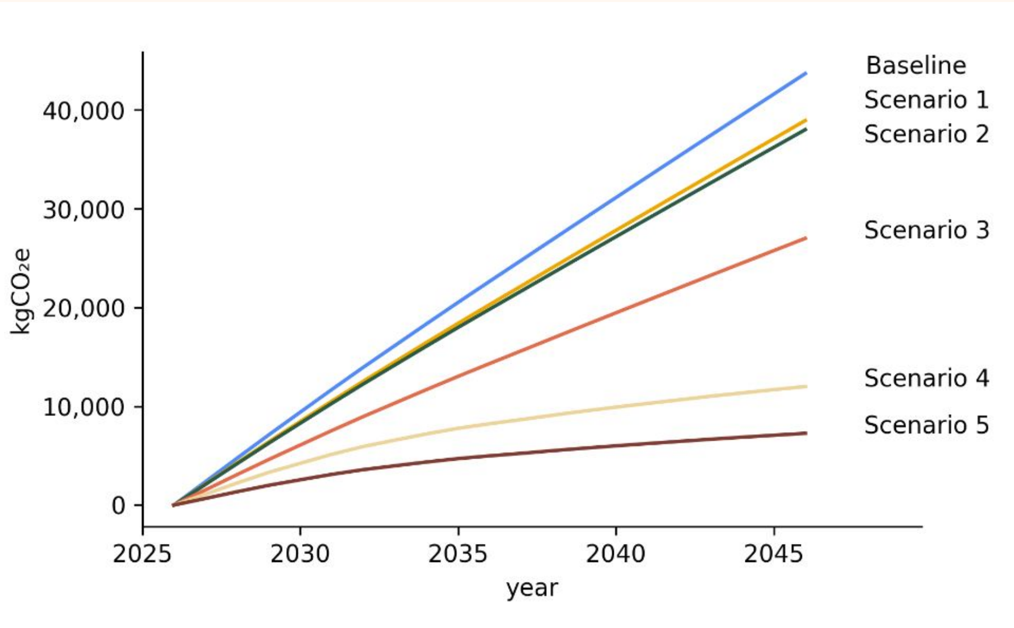


This graph shows the output needed from the heating system to keep the home warm on the coldest day of the year. It provides an approximate indication of the size of heating system that would be required.

In all of the scenarios modelled, it would be very possible for a heat pump to meet this requirement. The challenge in this home is that there is no outdoor space, so nowhere to put the external unit for a heat pump.

In scenario 3 onwards, the peak heat load is less than 3kW. This is really very low and means that direct electric heating is a possibility - though it is not as affordable to run as a heat pump, the demand is so low that it may be possible to manage. Adding mechanical ventilation with heat recovery and insulating the floors and walls gets heat demand to the point where it could be met by a small 1kW heater for the whole home.

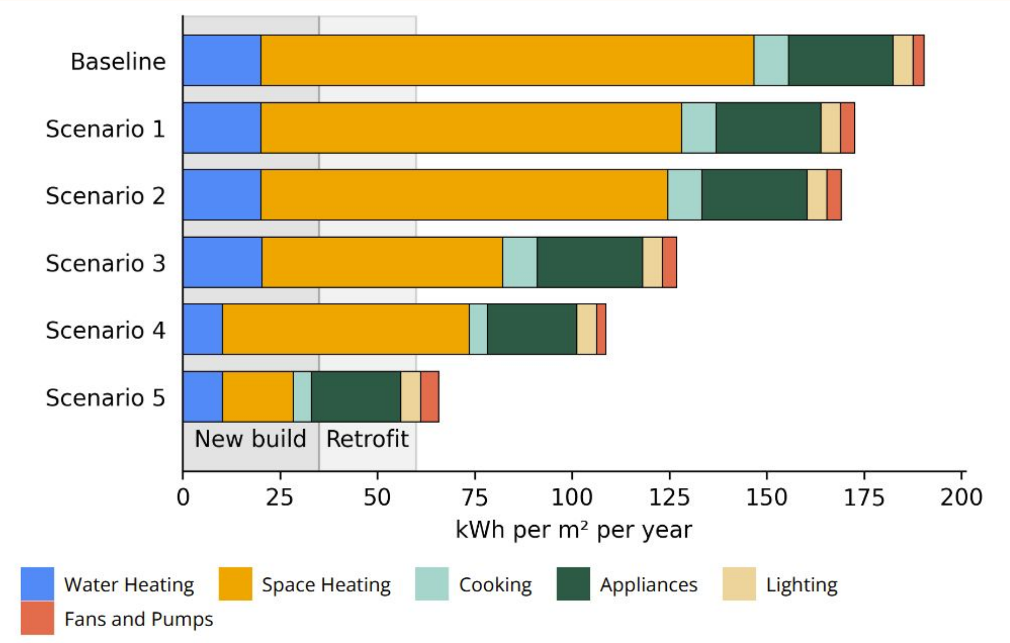
Back to back: Cumulative carbon emissions



This graph shows the carbon emissions over time associated with running all of the systems that use energy in the home. This includes heating, ventilation and lighting - but also an estimate of the energy used for cooking and appliances.

Scenarios 4 and 5 are where the biggest difference is made here, when electric heating is introduced. If a communal heat pump system was a possibility, rather than the direct electric heating assumed here, these would drop further. These kind of systems require planning, coordination and financing across a number of homes. So they aren't something you could decide to do as an individual - but they are something that could be led by a landlord, community group or local authority.

Back to back: Energy use intensity

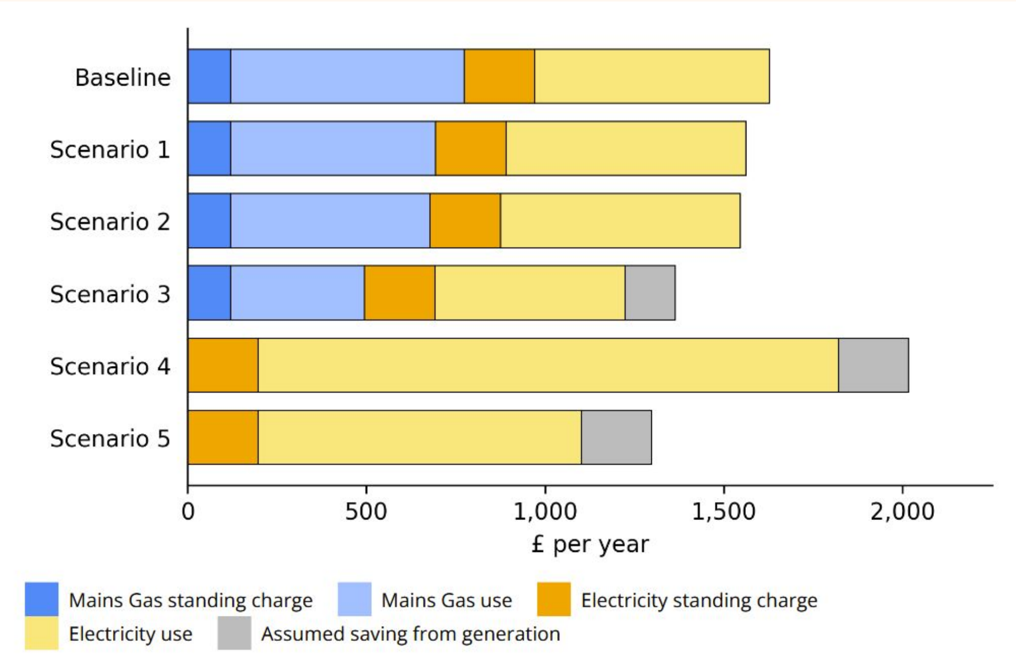


This graph shows the total energy use in the home per square metre of floor area per year. This is a useful metric for comparing homes against each other. The grey area to the left hand side of the graph are the targets for new build and retrofit developed by LETI.

The biggest improvements here are made by reducing the heat loss from the home by improving the building fabric and, in the final scenario, adding a ventilation system with heat recovery.

It is often harder in smaller homes when compared with larger homes to hit targets that are per square metre of floor area. The size of this home, at around 62 square metres of floor area, does mean it is harder to hit the LETI target shown here - though it almost makes it.

Backlink to back: Energy costs



This graph shows the estimated running costs of the home for each of the retrofit phases. You can see that the improvements in ventilation and draught proofing in the first two scenarios make a modest improvement in running costs.

We have assumed that once electrically powered heating is installed, cooking is switched away from gas. This saves more money because it means the gas meter could be capped off and the gas standing charge stopped. Solar panel offsets some of the running costs too.

Adding direct electric heating for space heating and a small hot water heat pump increases running costs. This is to be expected when electricity is so expensive compared to gas. There might be ways to mitigate this, through using smarter tariffs, but we've just shown a fairly standard tariff here. If a communal heat pump system was possible, running costs would come down significantly. Beyond that, deeper improvements to the building fabric can make some big differences to running costs, as shown in scenario 5 here.

3: Underdwelling

This house part of a terrace dug into a steep slope, with its back wall mostly against the ground. It is accessed from the lower level, while another house (the 'overdwelling') is built above it and is accessed from the higher ground on the opposite elevation.

Underdwelling elevation outlined in orange. Photo credit: A Gardner

These homes are fairly unique to Calderdale. Their form is a response to the demand for housing density on the steep valley slopes. They are usually part of a terrace. With the overdwelling above, this means mid terrace home only have one exposed elevation. As with the back to back houses this can influence temperature and humidity. If the house faces south and is relatively unshaded it will be light and benefit from solar gain in the winter, contributing to space heating. But it may also be prone to overheating, especially as there are few opportunities for cross-ventilation. Being against the ground on one side can help moderate this, with the thermal mass of the ground absorbing the excess heat. This should mitigate overheating at least for a few days in shorter heat waves, before the heat builds up in the walls, floor and ground.

If the home faces north or is very shaded it will be darker and the walls will take longer to dry out after rain. This makes the home colder and more prone to damp., although damp can also occur in south-facing underdwellings. The main area of concern are the rear rooms. These are either wholly or partially below ground, and often contain the kitchen. Ventilation of these rooms especially is often poor. Many residents use dehumidifiers almost continuously to try and tackle this problem. A well planned retrofit project that included improvements to ventilation and practical responses to the need for clothes drying would help to alleviate this issue.

The terraces are normally built with houses that are tall and thin - over three to five storeys including the overdwelling, cellars, and attic rooms. This can create a high stack effect - with warm air rising up rapidly within the home and any chimney flues. This can be beneficial in summer - but can also contribute to unwanted heat loss in the winter. So a strategy for tackling unused flues and chimneys should be part of any retrofit.

As with back to back dwellings, external space is often limited. This poses challenges for decarbonisation of heating. Communal, internal, or direct electrictric systems need to be considered alongside standard individual air source heat pumps with external units. With no roof, these houses also cannot easily benefit from individual solar panel systems.

3: Underdwelling

The retrofit options set out on this and the following page cover both fabric improvements and building systems and services improvements. We have generally assumed that work will be done in phases. These could be aligned with other upgrade, repair and maintenance work. In your home it might vary from the order suggested here, depending on your priorities and the context and condition of the building. It is also possible to do the work all in one go - if you have the budgets and capacity, and can perhaps live somewhere else while some of the work is done.

Underdwellings often have a small private yard or garden area by their entrance.

Scenario 1: Airtightness and ventilation - These homes have little opportunity for cross-ventilation, so installing a well planned ventilation system here is even more important. Draught proofing should include treatment of chimneys, which will have a large stack effect.

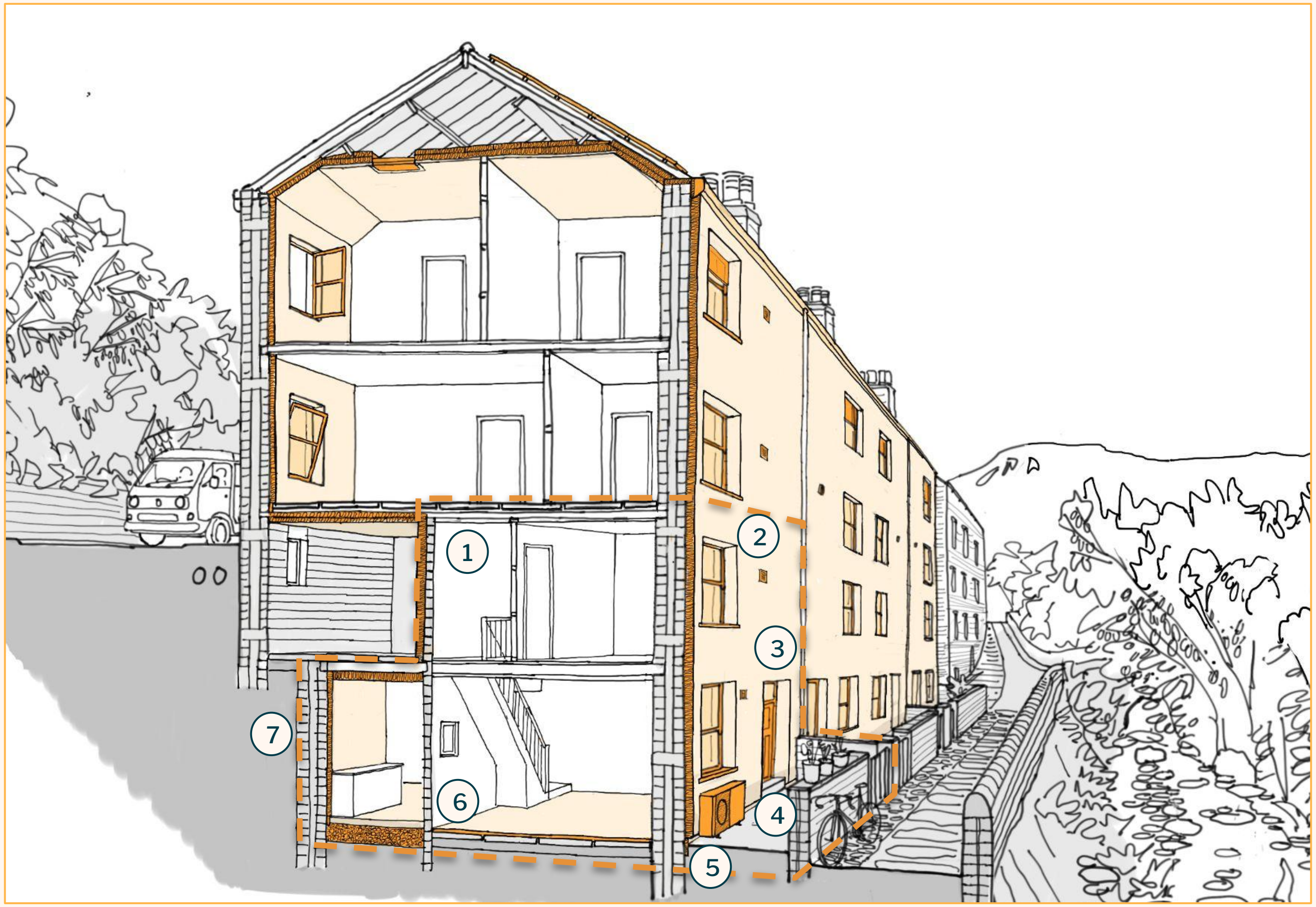
Scenario 2: Windows and doors - While there are not many windows and doors in this home, they do make up a significant proportion of the external wall area. Upgrading them helps to reduce heat loss, especially if they are installed to be airtight against the wall. In south facing homes, upgrading to triple glazing may help limit overheating risk. This should be balanced with daylighting in the detailed specification.

Scenario 3 : Heating - Underdwellings sometimes have a small private external area for an air source heat pump, so that is what we have modelled here. A small internal heat pump for hot water with direct electric heating is an alternative that limits external equipment as with the back to back home above. An alternative whole block solution is a shared ambient loop heat pump system. This is more expensive up front but has similar running costs to a standard air source heat pump.

Scenario 4: Floor and cellar insulation - We've suggested this later in the phasing as it's likely to be disruptive. If direct electric heating is used this would help reduce running costs. It's also likely to make a significant difference to comfort. We've added mechanical ventilation with heat recovery here. This is usually more disruptive and expensive to install than extract ventilation - but worthwhile if disruption is happening anyway and airtightness can be improved further. .

Scenario 5: External wall insulation - The wall is a relatively small area but this would cut heat loss to a minimum, as a 'whole block' project.

3: Underdwelling



Underdwelling retrofit. Credit: A Gardner

1: Where walls and floors are insulated that form the boundary with a neighbouring property the detailed specification will need to consider fire separation and being this up to modern standards.

2: Overheating is less of a risk in underdwellings, while maximising daylight may be more of a concern.

3: Upgrading doors that open onto living space can make a big difference to comfort even where heat loss is limited.

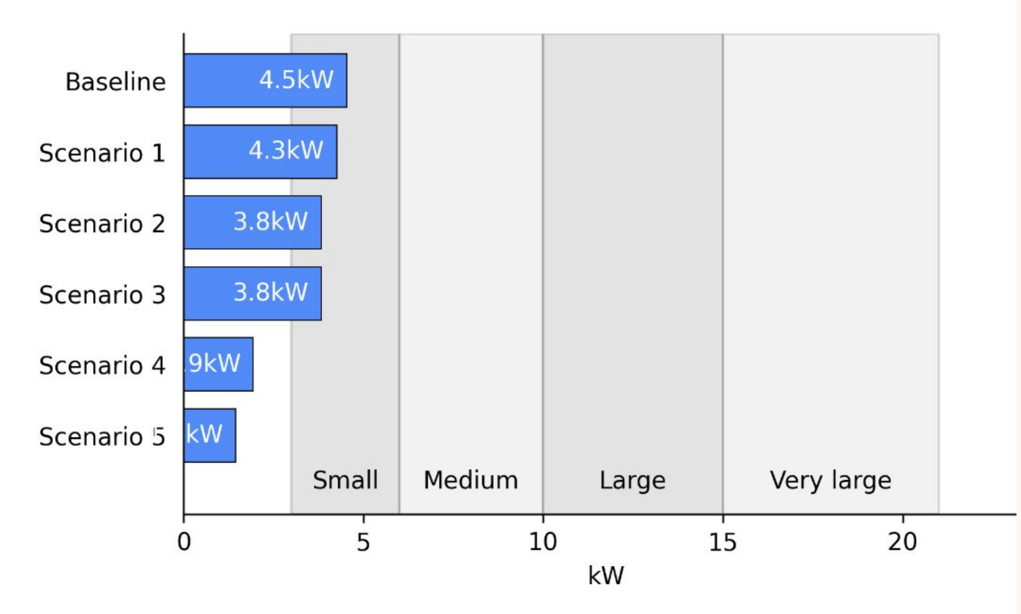
4: Some underdwellings may have space for an external heat pump unit - though in conservation areas and where neighbbours are very close this may be difficult. Shared loop and internal systems may be preferable in areas prone to flooding.

5: Where walls are externally insulated how the insulation meets the ground needs careful consideration and detailing. There will always be a thermal bridge here where the wall meets the foundations. This is more significant in thicker walls. It can be exacerbated by thermal bypass in rubblestone walls - where air moving within the wall reduces the effect of the insulation.

6: Both solid and suspended floor insulation is possible. In all cases moisture management and flood risk are key concerns. Where a suspended floor is damp or in a flood zone, a solid floor may be a better solution.

7: Walls against ground requires specialist advice to manage moisture risks and drainage.

Underdwelling: Peak heat load

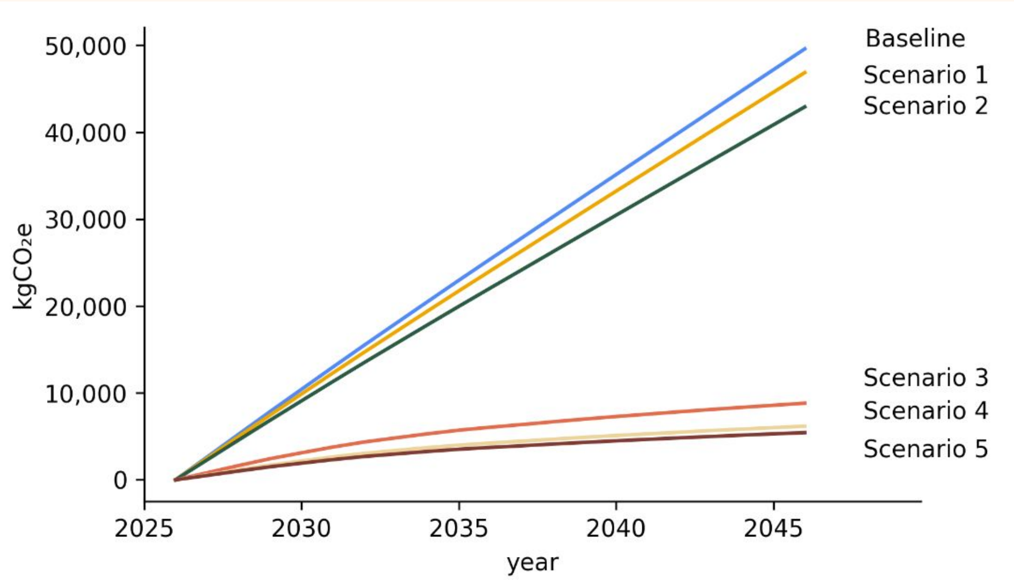


This graph shows the output needed from the heating system to keep the home warm on the coldest day of the year. It provides an approximate indication of the size of heating system that would be required.

In all of the scenarios modelled, it would be very possible for a heat pump to meet this requirement. The challenge in this home is that there is limited outdoor space, so finding room for the external unit for a heat pump could be a challenge.

In scenario 4 onwards especially, peak heat load is very low at less than 2kW. While we've assumed a heat pump is installed, direct electric heating is a possibility. Though it is not as affordable to run as a heat pump, the demand is so low that it may be possible to manage.

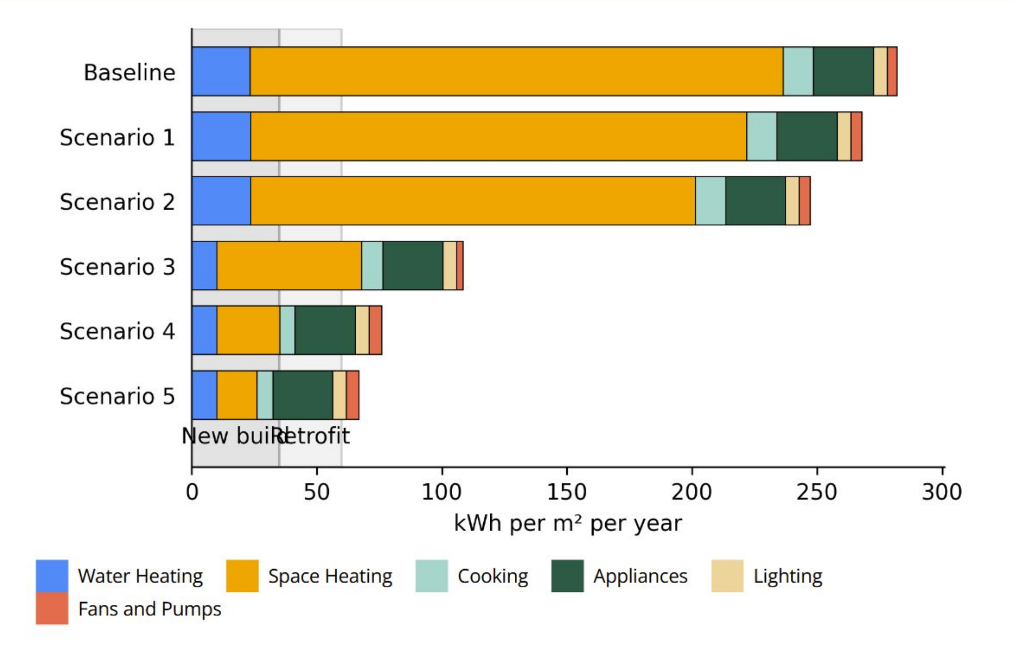
Underdwelling: Cumulative carbon emissions



This graph shows the carbon emissions over time associated with running all of the systems that use energy in the home. This includes heating, ventilation and lighting - but also an estimate of the energy used for cooking and appliances.

Scenarios 3, 4 and 5 are where the biggest difference is made here, when electric heating is introduced in the form of an air source heat pump. A communal heat pump system would have a similar impact. If neither of these are possible - because of a lack of outdoor space and if it's not possible to make a group project work - direct electric heating for space heating, potentially paired with a small hot water heat pump, would be an alternative possibility. Carbon emissions would be a little higher than shown here. In all of these one of the biggest challenges will be fitting equipment into the home - with many underdwellings not more that 50 square metres in area. Communal systems with minimal equipment are likely to be most attractive.

Underdwelling: Energy use intensity

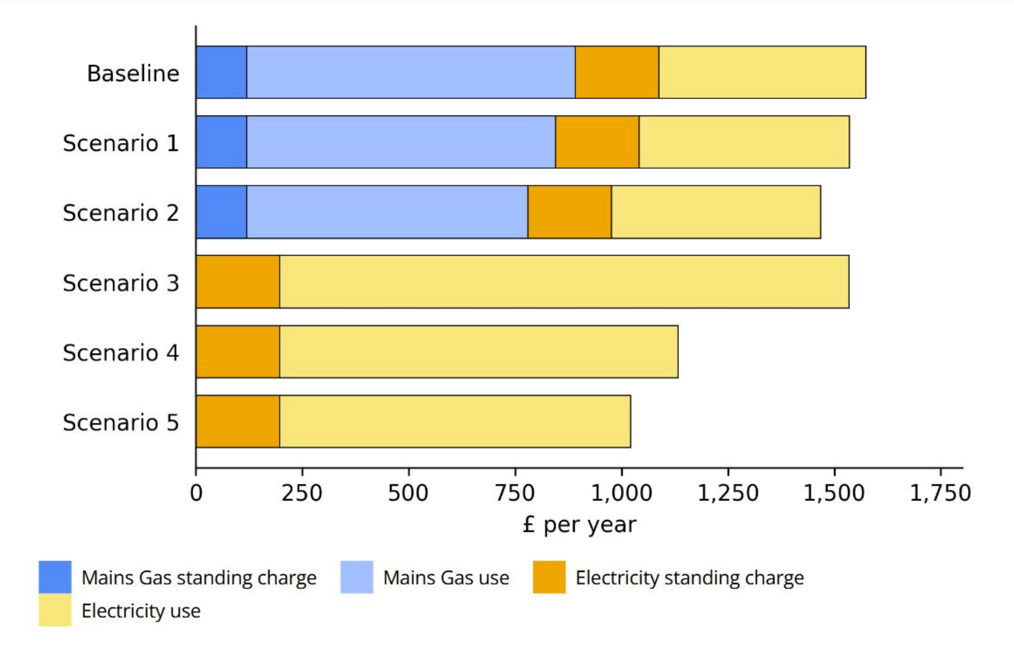


This graph shows the total energy use in the home per square metre of floor area per year. This is a useful metric for comparing homes against each other. The grey area to the left hand side of the graph are the targets for new build and retrofit developed by LETI.

The biggest improvements here are made by introducing a very efficient heat pump and reducing the heat loss from the home by improving the building fabric.

It is often harder in smaller homes when compared with larger homes to hit targets that are per square metre of floor area. The size of this home, at around 45 square metres of floor area, does mean it is harder to hit the LETI target shown here - though it almost makes it.

Underdwelling: Energy costs



This graph shows the estimated running costs of the home for each of the retrofit phases. You can see that the improvements in ventilation and draught proofing in the first two scenarios make a modest improvement in running costs.

Adding a heat pump in this case means running costs go up marginally. We have assumed that once electrically powered heating is installed, cooking is switched away from gas. This saves more money because it means the gas meter could be capped off and the gas standing charge stopped. Solar panel to offset running costs aren't a possibility here on an individual basis - the home has no roof and very little outdoor space.

The further fabric improvements set out in scenario 4 and 5 make the biggest difference to running costs here by cutting down on space heating demand. External wall insulation is modelled - though internal wall insulation with good airtightness may have a similar effect.

4: Overdwelling

The overdwelling is the companion to the under dwelling. It is built above and accessed on the opposite elevation, making use of the steep valley slopes. Commonly it fronts directly onto the pavement, though some houses may have a small set back from the street.

Entrance to overdwelling directly from the street.

Overdwellings are usually built as part of a terrace - with homes to either side and below. Unlike the under dwelling or the back to back, they are 'through terraces' with elevations to front and rear. The rear of the overdwelling is above the 'front' of the underdwelling. This allows greater cross-ventilation and greater access to daylight. Heat loss is also higher with two exposed elevations and the roof.

The rear elevation of the overdwelling is at a high level compared to the ground on that side. This means it is often very exposed. The rear side tends to be above trees and structures that might provide shade, so levels of solar gain are often high. This can lead to overheating. Cross ventilation is possible and can mitigate this. Windows at the rear of the 'ground floor' on the overdwelling can be left open to provide ventilation with few security concerns.

Wetting of the walls from wind driven rain is a an issue. This must be considered when insulating these walls. At a minimum pointing and gutters need to be kept in a good state of repair - though the height on the rear side also poses practical challenges, with scaffolding four storeys tall needed for any gutter or roof works.

The chimney stack also includes the flues from the underdwelling so is larger - meaning that floorspace in the overdwellings is constrained. The relationship between the rooms in the under and over dwellings can vary between homes and between terraces of homes - with cellars and other rooms 'interlocking' with each other. Understanding these arrangements in each home is important before embarking on any retrofit project - to understand especially the implication for fire separation and ventilation paths.

As with the back to back dwellings and the under dwellings, external space is often limited. This poses similar challenges for decarbonisation of heating - so communal, internal, or direct electrictric systems may need to be considered alongside standard individual air source heat pumps with external units.

4: Overdwelling

The retrofit options set out on this and the following page cover both fabric improvements and building systems and services improvements. We have generally assumed that work will be done in phases. These could be aligned with other upgrade, repair and maintenance work. In your home it might vary from the order suggested here, depending on your priorities and the context and condition of the building. It is also possible to do the work all in one go - if you have the budgets and capacity, and can perhaps live somewhere else while some of the work is done.

The rear elevation of overdwellings is often very exposed to sun, rain and wind.

Scenario 1: Airtightness and ventilation - Improving draught proofing and upgrading to a continuous ventilation system. Cross ventilation is possible here, but a planned system is still important. Thinking about how to enable secure night-time ventilation to enable cooling in heatwaves is also necessary.

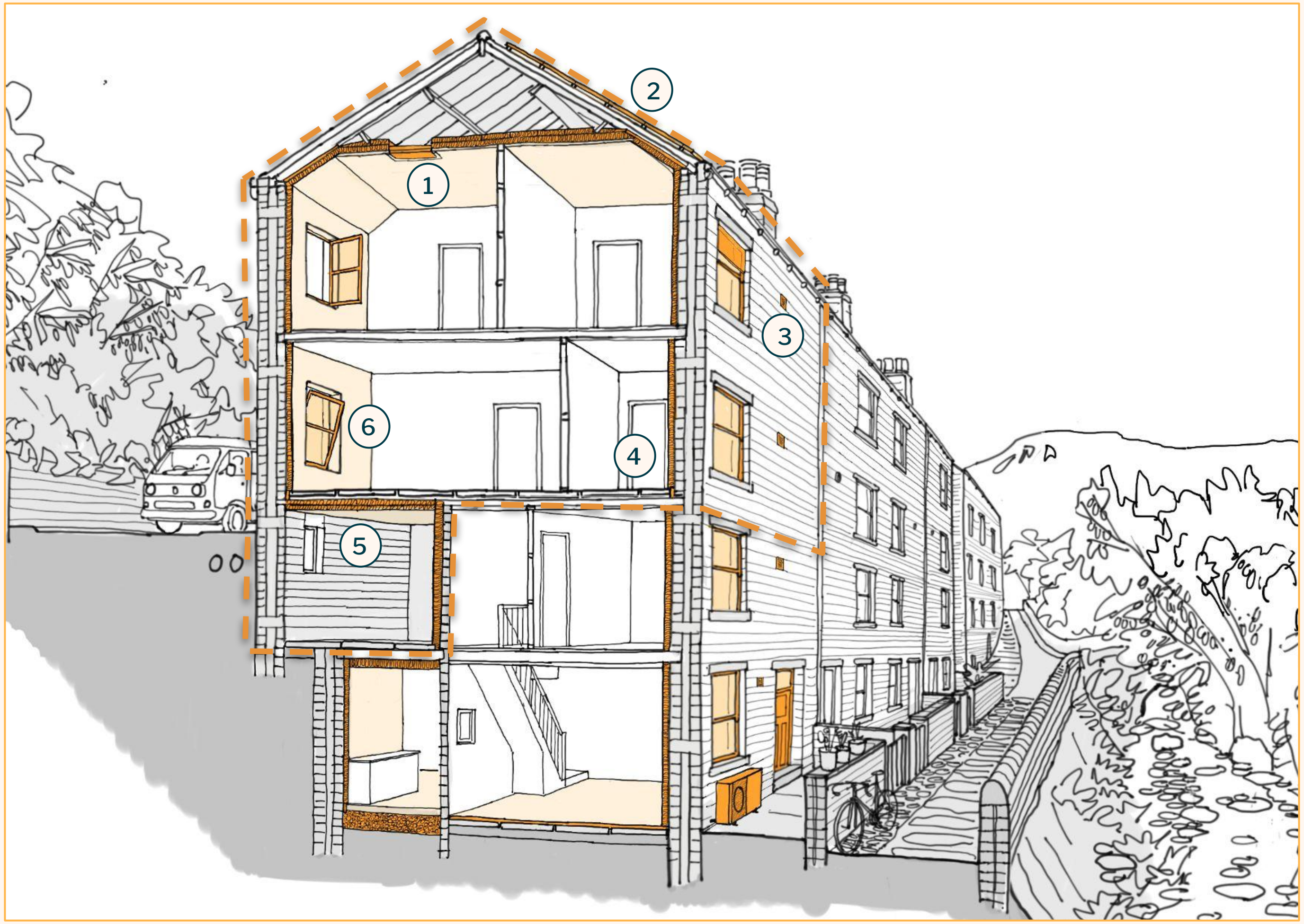
Scenario 2: Simple insulation - Topping up and making loft insulation airtight and making sure the loft hatch is also insulated and airtight. This shouldn't neglect the small areas of sloping ceiling on the top floor - so that this area doesn't become a cold spot where condensation and mould can form. Making sure the walls and floor that separate the living spaces from any cellar spaces are insulated and airtight - working from the cold side to minimise disruption if required. In an ideal world you'd combine all of this with the airtightness and ventilation work above.

Scenario 3: Heating - With little or no external space an air source heat pump would need to be wall-mounted. This is unlikely to be acceptable aesthetically or from a safety and maintenance point of view. Alternatives include a small internal heat pump for hot water with direct electric heating, or a shared ambient ground source heat pump as a whole block solution.

Scenario 4: Solar panels - Adding solar panels is an option to help reduce bills. Accessing the roof may be difficult and relatively costly given the height of scaffold required.

Scenario 5: Wall insulation and windows - These are best done together to allow better detailing of airtightness and insulation. Doing the windows first, using the scaffold for the PVs, is also an option, so long as this is planned and the windows are detailed to allow this. Internal wall insulation is shown - but external wall insulation to the rear may also be possible, as shown on the underdwelling example above.

4: Overdwelling



Overdwelling retrofit. Credit: A Gardner

1: Loft insulation is a good first step - but any areas of sloping ceiling and loft hatches should also be brought up to a good standard. Particular care should be taken to ensure insulation and airtightness works are continuous at the wall/roof junction.

2: Access to install solar panels can be tricky given on the rear the roof is 3-5 storeys above the ground. Carrying out any roof repairs at the same time would be sensible.

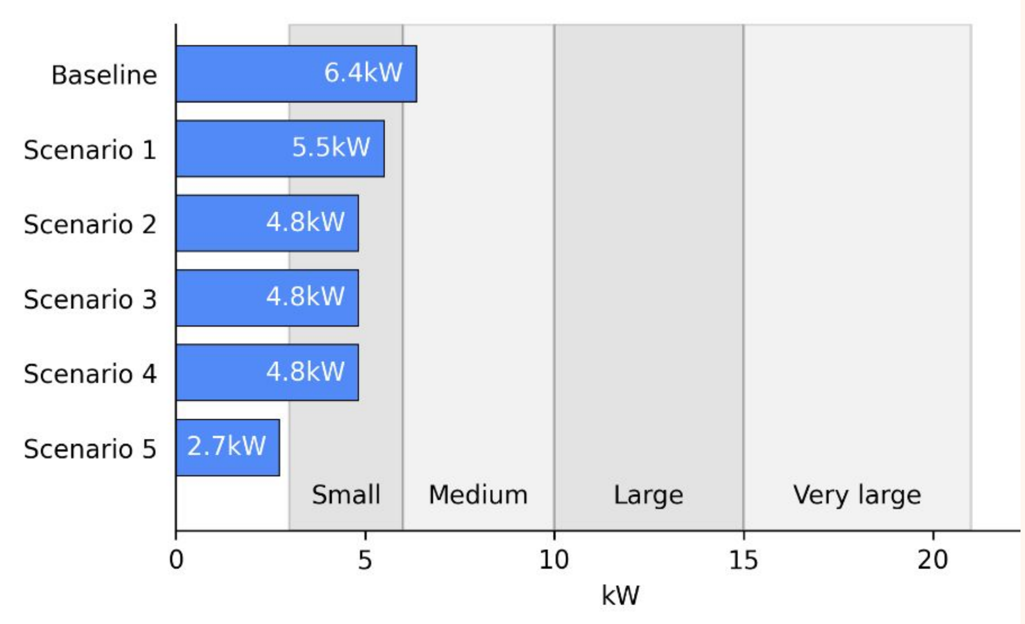
3: Especially where the rear elevation faces south, east or west upgrading to triple or high performance double glazing and adding shading will minimise overheating.

4: When planning insulation works it is important to consider fire and sound separation from neighbours, especially from the under dwelling below. Cooperation with neighbours may be necessary.

5: Generally we've assumed any cellars will be outside the heated envelope of the building, so the walls, floors and doors between this and living spaces should be insulated and made airtight. The cellar will need to be well ventilated to help manage moisture risks - and the relationship to external ground levels carefully considered in detailing.

6: Windows that have a secure vent option can help improve cross ventilation.

Overdwelling: Peak heat load

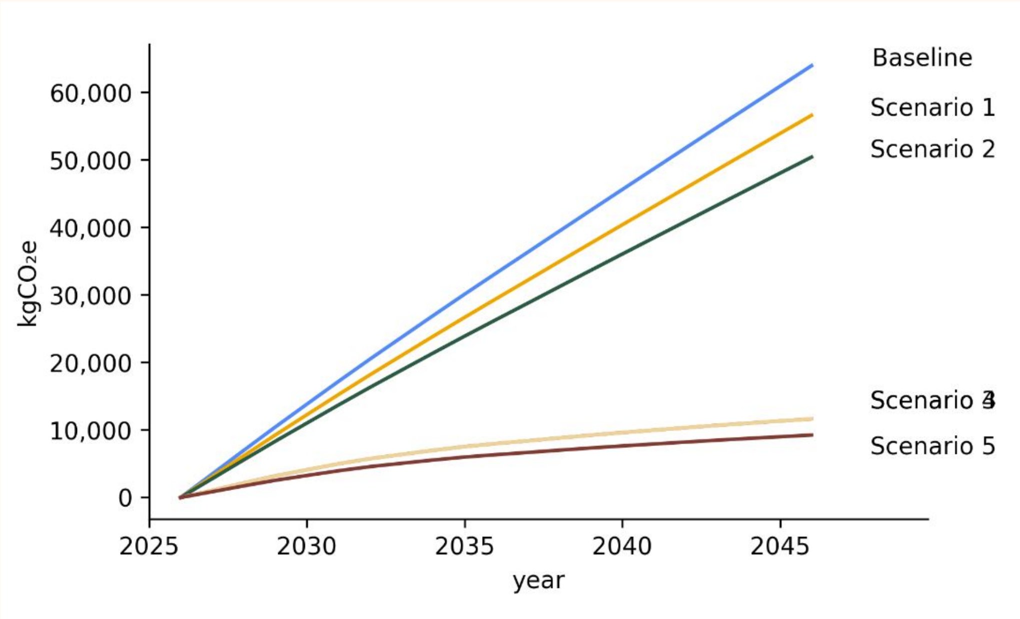


This graph shows the output needed from the heating system to keep the home warm on the coldest day of the year. It provides an approximate indication of the size of heating system that would be required.

In all of the scenarios modelled, it would be very possible for an air source heat pump to meet this requirement. The challenge in this home is that there is no outdoor space, so finding room for the external unit for a heat pump is unlikely to be possible.

We've modelled a communal loop heat pump system - but combinations of small internal heat pumps and direct electric for heating would also be possible. The very low peak heat load in scenario 5 makes this more possible. Though it is not as affordable to run as a heat pump, the demand is so low that it may be possible to manage.

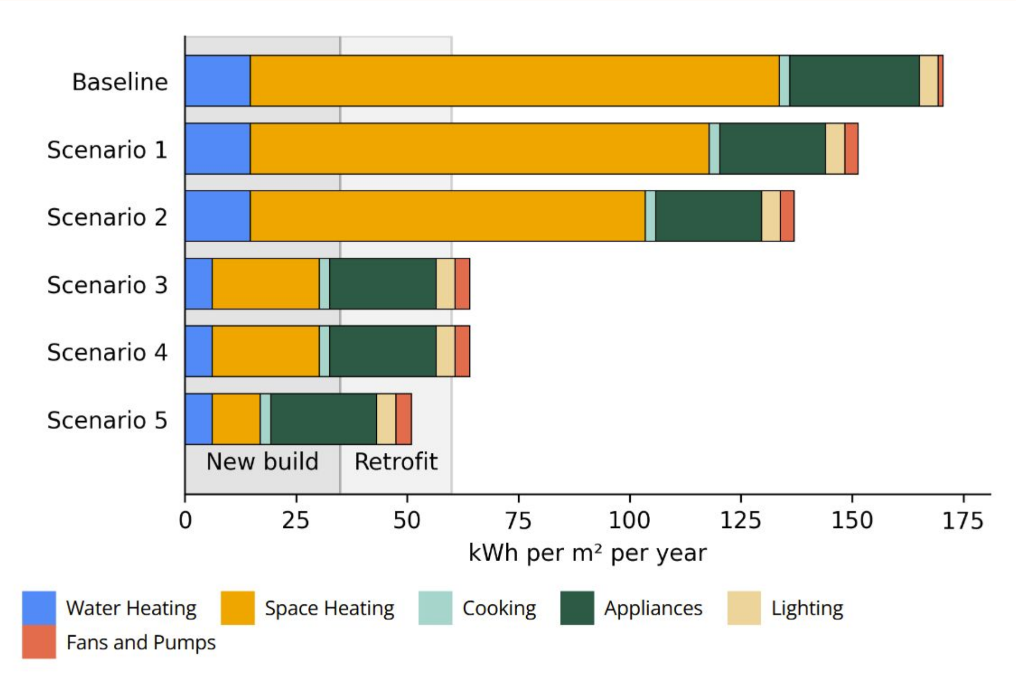
Overdwelling: Cumulative carbon emissions



This graph shows the carbon emissions over time associated with running all of the systems that use energy in the home. This includes heating, ventilation and lighting - but also an estimate of the energy used for cooking and appliances.

Scenarios 3, 4 and 5 are where the biggest difference is made, when electric heating is introduced in the form of a communal loop ground source heat pump. This would be relatively complex and expensive to install, but has lower operational carbon emissions than direct electric heating. In all of these one of the biggest challenges will be fitting equipment into the home. Communal systems with minimal equipment are likely to be most attractive. Though many overdwellings have access to cellar spaces in which it may be possible to house some equipment if it is well insulated and well installed.

Overdwelling: Energy use intensity

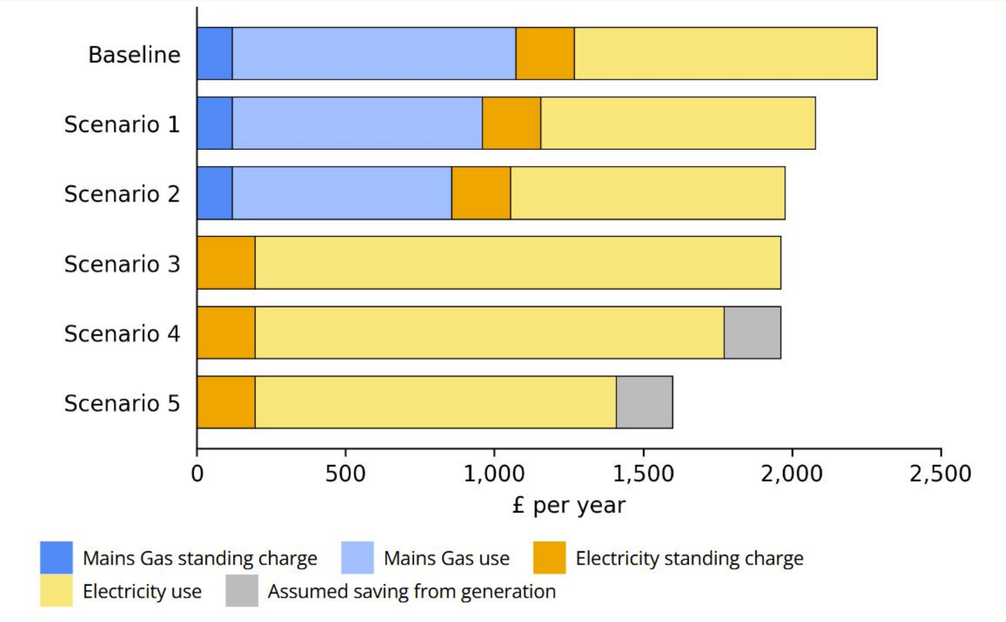


This graph shows the total energy use in the home per square metre of floor area per year. This is a useful metric for comparing homes against each other. The grey area to the left hand side of the graph are the targets for new build and retrofit developed by LETI.

The biggest improvement here is made by introducing a very efficient heat pump. Further improvements are made by reducing the heat loss from the home by improving the building fabric.

In this slightly larger home of around 100 square metres floor area, it has been shown to be possible to meet the LETI target. If direct electric heating was installed rather than a heat pump this is unlikely to be the case.

Overdwelling: Energy costs



This graph shows the estimated running costs of the home for each of the retrofit phases. You can see that the improvements in ventilation, draught proofing and insulation in the first two scenarios make a modest improvement in running costs.

Adding a heat pump in this case appears to make very little difference to running costs, while adding solar panels should result in some savings. If you are able to access dynamic or time of use tariffs it may be possible to make greater savings, but in this model we have just assumed a standard electricity and gas costs throughout. We have assumed that once electrically powered heating is installed, cooking is switched away from gas. This saves more money because it means the gas meter could be capped off and the gas standing charge stopped.

The further fabric improvements set out in scenario 5, adding wall insulation, make a difference to running costs here by cutting down on space heating demand.

5: Weaver's cottage

These are simple two storey homes. These are often some of the older homes in the Calder Valley, and some of the most likely to be listed to protect their heritage. They often have a cellar and some have attic rooms.

Weaver's cottage showing one blanked out window. Photo credit: A Gardner

These homes are usually built in short terraces, on some of the less steep slopes in the valley. Like many of the homes above they often open directly onto the pavement or onto a small 'entry' area at the front. At the rear small private yards are common - built into or onto the slope.

Flooding was an issue in some of the homes surveyed for this guide - with a sump pump installed in cellars to manage this. Though this is unlikely to be limited as an issue just to homes of this type in the area.

These homes were built at a time when it was still common for weavers to work from home, so they have rows of windows that let in more light for working at looms in the domestic textile industry. Though in many cases one or more of these windows have now be filled in, this still means that there is a high proportion of glazing to wall area. This means upgrading the windows can usually have a larger than usual impact on heat loss and comfort. Large gritstone mullions and surrounds frame the windows and doors. If insulating walls these need to also be insulated to avoid creating a thermal bridge that would increase heat loss and so risk condensation and mould.

Like many of the older homes in Calderdale, walls tend to be stone. These thick stone walls should not be thought of as 'solid'. Many have a dressed stone front, with a random rubblestone inner leaf and 'fill'. This means there are small gaps and cracks throughout the wall. These can mean the wall has greater insulating properties than assumed, but it also means that 'thermal bypass' of external insulation is a greater risk. This is where air moves around within the wall, literally bypassing the insulation and reducing its effectiveness. The thickness of the wall also means that there is a greater risk of thermal bridging at the ground and where the wall meets the roof. This all needs careful design and detailing if adding external wall insulation especially.

As older buildings, these homes tend to also have large format stone 'slate' roofs, rather than the smaller format standard slate that is more common in homes built after the railways arrived. These need careful handling in any building or retrofit project.

5: Weaver's cottage

The retrofit options set out on this and the following page cover both fabric improvements and building systems and services improvements. We have generally assumed that work will be done in phases. These could be aligned with other upgrade, repair and maintenance work. In your home it might vary from the order suggested here, depending on your priorities and the context and condition of the building. It is also possible to do the work all in one go - if you have the budgets and capacity, and can perhaps live somewhere else while some of the work is done.

Photo:
stone mullions to windows.

Scenario 1: Airtightness and ventilation **-** Improving draught proofing and upgrading ventilation system. These two measures work well together to improve comfort and indoor air quality, managing moisture. Treatment of any unused chimneys, vents and flues should be included in this.

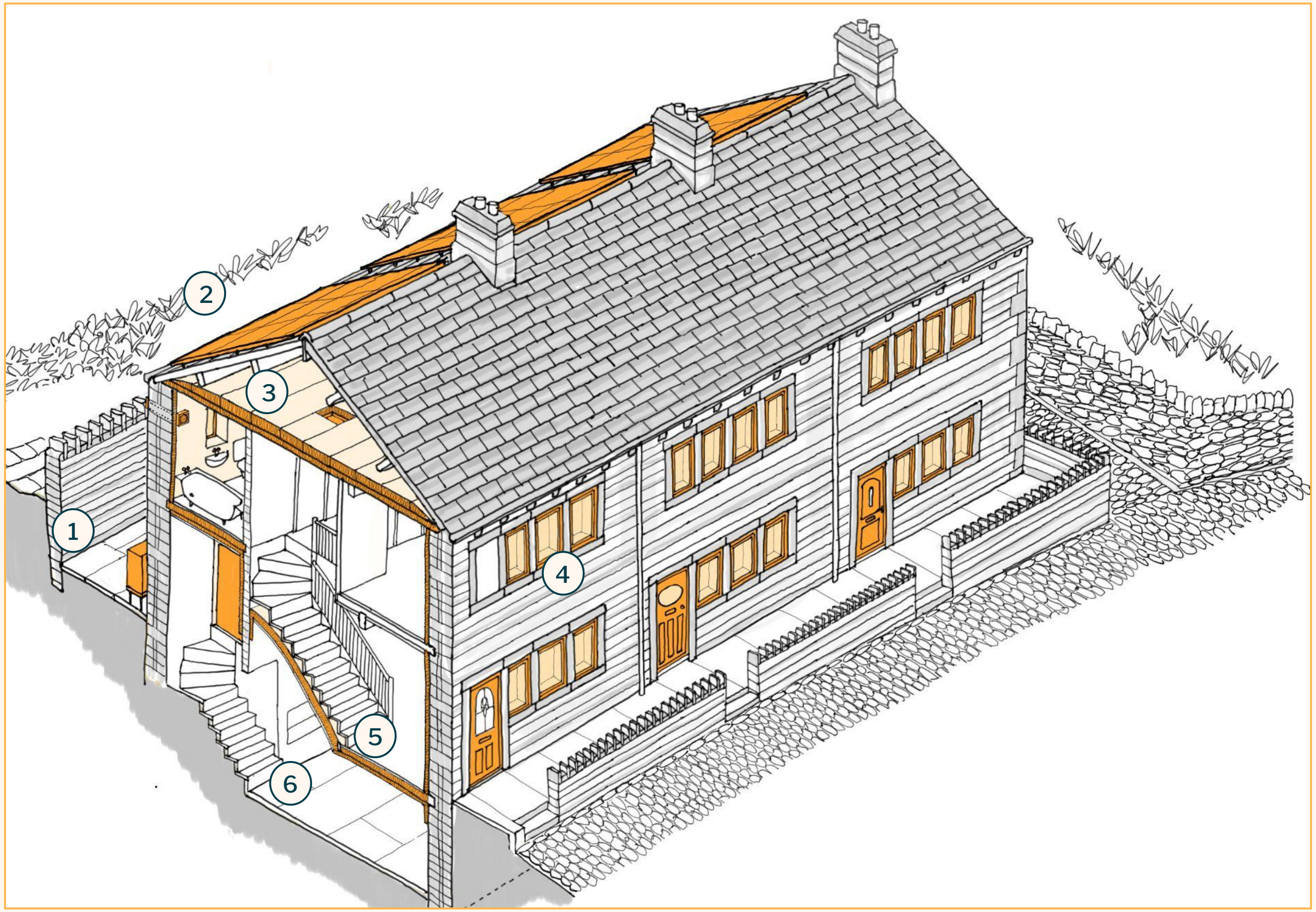
Scenario 2: Simple insulation - Topping up and making loft insulation airtight and making sure the loft hatch is also insulated and airtight. Making sure the walls and floor the separate the living spaces from any cellar spaces are insulated and airtight - working from the cold side to minimise disruption if required. In an ideal world you'd combine all of this with the airtightness and ventilation work above.

Scenario 3: Heating and solar panels - These homes usually have private outdoor space with room for an air source heat pump. A shared ambient loop or a combination of direct electric heating and small internal heat pumps are alternatives. As older homes there is likely to be some heritage sensitivity here. The planning authority may required solar panels just to rear roof slopes or panels that sit in line with the roof covering rather than on rails above it.

Scenario 4: Windows and doors - Individual windows are small but take up a significant proportion of the external wall. When deciding the glazing type there may be heritage limitations, but daylight and orientation should also be considered. Triple glazing may be beneficial for south-facing windows to control solar gain.

Scenario 5: Wall insulation - Given the potential heritage restrictions, and the rubblestone nature of the walls, we've shown internal wall insulation. Internal wall insulation can be disruptive, but has the advantage that it can be done room by room.

5: Weaver's cottage



Weaver's cottage retrofit.
Credit: A Gardner

1: The external unit to the air source heat pump, shown to the rear here, can be at a higher level if required to take it out of any flood zone.

2: Most of these homes have accessible roof space - though in some cases it might face the wrong way or be too shaded to really benefit from solar panels. There may also be heritage concerns, with in-roof panels being an option to minimise visual impact.

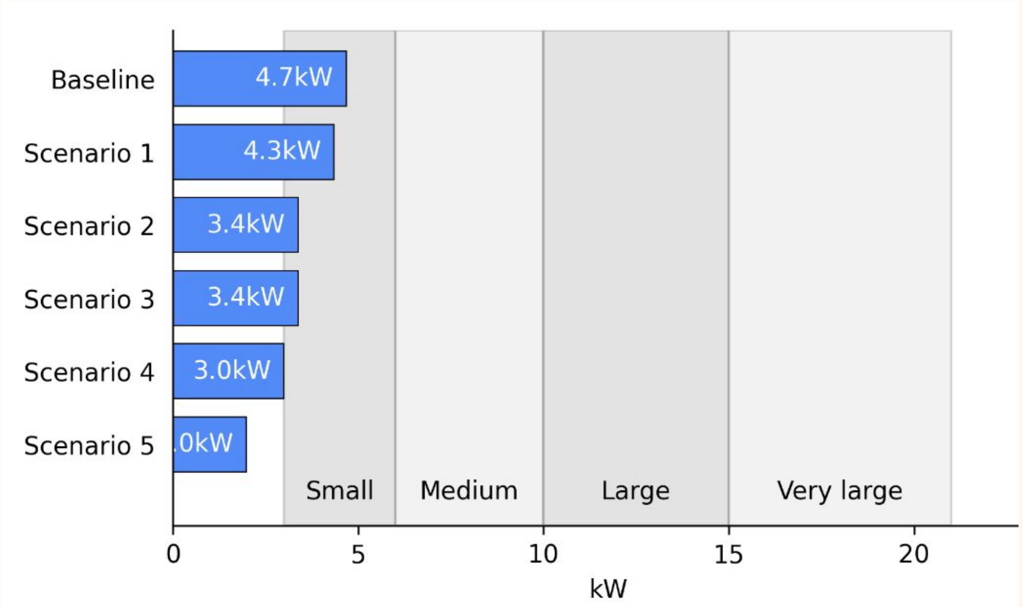
3: Loft insulation fitted with airtightness and attention to detail in how it meets the walls. This may be simpler with internal wall insulation than with external wall insulation, the the latter may be possible to the rear.

4: Upgrading windows must be done with care. In listed properties triple glazing might not be permitted permitted and thinner double glazed units have to be used. Vacuum glazing is an option, as is secondary glazing. The stone surrounds to the window also need to be considered to avoid cold spots with condensation.

5: Internal wall insulation to the front can include insulation to window surrounds. Care should be taken at ground level to manage moisture risks where the external surface is paved and close to the level of the internal floor.

6: The cellar is separated from the living spaces by insulation and airtightness work. Given limited floor space, with care it could house some heating equipment.

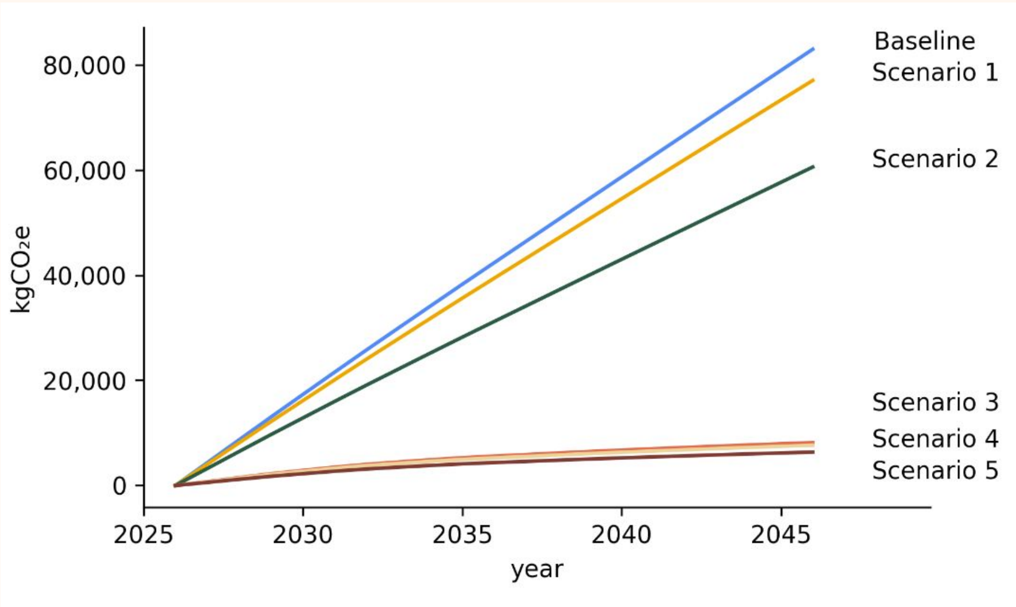
Weaver's cottage: Peak heat load



This graph shows the output needed from the heating system to keep the home warm on the coldest day of the year. It provides an approximate indication of the size of heating system that would be needed.

In all of the scenarios modelled, it would be very possible for an air source heat pump to meet this requirement - and a smaller unit generally. Though the peak heat load does drop very low, because in this type of home there is usually some external space, we have assumed a heat pump can be fitted. However if this was restricted for space or heritage protection reasons, as with some of the homes above, some use of direct electric heating would also be possible.

Weaver's cottage: Cumulative carbon emissions

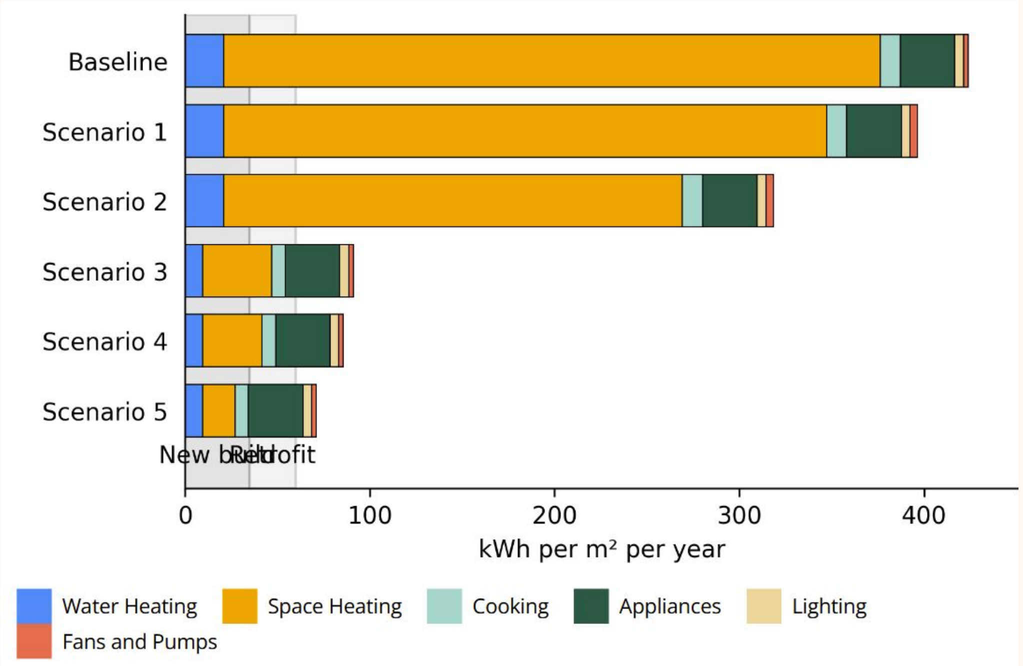


This graph shows the carbon emissions over time associated with running all of the systems that use energy in the home. This includes heating, ventilation and lighting - but also an estimate of the energy used for cooking and appliances.

Though the insulation works in scenario 2 do make a difference - and would be particularly noticeable in terms of comfort - Scenarios 3, 4 and 5 are where the biggest difference is made. This is due to electric heating being introduced in the form of an individual air source heat pump.

Upgrading the windows and doors makes a marginal improvement. For this reason generally we'd recommend that especially in homes where heritage is a major concern windows and doors are only changed at the end of their useful life when they are beyond repair, or if they are very poor single glazing. Likewise upgrading wall insulation might be done just when other works and replastering is planned.

Weaver's cottage: Energy use intensity

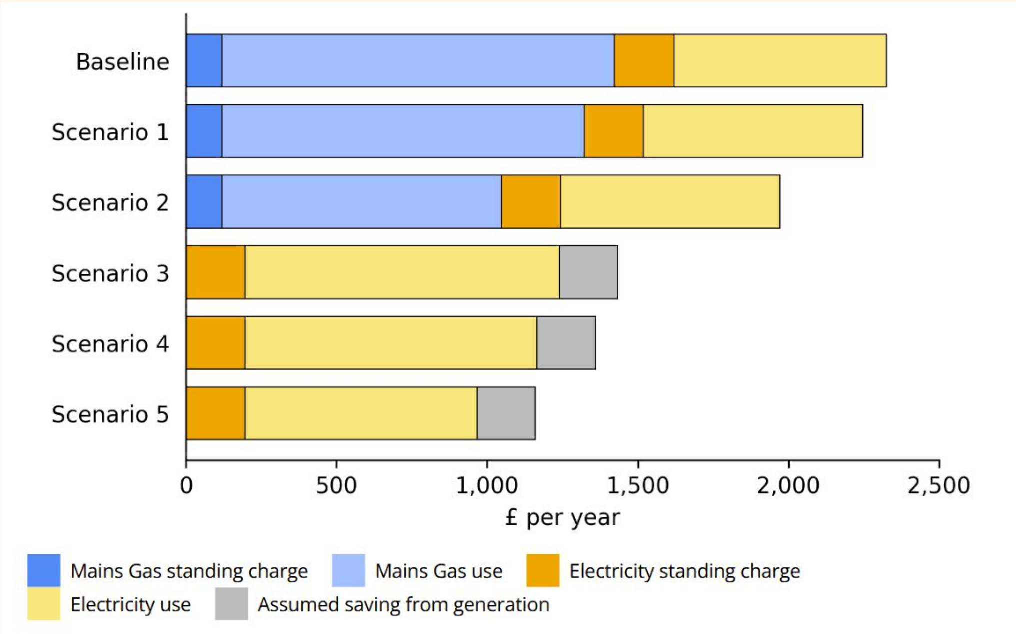


This graph shows the total energy use in the home per square metre of floor area per year. This is a useful metric for comparing homes against each other. The grey area to the left hand side of the graph are the targets for new build and retrofit developed by LETI.

The biggest improvement here is made by introducing a very efficient heat pump. Further improvements are made by reducing the heat loss from the home by improving the building fabric.

It is often harder in smaller homes when compared with larger homes to hit targets that are per square metre of floor area. The size of this home, at around 50 square metres of floor area, does mean it is harder to hit the LETI target shown here - though it almost makes it.

Weaver's cottage: Energy costs



This graph shows the estimated running costs of the home for each of the retrofit phases. Improvements in ventilation, draught proofing, and insulation in the first two scenarios make a modest improvement in running costs. Adding a heat pump appears to reduce running costs. In this case this is because it is efficient at space heating, but also because it has replaced a direct electric shower, so is also much more efficient and cheaper for water heating. Adding solar panels should result in some further savings.

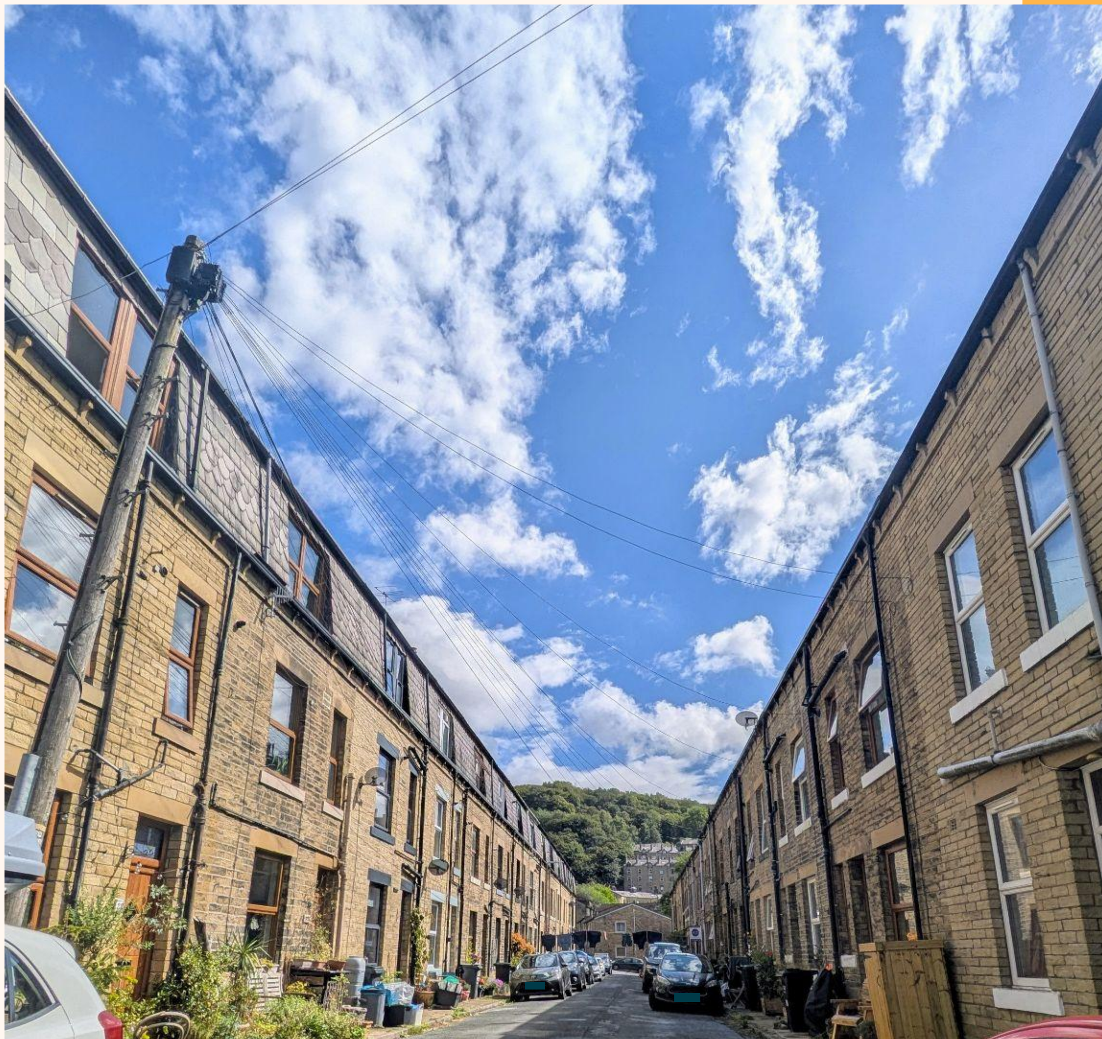
If you are able to access dynamic or time of use tariffs it may be possible to make greater savings,. We have also assumed that once electrically powered heating is installed, cooking is switched away from gas. This saves more money because it means the gas meter could be capped off and the gas standing charge stopped. The further fabric improvements in scenarios 4 and 5, replacing windows and adding wall insulation, make a smallish difference to running costs but would also improve comfort.

Common concerns

Across all homes in Calderdale there are some common issues that need to be considered when planning a retrofit or refurbishment project.

The following pages set out some of the issues you should consider when planning work in your own home.

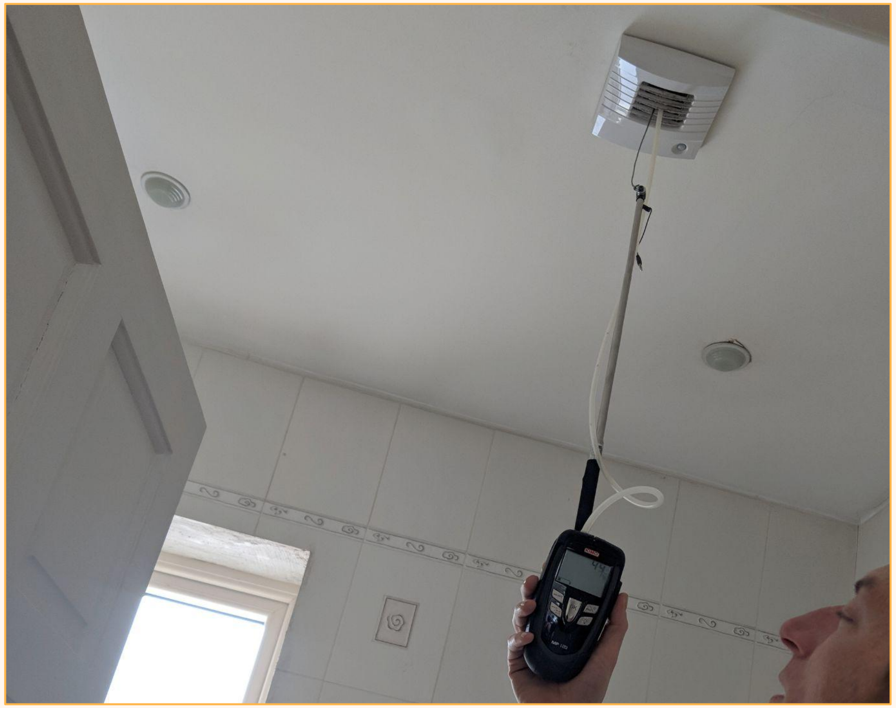
These are all relevant whether your home looks like the homes on the pages above or is a more recent home that looks more like the average semi-detached, detached, or terraced home in the rest of the country.



Street of 'back to back' homes in Hebden Bridge

Ventilation and indoor air quality

Having an effective and well planned ventilation system is important in any home. In Calderdale, where humidity can be high and where radon is a risk in some areas, it is even more important. Some homes are single sided, meaning that cross ventilation isn't possible, to remove pollutants or control humidity. Where homes are built against the ground this can increase the amount of moisture entering homes. Ventilation can help manage humidity, improving indoor air quality and reducing the risk of condensation and mould.



It's important that ventilation systems are well designed and installed. They should also be commissioned and tested once installed to make sure they are working as intended.

Ventilation options
Mechanical Extract Ventilation (MEV) or Mechanical Ventilation with Heat Recovery (MVHR) both offer planned and continuous ventilation. Providing fresh air and extracting moisture and pollutants. MEV just draws air out through mechanical fans, with fresh air supplied passively. MVHR provides balanced supply air, passing this over a heat exchanger next to the extract air so that some of the heat from the outgoing air is recovered. Which option is right for your home is likely to be a decision based as much on the practicalities of duct runs and budgets as it is about energy performance. In all cases systems should be properly designed and carefully installed and commissioned. (This is all covered by Part F of the Building Regulations). You should seek specialist advice if your home is at risk of high levels of radon as additional work may be needed to achieve better indoor air quality.

Ventilation and airtightness
Good draught proofing or airtightness work and ventilation are not in opposition. 'Build tight and ventilate right' is a good rule to follow. This will help reduce heat loss and risks to the building fabric through unplanned leaks. But also having a more airtight home helps all types of ventilation system work better, because air is more likely to follow planned paths, rather than bypassing them. Draughtiness is no guarantee of good air quality.

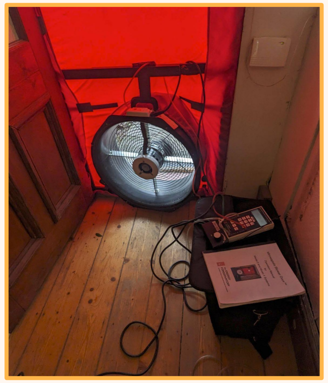
Chimneys, flues and stoves
Any airtightness and ventilation strategy needs to also consider planned ventilation that supports appliances like woodburning stoves. These need a good supply of air to burn safely and efficiently. (This is covered by Part J of the Building Regulations). Though there is mounting evidence that burning anything in your home damages air quality, so removing these or using them only in emergencies should be considered. Unused chimneys should be treated so that they don't create a path for significant heat loss.

Draught proofing and airtightness

Draught proofing or airtightness work and ventilation are not in opposition. When done well, they work together to create a comfortable home. Installing a ventilation system that works for your home as described on the previous page is important. Carrying out draught proofing and airtightness work will help this system to work more effectively.

Some of this work may be quite simple to do with readily available DIY materials. Some might require a more invasive approach, for example by removing and sealing behind skirting boards and window surrounds. Older homes have a reputation for being very leaky, though in many cases they perform better than this might suggest. This is especially true of homes with solid floors and wet plaster on walls. In retrofit we'd normally recommend aiming for at least an AP50 of 5, and better than that wherever possible. An AP50 of 2 or less is best to support the functioning of your ventilation system - but this isn't always possible. The lower the number, the better the performance:

- **7-18 (most between 8 and 12):** This is a typical existing UK house. It varies a lot by construction type and quality as much as by age. 18 is poor. 7 is reasonably good. Most homes are in the 8-12 range.
- **8:** This is the backstop value in the current Building Regulations for new homes.
- **5**: This aligns with AECB Retrofit Standard Step 1. Should ensure 'long and low' heating from heat pumps is comfortable.
- **2**: Normally only achieved through a deep retrofit, with complete external or internal retrofit measures. Aligns with the full AECB Retrofit Standard, Step 2.
- **1 or less:** As above but with exceptional attention to detail. EnerPHit, Passivhaus retrofit standard



It's difficult to know how airtight your home is without carrying out a test. This is usually done by fitting a large fan over a doorway and then pressurising or pressuring the home. Doing this has the advantage of letting you see where the leaks and gaps are, especially if combined with a thermal imaging camera or smoke pencil. This helps you know where the problem areas are you need to tackle.

Low carbon heat

The biggest step most people can take to reduce carbon emissions from their home is to move away from using fossil gas heating to a heat source that uses electricity. This is because the electricity grid is decarbonising and using more renewables. In many cases this will involve a heat pump of some kind. This is an old technology - using the same principles that make your fridge work. But it's new to many UK homes, so it may take some planning and adjustments to everyday practices.

It's possible to fit heat pumps on terraced homes where neighbours are close - though it's easier if a smaller heat pump is needed such as the 6kW unit shown here.

Changing heating temperatures and patterns
Heat pumps and modern condensing boilers are most efficient when the temperature of water they supply to radiators is low - below 55ºC and ideally around 45ºC or less. Weather compensating controls can allow this to reduce further when it is warmer outside, so the system can run most efficiently. 'Long and low' is often a more effective and efficient pattern of heating than the short intense bursts of high heat that were the common way of running older gas boilers.

Moving to a 'long and low' heating pattern should also mean greater comfort and better moisture management. There is less of a cycle of rapid swings in relative humidity and temperature. A constant steady heat is more likely to lead to building fabric gently drying out over time - so supporting the thermal performance of walls and floors. If you only have your heating on for a limited time at the moment this may increase your energy use and your bills - but if you are heating fairly continuously already you may notice little difference or even make a small saving.

Radiators running at lower temperature emit significantly less heat; a radiator at 45°C emits about one third of the heat of a radiator at 75°C. This means you may need to upgrade your radiators to more modern or larger versions. In extreme cases, radiators may need to be impractically large. This may make better insulation worthwhile so that smaller radiators can be fitted.

If you have an existing condensing combination boiler you may be able to test this by adjusting the flow temperature on your current boiler. This will also improve the efficiency of your boiler now. See the quick wins section below for details.

It is worth thinking of this as you plan and phase your works, even in advance of fitting a heat pump. For example, if you are insulating a suspended timber floor - at ground level or above a cellar - it might make sense to upgrade radiators and pipework at the same time. This would make use of the access provided by lifting floorboards.

Individual heat pumps
Heat pumps come in a variety of sizes. Even if your home has high heat losses, it may still be possible to fit a heat pump; the heat pump will just need to be big enough to match the heat demand. Larger heat pumps in homes with higher heat demand will use more energy and will cost more to run and may cost slightly more to install.

A limiting factor on the suitability of a heat pump may be your home's connection to the electricity grid. This should only be the case in large and very poorly insulated homes or in some isolated locations.

There might also be restrictions in the amount of space you have available for the external part of the unit. Noise can also be a limitation if your heat pump is close to living spaces and neighbours. There are requirements to meet minimal levels of noise both as part of planning requirements and as part of the Microgeneration Certification Scheme, which is a requirement to access some funding for heat pumps.

For all these reasons, we usually recommend that you aim for your home to have a peak heat load of less than 10kW, and preferably around 5kW.

If designed, installed, and commissioned correctly so it operates efficiently, a heat pump should cost about the same to run as a mains gas boiler, all other things being equal. It might be possible to run a heat pump more cheaply by accessing different electricity tariffs. 'Time of Use' and 'Dynamic' tariffs are where the price changes at different times of the day. In a reasonably well insulated home it should be possible to shift when your heat pump uses energy to take advantage of this - using energy when it is cheaper. Some suppliers also offer special heat pump only tariffs.

If your priority is to reduce carbon emissions, then just replacing your current fossil fuel system with a heat pump will make a big difference. If your home is already reasonably well insulated and you don't plan to do much more to the fabric this can be a good solution.

If you fit a heat pump now, but want to add insulation later, it might mean that your heat pump will be over-sized and no longer work as efficiently. It is therefore important to plan for this, and choose a system that is able to match reduced loads.

Shared heat pumps
It won't be possible for every home to have its own standard air source heat pump. Where there are groups of homes close together, communal systems can be a good alternative. A single central heat pump, which is most often a borehole based ground source heat pump, generates a low level of 'ambient' heat. This is circulated to homes in the system through shared pipework. Because of the low temperature the losses are low, so the system is more efficient than old-style high temperature district heating.

In each of the homes a smaller heat pump upgrades this heat to make it usable for space heating and hotwater. No heat metering is needed - each home just pays for the electricity to run their individual heat pump, and they are free to choose their supplier for this as normal. There is no need for external equipment on each home and the amount of space needed inside is fairly minimal. This makes it potentially ideal for tightly packed terraced housing as exists in Calderdale. It does have some challenges though. The big ones are organisation, funding and coordination - systems most cost effective when more homes join them, sharing the central heat pump and pipework. Fitting the shared pipework in roads and footpaths can also be disruptive and challenging, perhaps especially on some of the steeper hills around Calderdale. But it is a potential solution that could be explored.

Direct electric and storage heaters
As the electricity grid decarbonises, all forms of electric heating become low carbon. Heat pumps are preferable because they are usually cheaper to run and demand less from the grid, making better use of the renewable energy available. However, where these are not possible various forms of direct electric heating can be a good alternative - especially in smaller and well insulated homes where demand is low. Storage heaters can allow cheaper electricity to be used - and are generally much improved from the old 20thC models!

Woodburning and solid fuel stoves
Burning wood emits more carbon dioxide than burning coal. To be counted as low carbon, emissions would have to be reabsorbed by new growth trees and plants - which is not guaranteed. It is perhaps a questionable form of offsetting. We'd generally discourage the fitting of new woodburners.

Walls and moisture management

One of the best things you can do to improve the energy efficiency of your home is make sure the walls are dry. Calderdale is also in an area where high levels of wind driven rain and frost are common, both of which lead to greater wetting and potential damage, making this even more important.

Images clockwise from top left: *1. A gutter joint with a leak where a new and old gutter meet, causing dampness in the stone wall. 2. A clipped verge - the edge of a roof at the gable - showing staining where wind driven rain is making the wall damp. 3. Evidence of high levels of moisture in walls at ground level where rain hits paved areas and bounces up onto walls. 4. Areas of damp on internal walls caused by poor drainage at ground level where walls are partially against the ground.*

Making sure roofs are in good condition is the first and most important step in protecting walls. Detailing in Calderdale often involves minimal overhangs, with clipped eaves and verges. If these are not well detailed and kept in good condition, that can lead to damage and damp. Given the changing climate and increased rainfall expected in coming years it may even be sensible to revisit and modify traditional approaches. Adding lead flashings to verges and eaves that previously might have just relied on mortar and pointing to keep the rain out.

Gutters are historically wooden and painted black. They are often held in place by stone corbels rather than modern style clips or fixings. Modern plastic replacements with the same profile are available, but it can be difficult creating a decent join with neighbouring wooden gutters in poor condition so there are often gutter leaks. As the eaves are very narrow this can easily lead to the wall becoming saturated.

Soft landscaping and gardens are rare. Paved areas often run right up to walls, with rain splashing up and increasing the risk of damp. This can be addressed through careful detailing - though will need to be examined on a case by case basis.

Stone is a common building material in Calderdale. This is more porous than modern brickwork, making moisture management even more important. This would normally be used in combination with lime-based mortar for pointing, which enables moisture to escape and protects the stone by acting as a sacrificial element. Where this has been replaced with cement pointing this can cause problems.

The example homes above are all solid or rubblestone walls. However cavity walls are also common in Calderdale. Cavity walls were adopted in the 19th century in this region as a way of protecting from driving rain and helping walls to dry. It is important to understand what kind of wall you have before making plans to insulate it.

Walls insulation

Insulating walls can make a big difference by dramatically reducing heat loss. This raises surface temperatures, improves comfort and can cut energy bills. The climate and wall construction types in Calderdale means that extra care needs to be taken when insulating walls to protect them and the other structures around them from damage due to wetting and frost. Before wall insulation is carried out, all of the issues highlighted on the previous page should be addressed.

Using lime renders and plasters and insulation materials like woodfibre boards needs different skills to more standard drylining used in modern buildings - so training can be provided.

'Solid' walls

Many homes in Calderdale have solid walls of stone or brick, often 400mm thick or more. However, some of these may be less solid than they appear at first glance. Older stone walls especially tend to have a 'rubblestone' fill. This means that the outer face of the wall may be fairly neat or more random dressed stonework, while the inner face is made up of more random stone, but the central zone is just packed with looser smaller pieces of stone and often contains gaps and small cavities. The thickness of the wall is also a key consideration - especially in understanding the detailing at the foot and the eaves and whether internal or external wall insulation is preferred. If insulating thick walls, making sure not to create problem cold bridges at the head of the wall or at the foot is important. This is sometimes easier to achieve with internal wall insulation rather than external wall insulation. The porosity of the stone or brick is another key concern when thinking about insulation. Solid walls finished with lime mortars and plaster are able to dry out over time. Some have been damaged by using cement or gypsum based materials that prevent this drying action. When insulating these kinds of walls, it's important to use materials that don't block this drying action. Materials like woodfibre and hemp, with lime based plasters and renders, are often the most appropriate. These allow drying to still occur, minimising the risk of problems with trapped moisture. The amount of insulation is also a key consideration. Using a thinner layer of insulation that is well detailed and airtight is often a better solution for the health of the building and energy performance than using thicker but poorly detailed and insulation where airtightness is not considered.

Cavity walls

Calderdale also has many cavity walls, including some that are approaching 200 years old! Cavity wall insulation may be a possibility in some cases, but this should be done with extreme care and caution. The very exposed climate and the use of softer materials like stone makes cavity wall insulation more risky and standard approaches that are used elsewhere are unlikely to be suitable in many cases.

Climate adaptation

The UK's climate is changing, with summers becoming hotter. This means more of our homes are at risk of overheating. At the same time rainfall intensity is increasing. This affects building fabric and also in many places like the Calderdale it is increasing the risk of flooding. All of these factors should be considered when planning retrofit works, alongside thinking about energy use and carbon emissions.

Credit: A Gardner

Rainfall and flooding

As seen above, managing rainfall well is a key concern in the retrofit of homes and in keeping buildings in a good state of repair. As part of a retrofit it may be possible to improve this. For example by adding waterproof flashings or upgrading and repairing roof level details to make them more robust or by adding larger capacity gutters and rainwater drainage systems.

As well as water damage to buildings, flooding is a risk in a lot of Calderdale. Adding water butts can also help reduce flood risk by reducing surface water runoff. Making sure that ground level drainage is in good working order is also important, not blocked or damaged. You should also consider the materials used for ground surfaces. Adding hard surfaces should generally be avoided, as this increases surface water run off.

If you are in a flood risk zone, then this should be considered in any retrofit plan. You might be able to include work that makes your home more resilient to flooding. This might include using lime-based plasters that can more easily dry out after flooding, using floor coverings that are resilient like tiles, and also thinking about running electricity and other services at a higher level. It might also affect your choices for floor and wall insulation work.

Overheating

Though it may come as a surprise, as the climate changes homes in Calderdale are increasingly prone to overheating - especially in rooms on south-facing valley sides. While insulation, airtightness and improved ventilation and shading will all help to limit this, there are some simple steps you can take to manage and mitigate overheating risk on a DIY basis: https://www.heatwavetoolkit.com/home

Quick wins

Many of the retrofit works outlined in this guide are fairly extensive and may be expensive and disruptive. We understand that they may appear overwhelming or be beyond the budget of many people. However this doesn't mean there is nothing you can do. We've set out here some of the simple things you can do with limited time and budget to improve energy efficiency, reduce carbon emissions and help make a healthier home.

Building maintenance: Making sure your home is in good repair is one of the most important steps you can take to making it more energy efficient and healthy. Check and clear gutters and rainwater downpipes. This helps to avoid making your walls wet and cold through leaks. Unblock air-bricks that provide ventilation below suspended timber floors and check ventilation paths in your attic or cold loft space. Make sure that seals around windows and doors are in good condition - these do need to be renewed from time to time. Make sure that your roof is in good condition, fixing slipped tiles or damaged leadwork and flashing promptly. This will all help to keep your home warm and dry.

Ventilation: Make sure your home's existing ventilation system is in good working order. Clean dusty fans and make sure windows are openable and not painted shut. Make sure you use your system, by switching on cooker hoods and bathroom fans when you need to. This should improve the air quality in your home.

Basic draught proofing: Fitting key hole covers and draught-proof letter boxes can make a big difference to comfort, especially if your front door opens straight onto your living room. Door curtains and fabric draught excluders at the bottom of external doors and cellar doors can also help. None of these things are invasive and they are often easy to fit and can be removed and packed away in the summer if needed. Simple DIY strips around door and window frames and around loft hatches will also make a difference, reducing the amount of cold air entering your home. Just make sure that your ventilation system is also working well (as above), so the air in your home stays healthy.

Heating system and controls: Spend some time properly checking how you use the controls for your existing heating system, so that you are using it effectively. If you have a central heating system with a condensing combi boiler, you may also be able to adjust some of its settings to make it work more efficiently. For example by adjusting the flow temperature downwards so that the boiler works more efficiently and testing the 'heat pump readiness' of your home.

Quick wins

Laundry: Clothes should dry in a place that is well ventilated and has some heating. This is so that they dry quickly and the moisture doesn't stay in your home. Drying clothes outside is best if you have space - though given the climate and the limited outdoor private space in some homes in Calderdale that is not always possible! Avoid drying clothes on radiators as this makes your radiators less efficient. If you have a hot water store or cylinder, or plan to add one, this is a good place for drying clothes, as it makes use of waste heat. If this is near a ventilation extract to a bathroom or utility space, that's even better. There is a useful article here about this:
https://www.dewasdrogen.nl/wp-content/uploads/2021/05/MEARU-Laundry-Design-Guide.pdf
Tumble dryers can be a good solution where drying space is limited - but try and make sure it's an energy efficient heat pump version. These cost a little more up front, but will save money over time - they are becoming more standard.

Cooking: Simple changes like putting lids on pans when cooking and making sure you switch appliances off fully can help cut your electricity bill. If you cook using fossil gas, you can replace this with an induction hob and an electric oven. This will improve energy efficiency and remove your reliance on fossil fuels, whilst also improving indoor air quality within your home. If you have switch to a heat pump this may also give you the opportunity to remove your gas supply altogether - and so avoid the standing charge for this fuel in future. There is a useful article here about it:
ethicalconsumer.org/home-garden/shopping-guide/gas-electric-cookers

Showers and hot water use: If you have an electric shower, but plan to move to a heat pump-based heating system in future, it's worth considering replacing this with a mains fed shower as part of your plans as this should reduce overall energy use. Check water flow when you do this - low-flow showers that require less water will always be more energy efficient.

Lighting: Upgrading lighting can make a big difference to energy efficiency but also the look and feel of your home. In most cases you probably don't have old-style incandescent light bulbs, having replaced them with compact fluorescent lights or halogens - but you can make further improvements by replacing these with highly energy efficient LED lighting. This gives you more light output for every watt used. The light is also often better quality, with a range of colour temperature choices available.

Using Renewable Energy: You can maximise your savings from existing renewable energy systems by using more of the energy generated directly in your home, instead of exporting it to the grid. Adapting your habits, for example by using your washing machine when it's sunny, or using a slow cooker during the day, can all help. Adding storage for the energy you produce is also possible. If you have a hot water cylinder or store, it's often possible to fit a 'PV diverter' for a few hundred pounds that helps you make use of excess energy to create hot water.

Appliances: Replacing old kitchen and laundry appliances with the most efficient model you can afford when replacement is required will help reduce your energy use. Look for the energy rating when buying new and replacement appliances. The amount of energy needed by appliances is also dependent on your behaviour. The Energy Saving Trust produces useful information on this :energysavingtrust.org.uk/advice/home-appliances/

Monitoring: Monitor your existing energy use, so that you understand where energy is going and can potentially reduce it through changes in your patterns of use. This can be as easy as checking your smart meter data or taking more frequent meter readings. It can also be useful to monitor the environment in your home, especially its temperature and humidity. This can also be done very simply with a small battery-powered hygrometer/thermometer and a notepad, or you can use more advanced monitoring.

Retrofit Process

For the best outcomes when planning and carrying out retrofit improvements to homes it is important to follow a robust and rigorous process. This helps you understand clearly what you want to achieve and where you are starting from. It is a part of responsible retrofit and helps to avoid unintended consequences.

While the list here suggests a simple linear process, this is often not quite how it works in reality. You might decide on your brief and carry out an assessment, but then have to change your brief because you find out something you wanted to do isn't possible, or repair work is needed before you can do the retrofit elements.

You might also just do the detailed design work phase by phase. If you do this it's important to have a well thought out overall plan, that coordinates the different phases and aspects of the work, so it all joins up and performs as expected in the end.

The retrofit measures in the example homes in this guide have deliberately been set out in possible phases or batches of work that could be done together to reflect this reality.

1. **Retrofit brief:** This is the most important part of any building retrofit project. It should cover what you want to achieve - whether your focus is on reducing carbon emissions, improving comfort and health, or reducing bills. It should also include an estimate of budget and any other constraints on timescale or practicalities - like how much disruption is acceptable. Being clear about all of this at the outset will help you make good decisions later.
2. **Retrofit Assessment:** This is the second most important part of a retrofit! To safely achieve your aims, you need to know where you are starting from. Look at the existing energy performance of the home, but also its condition and wider context. The assessment should include the planning and heritage status, and practical and logistical issues related to retrofit - like space and access.
3. **Retrofit Options and Plan:** Once you know what you want to achieve and understand the context, you can test different options that take responsible approaches to retrofit and get to the comfort, cost and carbon outcomes you want. Settling on a plan informed by this process - whether that's about doing the work all in one go or step by step over time.
4. **Retrofit Design:** To make sure the planned work is done to a good standard a detailed design and specification will need to be prepared. This should be done by a competent person who can make sure the design is compliant with the building regulations. In some cases, for example with heat pumps and solar panels, this is done by a specialist installer. In other cases an independent designer may be needed. Make sure during this all the statutory approvals you need - planning, building control, party walls and the rest - are considered. Health and safety during construction and in use also needs to be thought about.
5. **Construction**: This is what people often picture when you talk about retrofit. Done well, with the right suppliers and contractors, and with sound preparation as outlined above, it can be a fun if disruptive process. It can be done in phases or all in one go. You might work with a single main contractor, a range of individual contractors for different phases of the work, and even do some of the work yourself. In all of these contexts make sure you understand your obligations as a client in making sure the work is done safely.
6. **Completion and handover:** This is the end of the construction stage and should not be neglected. Any new systems - ventilation and heating - in your home should be properly commissioned so they are working well. Obtain the certificates, guarantees and warranties that confirm the work has been done properly and set out your protection should something go wrong. You should be given guidance on any new systems and on what to do if there is a problem.
7. **Evaluation and monitoring:** Once the work is finished it's a good idea to check it is performing as expected. This can be something as simple as keeping a track of your monthly bills - or, if you're interested, doing more advanced monitoring and evaluation of the work. This can be a helpful to share with friends and neighbours - who might be thinking about retrofit work for their own homes!

Next steps

We hope this guide proves to be both inspiring and informative, helping you to understand what you can do next to achieve a successful retrofit project in Calderdale.

The most important steps you can take to start planning improvements to your home involve working to understand it better and address any repairs or maintenance work that is needed.

This could include:

- Checking the condition of walls, roof, windows and doors for any damage or repairs that are needed.
- Checking for any restrictions there might be on your home - whether it is listed or in a conservation area. This should include checking the planning history of your home and hunting out any certificates and approvals you have for past work done like extensions or attic conversions.
- Reviewing the 'quick wins' pages above to see what you might be able to do now with minimal intervention and risk.
- Commissioning a retrofit assessment and whole house retrofit plan, to help you make decisions about what work to do and in what order.
- Talking to your friends and neighbours to explore the potential for group works and and so they know what you might be planning.
- Checking with your local authority to see what public schemes and grant funding that you might be able to access.

Calderdale Council commissioned this guide. They are also planning to do more to support retrofit in the area - so look out for updates!

Appendices

References and further reading

Calderdale retrofit context:

Calderdale Citizen's Jury:
https://new.calderdale.gov.uk/housing/healthy-homes-service/citizens-jury and https://tlchub.org.uk/citizens-jury/

https://www.ukradon.org/information/ukmaps

https://www.gov.uk/check-long-term-flood-risk

Vernacular architecture in Calderdale:

Workers Housing in West Yorkshire 1750-1920, Lucy Caffyn

Houses in the Landscape A regional study of vernacular building styles in England and Wales, John and Jane Penoyre

Older buildings and retrofit:

SPAB: Society for the Protection of Ancient Buildings spab.org.uk

STBA: Sustainable Traditional Buildings Alliance - https://stbauk.org/

Historic England:
https://historicengland.org.uk/advice/technical-advice/retrofit-and-energy-efficiency-in-historic-buildings/

Sustainable Renovation Guide, Pebble Trust, SEDA and Chris Morgan:
https://www.thepebbletrust.org/sustainable-renovation-guide/

Funding and finance:

Boiler Upgrade Scheme:
https://www.gov.uk/apply-boiler-upgrade-scheme/what-you-can-get

VAT:
gov.uk/guidance/vat-on-energy-saving-materials-and-heating-equipment-notice-7086

Standards and Certifications:

MCS: Microgeneration Certification Scheme: https://mcscertified.com/

PAS2035**:**
https://www.bsigroup.com/siteassets/pdf/en/insights-and-media/insights/brochures/pas_2035_2023.pdf

Professional bodies and organisations:

National Retrofit Hub: https://nationalretrofithub.org.uk/

RICS Retrofit Standard:
https://www.rics.org/profession-standards/rics-standards-and-guidance/sector-standards/real-estate-standards/retrofit

AECB: Association of Environmentally Conscious Building; http://aecb.net/

LETI: Low Energy Transformation Initiative: www.leti.uk

Overheating in retrofit:

Good Homes Alliance Overheating Toolkit: https://kb.goodhomes.org.uk/tool/

https://www.heatwavetoolkit.com/home

Heating controls:

Heating Hub:
www.theheatinghub.co.uk/articles/turn-down-the-boiler-flow-temperature

The Centre for Sustainable Energy publish useful video guides on heating controls:
https://www.cse.org.uk/advice/central-heating-controls/

Modelling methodology

The modelling of example home in this guide used Home Retrofit Planner. This is a retrofit planning tool developed by Carbon Coop/URBED and now People Powered Retrofit to support retrofit planning and decision making. You can read more about it here: https://retrofit.coop/home-retrofit-planner

Home Retrofit Planner is based on an adapted version of the full 'Standard Assessment Procedure' (SAP). This is the UK's national methodology for calculating the energy performance of domestic buildings. Our model is a useful representation that allows different approaches to be compared. It does not produce guaranteed absolute predictions and should not be treated as doing so. We strive to be accurate, but understand that any model is an approximation. It can be helpful in comparing options, but cannot fully reflect reality. There are a couple of key differences in how we use it compared to SAP:

- **Climate:** When producing EPCs SAP uses a 'national average' climate dataset. Instead we use climate data for the region of the UK that the home being modelled is in. This should be more accurate - but these assumptions may not prove true in any given year. So if there is a colder or milder winter than average the home may use more or less energy than predicted here.

- **Appliances and Cooking:** We include this in the overall results so that it includes the total energy use, not just those parts covered by the building regulations.

- **Carbon emissions:** The electricity carbon intensity figures for cumulative carbon emissions are from Future Energy Scenarios 2024, published by the National Energy System Operator (NESO). This estimates the effect of the decarbonisation of the electricity grid. We use the least optimistic "Counterfactual" scenario. This is as recommended in RICS, 2024, '*Whole life carbon assessment for the built environment: Second Edition, Version 3*'.

Some other key assumptions we have made in modelling include:

- Peak heat load assumptions:
  - External design temperature: -4.5°C
  - Internal target temperature: 20°C
- Heating energy use assumptions:
  - Heating schedule for boilers: 9 hours weekdays, 16 hours weekends, 21°C target living room temperature.
  - Heating schedule for heat pumps: 18 hours per day every day, 20°C target living room temperature
  - Heating not switched off in the summer.
  - Where secondary heating system present, e.g. a woodburner to supplement a gas boiler, 70% of heating provided by the boiler and 30% by the woodburner.
  - All water use <125l per day
  - Where electric shower present 50 / 50 split used for water heating.
  - Gas boiler efficiency: 90% for space heating, 80% for hot water.
  - Heat pump efficiency (all types): 3.5 (350%) for space heating, 2.1 (210%) for hot water.
- Lighting: 1 low energy light fitting per room.
- Appliances: Representative spread, including a tumble dryer in most homes (a common thing in Calderdale).
- Fuel costs: All electricity use on standard tariff, and fuel costs to match the current price cap.
- Solar panels and roofs: All solar arrays given SE/SW orientation and 20-60% overshading. Solar usage based on one person home all day

Glossary

ACH: Air changes per hour: This is usually used as a measure of ventilation. It is the rate at which the volume of air in a room or building changes. So a room that has 2 air changes per hour is ventilated twice as much as a room with 1 air change per hour. It is also used as a measure of airtightness.

Air permeability: This is the volume of air that moves through a square metre of outside surface in an hour. It is a way of measuring how draughty your home is. This is usually stated as a certain number of metres cubed per hour per square metre of building surface area at a given pressure (usually 50 Pascals). It is written as $m^3/hr{\cdot}m^2$@50pa. This is sometimes called the q50 figure.

Air tightness: This is another way of measuring how draughty your home is. It is measured as the rate of change in the volume of air in the house in an hour at a given pressure (50 Pascals). It is written as 1 ACH@50pa. This is sometimes called the n50 figure.

Air Pressure Test (or "blower door test"): This is a method for testing air permeability and airtightness. A fan is fixed to a door or window and used to change the air pressure in a building. The rate at which the fan has to work to achieve a certain pressure within the house is measured. This is used to calculate the air permeability and/or airtightness figures described above. Whilst conducting the test, the tester can identify the main leakage areas in the property so that they can be targeted in the planned works.

A2AHP: Air to Air Heat Pump: An air to air heat pump is a type of low carbon heating system. It uses the latent heat of outdoor air and upgrades this through a pump and compressor to provide heated air for space heating. It is a kind of heating system often used in hotels and commercial spaces and does not require radiators or underfloor heating - but also does not provide hot water. Heat pumps do require electricity to run the pump, but this is just a fraction of the useful heat they produce. The system consists of an outdoor unit that gathers heat from the air, connected to indoor components that distribute warm air. Thought will need to be given to where all of these parts are located - but especially the external unit, which will take up space outside and may be noticed by neighbours. Some planning restrictions may apply, especially in conservation areas.

ASHP: Air Source Heat Pump: An air source heat pump is a type of low carbon heating system. It uses the latent heat of outdoor air and upgrades this through a pump and compressor to transfer this heat to water for 'wet' space heating systems and hot water. Heat pumps do require electricity to run the pump, but this is just a fraction of the useful heat they produce. The system consists of an outdoor unit that gathers heat from the air, connected to indoor components that store and distribute heat around your home. Thought will need to be given to where all of these parts are located - but especially the external unit, which will take up space outside and may be noticed by neighbours. Some planning restrictions may apply, especially in conservation areas or listed buildings.

Comfort Take-Back (rebound effect): This is where some of the benefits of energy efficiency improvements in your home are taken in greater comfort - so keeping your home warmer - rather than in using less fuel. The extent to which this occurs will depend on the preferences of your household. This is not necessarily a bad thing - if your home was very cold before, it will have health benefits if you're now able to keep your home warmer. This is also why in developing our scenarios we assume a reasonable internal temperature - and that your home will get warmer if it was cold.

ECO: Energy Company Obligation: This is a funding scheme for energy efficiency works for which some householders in particular neighbourhoods or postcodes or who receive certain benefits may qualify. It can fund things like loft insulation and new boilers - and requires that you use certain installers and follow certification schemes like PAS2030/PAS2035 (see below).

Glossary

Fabric First: A fabric-first approach to retrofit looks to make repairs and improvements to the building fabric before addressing building services or adding renewable generation. It is characterised by very good levels of insulation, paying close attention to airtightness and minimising thermal bridging. However, it also means looking to fix some of the basics, like repointing brick walls and fixing guttering, before adding new measures.

FIT: Feed-in Tariff: This was a subsidy payment made on small scale renewable electricity generating installations like solar electric photo-voltaic panels. It pays a unit price per kilowatt hour generated. The scheme is now closed to new applicants, but systems that were registered on the scheme before April 2019 will continue to receive inflation-linked payments. It has been partially replaced by the 'Smart Export Guarantee'.

GSHP: Ground Source Heat Pump: A ground source heat pump is a type of low carbon heating system. It uses the latent heat of the ground and upgrades this through a pump and compressor to transfer this heat to water for 'wet' space heating systems and hot water. Heat pumps do require electricity to run the pump, but this is just a fraction of the useful heat they produce. The system consists of an underground collection loop or borehole that gathers heat from the ground, connected to indoor components that store and distribute heat around your home. It is likely to require significant groundworks and excavation - so you need land and permission to use that land for this purpose for it to work. It has the advantage of the external parts often being less noticeable than other forms of heat pump. A variation on this is an 'ambient loop' system which extracts heat from the ground at a lower temperature and distributes it to individual buildings that contain an 'upgrade' heat pump that can bring the water temperature up to a level required for space heating and hot water. This is usually something that is used in communal developments - with the ground source ambient loop shared among a group of buildings.

HEM: Home Energy Model: This is the forthcoming replacement for the UK's current National Calculation methodology, SAP. It will be used to build energy models of homes to show how they meet energy efficiency regulations.

K (degrees Kelvin): The kelvin is the unit of temperature in the International System of Units (SI). It is commonly used in building physics calculations. 1 degree Kelvin is equivalent to 1 degree celsius/centigrade (°C). However instead of the scale starting at the freezing point of water, it starts at 'absolute zero'. This is the coldest possible temperature in the universe (equivalent to -273°C).

kWh: Kilowatt-hour: This is a unit of energy – a measure of the total amount of work done over a period of time. 1 kilowatt-hour would be used by a 1kW rated electric fire left on for one hour. A 10W (0.01kW) bulb left on for one hour would use 0.01kWh.

MVHR: Mechanical Ventilation with Heat Recovery: 'Mechanical Ventilation with Heat Recovery' or MVHR is a type of continuous ventilation that also pre-warms fresh air coming into the home. Extract valves are fitted in 'wet' rooms (kitchen, bathrooms, toilets). These valves take air away quickly but quietly, travelling through ducting to a central fan unit. A 'boost' function increases the extract rate during cooking or bathing. Intake air is brought through the central unit from outside and passed over a heat exchanger that sits between the intake and exhaust air supply paths. This pre-warms the incoming air so it is more comfortable. This pre-warmed fresh air is then ducted to inlet (supply) valves in living rooms and bedrooms. An MVHR system contains filters, so can help remove dust and particles from incoming air, helping to make the air in a home healthier. They are also easier to acoustically separate from outside, so can be helpful to keep noise down if you live near a busy road or under an airport flightpath. You can of course still open windows if you want a breeze or more fresh air. The most challenging part of MVHR in retrofit is often finding suitable space for ducts to run - especially if space is limited or ceilings are low - and for the central unit and intake and exhaust ducts.

Glossary

MEV: Mechanical Extract Ventilation (Centralised): Centralised MEV systems extract the moisture and air pollutants from rooms like bathrooms, WCs and kitchens through a central fan unit. The fans in MEV systems run continuously but quietly drawing stale air through ducts to the central unit. Fresh air to balance the continuous extract is provided either by trickle vents in windows to allow a low level of background ventilation, or through wall inlet vents. The most appropriate option will depend on your whole house plan, what wall space is available, and whether you are planning to replace windows and their existing condition. It is important that you keep vents open to provide a good rate of fresh air, which helps air quality, comfort and health. You can of course still open windows if you want a breeze or more fresh air. The most challenging part of centralised MEV in retrofit is finding suitable space for ducts to run - especially if space is limited or ceilings are low. dMEV (see below) may be an alternative option where this isn't possible.

MEV/dMEV: Mechanical Extract Ventilation (decentralised): Decentralised MEV systems extract the moisture and air pollutants from rooms like bathrooms, WCs and kitchens through individual continuously running fan units.. The fans in MEV systems run continuously but quietly. Fresh air to balance the continuous extract is provided either by trickle vents in windows to allow a low level of background ventilation, or through wall inlet vents. The most appropriate option will depend on your whole house plan, what wall space is available, and whether you are planning to replace windows and their existing condition. It is important that you keep vents open to provide a good rate of fresh air, which helps air quality, comfort and health. You can of course still open windows if you want a breeze or more fresh air.

Performance gap: This is the difference between intended outcomes at briefing and design stage and the built result. It is commonly used to refer to a failure to achieve projected energy savings. It can also relate to a range of outcomes including comfort and indoor air quality. It is the result of a range of factors that can occur throughout the design and building process.

Radon: Radon is a radioactive gas that can't be seen, smelt or tasted: you need special equipment to detect it. It comes from the rocks and soil found everywhere in the UK, though is more prevalent in some areas of the country. The radon level in the air we breathe outside is very low but can be higher inside buildings. The risk of radon build up can be reduced through good construction detailing and a properly designed ventilation system.

Regulated emissions: These are the energy uses and resulting carbon dioxide emissions that are covered by Building Regulations in the SAP rating (see below). These include the energy used to heat, light and ventilate your home and provide its hot water.

RH: Relative Humidity: Relative humidity is a measure of how saturated with moisture the air is: how close it is to reaching its maximum holding capacity. It is expressed as a percentage. When RH is at 100%, the air is saturated. It has reached 'dew point' - so any more water added to the air will condense into liquid form. An accepted healthy range for RH is 40 - 70%, though it's not always possible to stay below 70% RH in the mild but damp conditions that are often experienced in the UK in spring and autumn. On cold winter days, which are also drier, it should be possible to achieve this as long as your home is heated to a reasonable temperature - you may sometimes even find it gets a little dry. Risks of condensation and mould increase when the internal temperature, and in particular surface temperatures, drop below 15°C for extended periods and relative humidity is high (this is one of the reasons why paying attention to thermal bridges is important). The duration of any peaks in RH is also important - a very short peak above 70% isn't likely to be problematic, but once this happens for several consecutive hours then the risk of mould increases

Glossary

RHI: Renewable Heat Incentive: The Renewable Heat Incentive is a subsidy payment for installations that generate heat, like heat pumps and biomass boilers. It pays a few pennies per kilowatt hour of heat generated. To qualify any system will need to be MCS (see above) certified and meet a number of other criteria. The scheme closed to new applicants for domestic properties in March 2022 and has now been replaced by the Boiler Upgrade Scheme.

Retrofit: New houses can be built to a very high level of energy efficiency. Older houses, built when our expectations of comfort were much lower, when energy was cheaper and our knowledge of insulation was much less, tend to perform poorly in terms of energy efficiency, carbon emissions and comfort. These homes therefore need to be augmented with energy saving measures – both in fabric and services - or renewable energy generating measures, to bring them up to a more acceptable standard. This process is known as retrofit, i.e. 'retrospectively fitting' measures to an existing property.

SAP: Standard Assessment Procedure: SAP is the system used to assess energy use in UK homes. The UK government devised SAP as a way to compare homes and test them against Building Regulations. SAP forms the basis of the energy model used in this report. SAP makes assumptions about the number of people living in a home and how it is heated and used, based on averages for the UK. You may not be 'average' and may use your home in different ways. So, SAP is not an exact predictive tool. In Home Retrofit Planner we have taken SAP as our base calculation methodology and adapted it so that we can adjust some of the key assumptions.

SAP model: The SAP model is the tool used to calculate the energy and carbon performance of a home and produce its SAP rating. It uses a standard set of calculations, set out in publicly available documents.

SAP rating: Domestic buildings are given a SAP rating in the Building Regulations approval process for new-build homes. Energy Performance Certificates (EPCs) for sales and lettings of existing homes also include a SAP rating - sometimes called an Energy Efficiency Rating. The higher the SAP rating, the better the building is in terms of fuel costs. It is worth noting that it does not take carbon emissions into account at all. This is one reason why you can change to a lower carbon heating system, that runs on electricity, but the SAP rating gets worse - because electricity is more expensive than gas. The SAP rating only covers regulated energy uses. It does not cover appliances or cooking. This is one reason why energy use in homes can be higher than that shown on an Energy performance Certificate.

SEG: Smart Export Guarantee: A tariff paid to small-scale low-carbon generators for electricity exported to the National Grid. It's a replacement for the export element of the Feed In Tariff.

Thermal ('Cold') bridge: This is an area of the building where insulation is reduced compared to the surrounding building elements, meaning that heat flows at a higher rate through the 'bridge' created. It can be the result of the shape of the building at this point or missing insulation. This can cause cold spots on the inside building surface or within the structure. If the temperature at this point is low enough it creates a risk of surface condensation and mould growth. It should be avoided wherever possible through careful design.

Thermal imaging: This is the process of using a 'heat camera' or thermal imaging camera to look at buildings. Instead of using the visible light spectrum this uses infrared to 'see' heat. This allows you to see where heat is escaping from a building. You can do this from inside or outside the building. It can be very useful when used alongside an air pressure test as it enables you to 'see' draughts. It takes skill and experience to interpret images correctly - but is a very helpful tool in visualising heat loss. A temperature difference of ten degrees between inside and outside is ideal to make this easier.

Glossary

Unregulated emissions/ energy use: These are the energy uses and resulting carbon dioxide emissions that are not covered by Building Regulations. They are less directly related to the building fabric and include cooking and electrical appliance use. Appliance use covers laundry washing and drying, fridges and freezers, and consumer electricals such as TVs and computers.

U-value: This is a measure of the thermal performance of a building element. U-value is measured in watts per square metre per degree of temperature difference (measured in Kelvin). So, if a wall has a U-value of 1 $W/m^2 \cdot K$, it loses 1 watt per square metre of wall area per degree of difference between inside and outside. So, if it is 0°C outside and 20°C inside and the wall is 10 square metres, it would lose 200 watts of heat – equivalent to the power used by a set of hair-straighteners.

Vapour Open - Vapour Permeable and Hygroscopic ('Breathability'): This has nothing to do with air or breathing. If a material is described as 'breathable' it actually refers to the behaviour of materials in relation to water vapour and moisture - so we prefer to use the terms vapour open or hygroscopic. This is about how easy it is for moisture to travel through a material. This can be by transfer in the air passing through small holes or pores in the material - known as vapour permeability. It can also be through capillary action in materials like timber, where moisture travels along small tubes in the material. Or absorption in materials like lime and clay (hygroscopicity)

Watt: This is a unit of power – that is the rate at which work is done or energy is used. 1 watt is equivalent to 1 joule per second. A 100-watt lightbulb uses 100 joules per second. 1 kilowatt (kW) = 1000W.

Whole House Retrofit: This is a holistic approach to retrofit and energy efficiency work that considers the whole building as a system. It does not necessarily mean that all the work has to be done in one go. It does mean that the relationship between different measures and systems is considered. It also means that the risk of unintended consequences is considered and mitigated.

W/K - Watts per degree Kelvin (heat loss): This is the rate at which heat is lost through a building element. It is measured in Watts per degree of temperature difference between inside and outside, in degrees Kelvin.

Zero Carbon / Net Zero Carbon If a building or service is 'zero carbon' it results in no carbon dioxide emissions. Most often this is qualified by 'in use' meaning that whilst it might have taken energy and resources to create - which result in carbon emissions - during its use phase there are no emissions. So in the case of a house, the energy used by a house during its occupation does not result in carbon emissions.'Net Zero Carbon' means that there are still some carbon emissions associated with the building or service - but these are offset in some way. This might be over time - so for example a house generates as much electricity as it uses in a year from solar panels, but still needs to use electricity from the national grid that has associated carbon emissions at times when the solar panels are not generating. Alternatively the home may use a fuel, such as a form of biomass, which in theory is 'zero carbon' because new biomass growth will absorb the resulting carbon emissions. However this is a carbon accounting minefield, and can lead to perverse incentives. If you'd like to know more about this, the best reference is the UK's Net Zero Building Standard: https://www.nzcbuildings.co.uk/

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