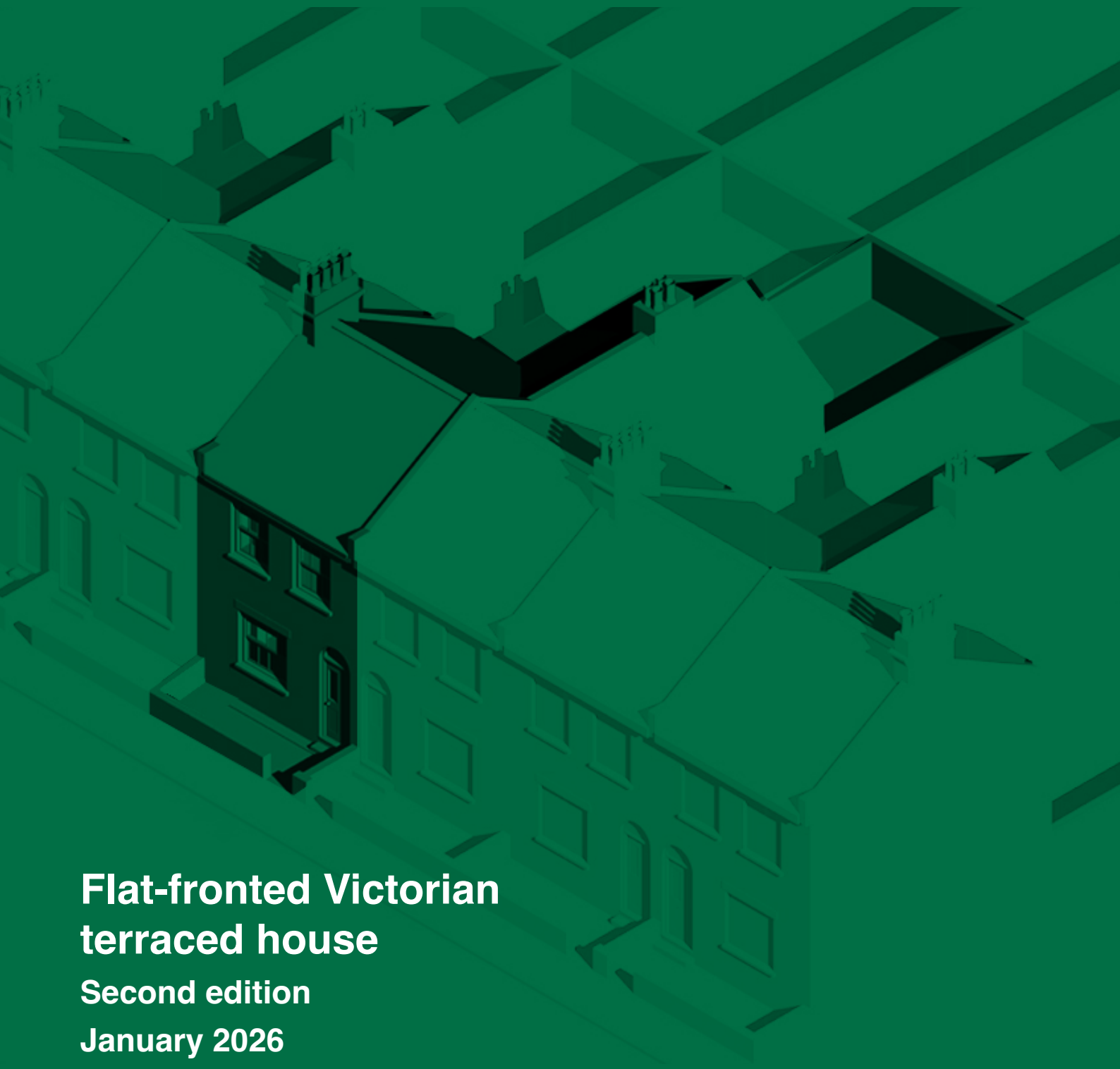
RETROFIT PATTERN BOOK



Flat-fronted Victorian terraced house

Second edition

January 2026

5th studio

Certified B Corporation

What is retrofit?

Retrofit is the process of upgrading the building fabric or services within the home. This is done with the aim of reducing heat loss through the fabric (roofs, walls, windows, and floors) and to improve the efficiency of the systems that heat the home. Renewable technologies and smart tariffs can also be integrated to provide energy in the most sustainable and cost-efficient way. Retrofit can bring added benefits, with improved thermal comfort and ventilation to significantly improve the comfort and health of the home.

Why a Retrofit Pattern Book?

A Retrofit Pattern Book is an essential guide to retrofit, illustrating how homeowners can make improvements to their home's energy use, operating cost, and carbon emissions while also enhancing comfort.

It demonstrates the value of investment in improving the building fabric, domestic energy efficiency and adopting decarbonising energy sources.

Why should we retrofit our homes?

Heating homes in the UK accounts for 12 percent of the nation's greenhouse gas emissions, reducing these domestic emissions through retrofit is a key component to the UK plan for achieving the Net Zero target by 2050.

Retrofit also aims to ensure that homeowners can afford to enjoy warmer and more comfortable homes which retain more heat, benefit from lower energy bills and access to smart tariffs and renewable heating sources.

The UK's housing stock includes some of the oldest and least thermally efficient housing types in Europe. Our historic homes were built with different materials and standards of construction to today, to suit a different way of life and very different expectations of comfort. While much-loved these historic homes do not meet the standards of comfort or thermal efficiency that are expected of modern homes.

There are over 7 million Victorian terraced houses in the UK, and these are a common and much-loved feature of villages, towns and cities across the country. This Retrofit Pattern Book was developed as a guide for owners of these homes, as we believe an understanding of the original design and function of these historic buildings can support owners to thoughtfully plan changes to the fabric of their home. Delivering warmer more comfortable homes, with reduced energy use and bills, whilst avoiding the unintended consequences of inappropriate changes.

To help to prioritise the improvements that can be made, the Patten Book includes predicted energy savings from different levels of improvement related to timescale, levels of skill required, and the likely extent of disruption. These should be read as guidance, not guarantees.

Every home is different in age, style and state – both from its neighbours and from its form when it was originally built. The levels of comfort that occupants expect from their homes has also changed since these homes were built and each household has different needs and expectations of comfort. These variations make it difficult to accurately predict energy savings without completing an assessment of each individual home.

It goes without saying that making changes to the fabric of buildings requires skill and technical competence. Homeowners should always seek independent advice before commencing work.

We hope this Retrofit Pattern Book inspires confidence that historic homes can be made more energy efficient, and less expensive to run, whilst retaining their essential character and that this is a worthwhile and achievable endeavour.

This document has been produced by 5th Studio in collaborating with JGC Consulting who have provided their expertise on domestic energy use.

We are also grateful to Etude, a UK business specialising in low-energy building design, who provided an independent peer review of the Retrofit Pattern Book.

Every care has been taken to confirm the accuracy of the information within this document at the point of publication but, as the context of this advice can subject to external changes (including government policy, energy tariff and other changes),aspects of this advice might not remain accurate over the long-term and should be checked for updates.

Neither 5th Studio nor JGC Consulting shall be held responsible for any errors or omissions within the document, nor accept any liability whatsoever for any losses arising from the use of this document, reliance on the information contained within it, or for any consequential loss arising from the application of the document, except to the extent this would be prohibited by law or regulation.

You should carefully assess what retrofitting options may be available or suitable for you and your home and should seek independent advice before commencing works.

5th studio with Joel Gustafsson Consulting

Certified B Corporation

5th Studio is a certified B Corp: we're counted among businesses that are leading a global movement for an inclusive, equitable, and regenerative economy.

This certification is a significant milestone on the journey of the practice, and part of our continuous improvement as an ethically-driven and environmentally sensitive business.

Contents

1

Quick wins & summary

If you only make a few upgrades to your house, you should:

1. Complete any **maintenance tasks** that are undermining the thermal performance of your house – leaks, blocked vents, etc.

2. Insulate your **loft**.

3. Address heat losses from **draughts** (draught seal windows and doors) while making sure that your kitchen and bathroom extract ventilation fans work efficiently.

4. Install an **air source heat pump** (and possibly a battery) using smart tariffs to reduce the costs and carbon emissions of your energy.

Summary

The Retrofit Pattern Book is intended as a guide for homeowners. It provides general information on energy use and illustrates how best to increase energy efficiency, whilst maintaining comfort and reducing the risk of unintended consequences.

The Victorian 'two-up-two-down' terraced house with a garden has come to represent, in the UK, the typical family home. This type of house has, over time, informed different space standards and sizes used in the design of new homes.

Built over 100 years ago, the character of these houses means they remain a popular house type, with Victorian terrace homes representing some 8.5% of England's housing stock. However, they were not constructed to the same energy standards as today's homes so are likely to need substantial retrofit to support the UK's goals of becoming net zero by 2050.

Retrofitting these homes offers the opportunity to greatly increase the comfort, health and energy efficiency of these homes, bringing multiple benefits to residents and the long-term stability of the building.

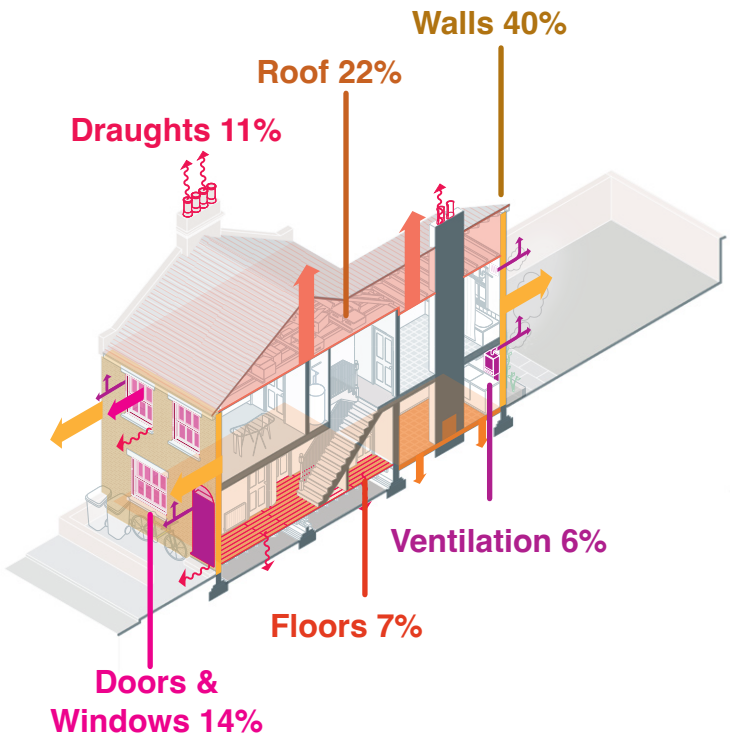
If you only make a few upgrades to your house, you should consider the benefits of:

1. Completing any **maintenance tasks** that are undermining the thermal performance of your house – leaks, blocked vents, etc.
2. **Insulating** your loft
3. Addressing heat losses from **draughts** (uncontrolled ventilation) while making sure that your kitchen and bathroom extract ventilation fans work efficiently

By this point your annual energy use could well have been reduced by c.20%

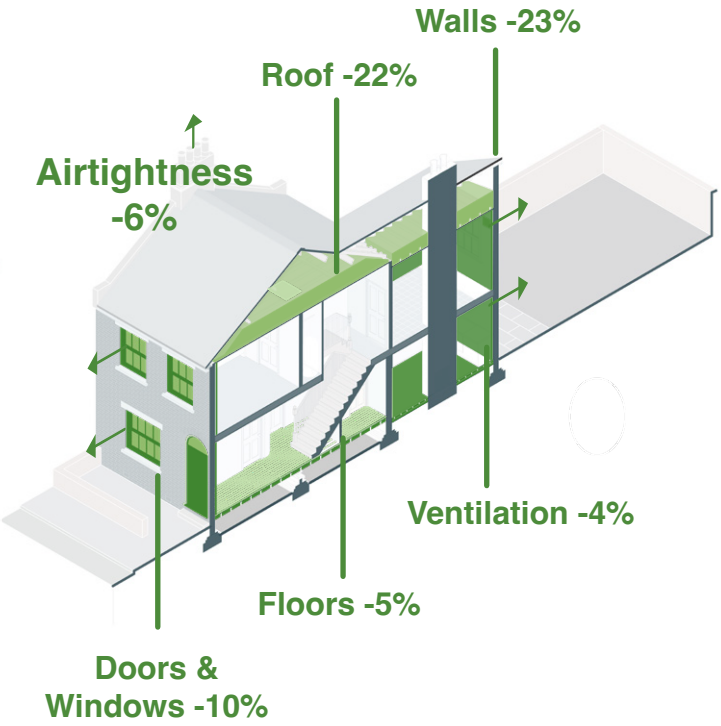
4. Installing an **air source heat pump** (and possibly a battery) using smart tariffs to reduce the costs and carbon emissions of your energy.

Where the typical terraced house loses heat



The unmodified typical Victorian terraced house (the Baseline condition) loses heat in multiple ways, the above is the likely percentage of peak heat losses from the main areas of the house.

Potential to reduce peak heat loss



Total reduction = 70%

The diagram above shows the potential percentage reduction in peak heat loss which the highest level of building fabric improvements (Level 3) could offer, compared to the losses of an unmodified Victorian terraced house (the Baseline condition).

2

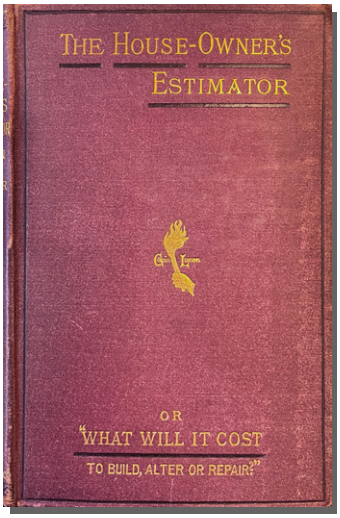
Introduction

The Retrofit Pattern Book provides general information on energy use and illustrates how best to increase energy efficiency, and maintain or increase comfort while reducing the risk any damage arising as the unintended consequence of inappropriate use of materials.

It is primarily intended for use by homeowners, but might also be of use to landlords or people in construction trades working on home retrofit projects.

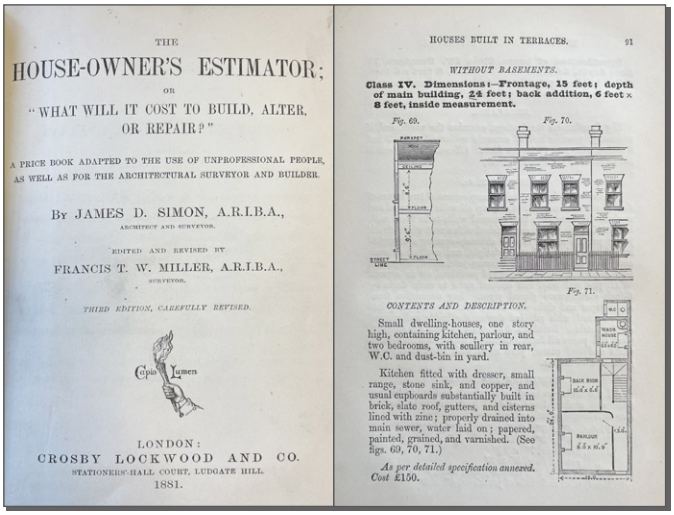
What is a pattern book?

A pattern book is a manual that illustrates general examples or ‘patterns’ for the design of homes.



The origins of the pattern book lie in the ‘Ten Books of Architecture’ published by the ancient Roman architect Vitruvius. The rapid expansion of British cities in the 1800s led to the publication and widespread adoption of a series of pattern books on housing. The books were aimed at builders and landowners, providing enough guidance and detail for non-architects to build in an approved style.

Pattern books are still published today in the form of computer design packages, supporting both the construction industry and prospective households.



THE
HOUSE-OWNER'S ESTIMATOR;
OR
"WHAT WILL IT COST TO BUILD, ALTER, OR REPAIR?"

A PRICE BOOK ADAPTED TO THE USE OF UNPROFESSIONAL PEOPLE, AS WELL AS FOR THE ARCHITECTURAL SURVEYOR AND BUILDER.

By JAMES D. SIMON, A.R.I.B.A.,
ARCHITECT AND SURVEYOR.

EDITED AND REVISED BY
FRANCIS T. W. MILLER, A.R.I.B.A.,
SURVEYOR.

THIRD EDITION, CAREFULLY REVISED.

Cupis Lumen

LONDON:
CROSBY LOCKWOOD AND CO.
STATIONERS'-HALL COURT, LUDGATE HILL.
1881.

HOUSES BUILT IN TERRACES. 91

WITHOUT BASEMENTS.

Class IV. Dimensions:—Frontage, 15 feet; depth of main building, 24 feet; back addition, 6 feet × 8 feet, inside measurement.

Fig. 69. Fig. 70.

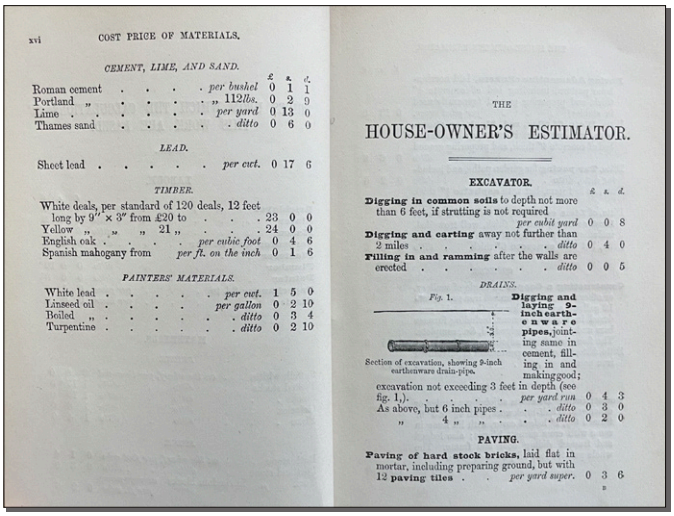
Fig. 71.

CONTENTS AND DESCRIPTION.

Small dwelling-houses, one story high, containing kitchen, parlour, and two bedrooms, with scullery in rear, W.C. and dust-bin in yard.

Kitchen fitted with dresser, small range, stone sink, and copper, and usual cupboards substantially built in brick, slate roof, gutters, and cisterns lined with zinc; properly drained into main sewer, water laid on; papered, painted, grained, and varnished. (See figs. 69, 70, 71.)

As per detailed specification annexed. Cost £150.



xvi COST PRICE OF MATERIALS.

CEMENT, LIME, AND SAND.

		£	s.	d.
Roman cement	*per bushel*	0	1	1
Portland „	„ 112*lbs.*	0	2	9
Lime	*per yard*	0	13	0
Thames sand	*ditto*	0	6	0

LEAD.

Sheet lead	*per cwt.*	0	17	6

TIMBER.

White deals, per standard of 120 deals, 12 feet long by 9″ × 3″ from £20 to		23	0	0
Yellow „ „ „ 21 „		24	0	0
English oak	*per cubic foot*	0	4	6
Spanish mahogany from	*per ft. on the inch*	0	1	6

PAINTERS' MATERIALS.

White lead	*per cwt.*	1	5	0
Linseed oil	*per gallon*	0	2	10
Boiled „	*ditto*	0	3	4
Turpentine	*ditto*	0	2	10

THE
HOUSE-OWNER'S ESTIMATOR.

EXCAVATOR.

	£	s.	d.
Digging in common soils to depth not more than 6 feet, if strutting is not required *per cubic yard*	0	0	8
Digging and carting away not further than 2 miles *ditto*	0	4	0
Filling in and ramming after the walls are erected *ditto*	0	0	5

DRAINS.

Fig. 1.

Section of excavation, showing 9-inch earthenware drain-pipe.

Digging and laying 9-inch earthenware pipes, jointing same in cement, filling in and making good; excavation not exceeding 3 feet in depth (see fig. 1.) *per yard run*	0	4	3
As above, but 6 inch pipes *ditto*	0	3	0
„ 4 „ „ *ditto*	0	2	0

PAVING.

Paving of hard stock bricks, laid flat in mortar, including preparing ground, but with 12 **paving tiles** *per yard super.*	0	3	6

Above: Simon, J.D. and W., M.F.T. (1889) The house-owner’s estimator: “or what will it cost to build, Alter, or repair?”. London: Crosby Lockwood. Source: RIBA archive.

A Retrofit Pattern Book

This Retrofit Pattern Book has been prepared in the spirit of its 19th century forebears, to provide general guidance to improve the energy efficiency of the **flat-fronted Victorian terraced house**.

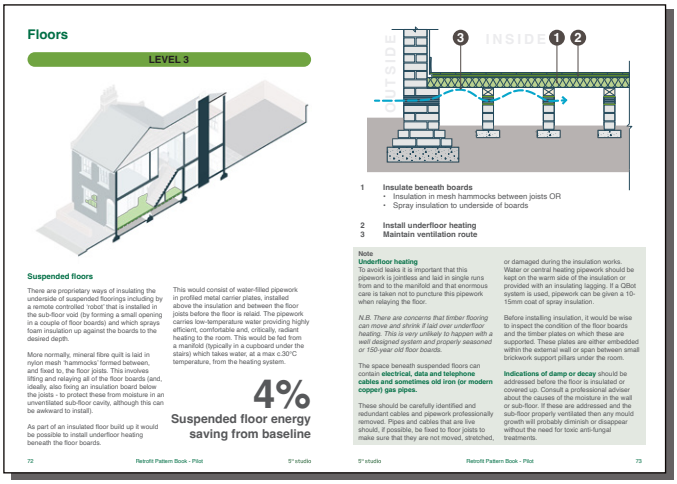
Unlike the original pattern books, this book is aimed at homeowners rather than house builders. It is intended to provide a guide to how this type of house has evolved, improving the homeowners understanding of how retrofit could benefit their property.

This book describes how the house was intended to operate, the nature of subsequent changes to its pattern of use, heating, lighting, etc, and how this has affected the homes current performance, comfort levels, and energy efficiency.

The Retrofit Pattern Book provides general guidance on energy use and illustrates how best to increase energy efficiency through a series of levels of intervention.

These interventions are described to help the homeowner understand how to improve comfort and reduce the risk of unintended consequences.

It also describes the additional energy savings, energy cost and carbon emission reductions which investment in improving services (heating appliances) and domestic renewable energy generation can bring.



Above: Example Retrofit Pattern Book measures page.

Climate, weather, and carbon

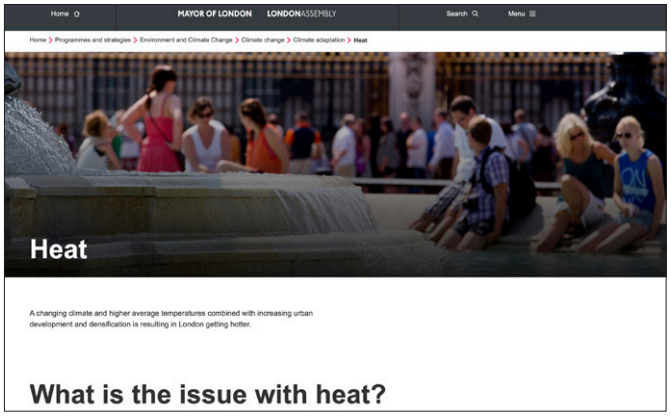
It is not clear that an increase in global temperatures will result in warming of the UK all year round. It is possible that our weather will become more extreme, with hotter summers but colder winters.

We are already witnessing variations in the frequency and intensity of storms in the UK. Our weather which has historically been dominated by the effect of the Gulf Stream, might change more dramatically if warming of the planet affects the reliability of this ocean current.

Within these global and national uncertainties, there are yet more that are connected with the weather in different regions of the UK. Within the colder, drier, warmer, and wetter regions there are additional differences between the temperature of cities and towns and that of the surrounding countryside.

The Urban Heat Island effect (UHI) can cause cities, such as London and Manchester, to be up to 5°C warmer than neighbouring rural areas.[1] This is because the sun's rays are absorbed by hard surfaces rather than by vegetation such as trees, plants and grass. Radiation from our hard surfaces is released into the air as heat. The UHI reduces the ability for cities to cool and impacts on our own capacity to regulate body temperature.

https://www.london.gov.uk/programmes-and-strategies/environment-and-climate-change/climate-change/climate-adaptation/heat



Warmer external temperatures will reduce the heat demand from homes in the winter but can increase the need for cooling (A/C units) and ventilation in the summer. Wetter weather can reduce the capacity of external walls to be internally insulated without creating conditions for the development of condensation, mould growth, or timber decay. Increased humidity in the air also increases the need for ventilation of rooms.

In the context of the above uncertainties, it is clear that we need to reduce the risk of climate change and the unpredictable ways in which it might affect our homes built fabric, comfort, and energy usage.

Carbon emissions from the UK's existing homes contribute between 17%[2] of UK carbon emissions. Over 80% of these homes will be still be in use in 2050.[3] It will be very challenging for the UK to reach the legal target of Net Zero in 2050 unless we retrofit every home that does not meet current energy standards.

In addition to responding to the climate and carbon imperative, the benefits of retrofitting our homes include:

- Creating warmer, less noisy and more comfortable homes;
- Reducing fuel poverty and the cost of living;
- Creating homes that are free of mould and draughts that can cause allergies and respiratory illnesses; and
- Supporting jobs and the local economy.

1. Carbon Brief, How 'urban heat islands' will intensify heatwaves in UK cities. https://www.carbonbrief.org/guest-post-how-urban-heat-islands-will-intensify-heatwaves-in-uk-cities/
2. Department for Energy Security & Net Zero, 2022 UK greenhouse gas emissions, provisional figures. https://assets.publishing.service.gov.uk/media/6424b8b83d885d000fdade9b/2022_Provisional_emissions_statistics_report.pdf
3. UK GBC, Climate Change Mitigation. https://ukgbc.org/our-work/climate-change-mitigation/.

Climate resilience

Climate change is likely to exacerbate the existing environmental conditions and risks to the UK's housing stock. Extreme weather events will increase the frequency of intense rainfall and the extent of flooding. Droughts can lead to clay soils shrinking, increasing risks from ground movement and subsidence, and increasing incidence of heatwaves can lead to overheating of homes with associated health risks to inhabitants.
moving with the building.

Flooding

Consideration should be given to anticipated or historic flood levels when positioning new services and equipment such as ASHP.

Insulation to walls could incorporate a breakline above the floodline to allow any water damaged materials to be carefully removed without impacting undamaged areas.

Detailed advice is available from a range of sources, covering details like flood proof air bricks, door barriers, etc.

Overheating

When replacing windows care should be given to ensuring adequate openable areas, with consideration to security and fall risks.

This house type traditionally is easily ventilated, but the introduction of mechanical ventilation systems can support some cooling of spaces.

Subsidence and heave

It is key that before investing in significant building fabric improvements that known subsidence issues are addressed – this might include underpinning works or minimising residual environmental risks (trees etc.).

Once fabric improvements have been completed it is not uncommon for warmer dryer conditions to lead to minor cracking of painted/plastered surfaces. Care should be taken to differentiate between this and further structural cracking which requires professional inspection.

Natural materials can offer greater flexibility, moving with the building.

Approaches to reducing carbon emissions, energy costs, and comfort and health.

Since the first edition of this Retrofit Pattern Book in 2023, increasing pressures on the cost of living have been accompanied by the emergence of alternative approaches to reducing domestic energy costs and carbon emissions. This has been enabled by two areas of development:

- New Air Source Heat Pump (ASHP) technologies, together with the lifting of planning restrictions on locating ASHP and the simplification of UK Power Networks (UKPN) procedures and costs of connecting domestic ASHP to the electrical grid.

- Smart domestic energy tariffs and the use of batteries to maximise the costs benefits of smart tariffs

These changes have changed the discussions about retrofit and the relative prioritisation of fabric or technological measures.

The following notes compare these alternative approaches.

‘Fabric First’ approach.

This traditional approach focuses on making the building’s ‘fabric’ (its insulation, windows, and doors) as efficient as possible before installing other systems.

The ‘Fabric First’ order of priorities is:
- Deep insulation and fabric upgrades to reduce heat loss before adding heating systems.
- Heat pumps: heat pumps (including ASHP) are typically installed after significant fabric upgrades have been completed to ensure the building’s heat demand is low enough for the heat pump to be effective.

‘Fabric Fifth’ approach.

This approach prioritises reduction of energy costs by using heat pump and battery technologies to exploit the current tariff regime of differential electricity pricing across the day to reduce the cost of decarbonised heating.

The five stages of this approach are:
- Install a heat pump: This provides a significant and immediate reduction in emissions by switching from fossil fuels.
- Install smart meters and controls: This is used to manage energy use efficiently and avoid peak charges.
- Draught-proofing and basic efficiency measures: This includes simple, low-cost steps to improve comfort, such as sealing air leaks.
- Install photovoltaic panels (PV) and battery storage: This adds renewable energy generation to further support an all-electric home.
- Major fabric upgrades: This final step includes deep insulation and other structural improvements to walls, floors, and roofs.

Comparative notes:

The ‘Fabric First’ approach relies on extensive and expensive improvement works before any benefit can be realised from the electrification of heating and the use of smart tariffs to significantly reduce energy costs.

The typical lifespan of heat pumps is of the order of 15-20 years if properly maintained. The typical lifespan of fabric improvement measures is of the order of 60+ years.

Current smart tariff energy contracts have arisen in response to previous or traditional patterns of usage. There is no projection as to the longevity of these current smart tariffs.

The simple electrification of existing heating demand – even if using batteries to balance the load on the electrical grid – does not reduce the demand on the already constrained electrical grid capacity at national, regional, and local levels.

The ‘Fabric Fifth’ approach aims to provide affordable thermal comfort for households, with some related improvements in health and wellbeing. However, it does not address the equally important comfort and significant health issues related to draughts, condensation, damp and mould and other underlying issues of fabric conditions, maintenance and comfort.

The ‘Fabric Fifth’ approach does not address the need, at an individual, community, or global level, to reduce the demand for heating energy, however this is provided.

Uncertainty over the electrical grid capacity in the UK is limiting the availability of Zero Bills schemes. The media attention that they have attracted distracts from consideration of the wider issues of energy use, carbon emissions, cost, and comfort.

Retrofit Pattern Book approach

This approach adopts the use of smart tariffs and heat pumps to reduce energy cost and carbon emission. The Retrofit Patter Book approach importantly suggests that this follow completion of critical maintenance tasks and some simple and cost-effective improvement of the thermal performance of the home.

This approach will improve the comfort and health of households by reducing draughts, damp, and mould. It also bring advantages through reducing the size and cost of heat pumps and thus running costs.

The reduction of heat loss reduces the electrical demand from heat pumps to meet this reduced heating demand – and thus reduces the demands of the constrained electrical grid capacity.

Key terms and goals

It is important to understand there are a range of goals for improving the thermal performance of your house, and that each of these can have very different effects on your energy bills and comfort.

Ventilation, condensation and mould

Improving levels of insulation and airtightness can reduce heat loss from the home but has associated risks to building fabric and domestic comfort. Improvements should be accompanied by ensuring that extractor fans from kitchens, shower and bathrooms are providing an appropriate level of controlled ventilation, to compensate for the reduction in uncontrolled ventilation (draughts).

Reducing levels of ventilation below minimum standards, in combination with more widespread heat, provides the warm and humid / moist conditions in which mould and mildew can develop, and dry and wet-rot fungi can propagate.

These conditions are also beneficial to the growth of mite and bug populations, the consequences of which are believed to have contributed to an increased diagnosis of respiratory complaints. An example is the increased occurrence of asthma over the last 50 years, where the rise in that condition can be seen to coincide with the widespread installation of domestic central heating.

Reducing the energy demand

Improving the physical fabric of your home, through measures that improve the thermal efficiency (such as the insulation and airtightness of the house) will directly reduce energy use, fuel bills, and carbon emissions associated with heating the home, as less heat is lost through draughts and uninsulated surfaces.

Decarbonising the heat source

It is possible to upgrade a typical boiler that runs on fossil fuels (oil or gas) to an air source heat pump (ASHP) or less commonly ground or water source heat pump.

A heat pump is a device capable of transferring heat from an external source, i.e. air, ground, or water, into a building heating system. A typical domestic heat pump is capable of producing three times more heating energy than the electrical energy that it consumes in doing so.

This approach can significantly reduce carbon emissions and may, due to the high efficiency of heat pumps, reduce energy use associated with heating your home. However due to the relative costs of electricity and gas, this may not reduce your bills unless you also complete retrofit measures to reduce the energy demand of your home.

Smart and variable tariffs

Whilst typical electricity prices are much higher than gas prices, innovations in the energy supply markets have resulted in smart and variable pricing tariffs that offer significant reductions in the price of electricity during 'off-peak' hours.

With smart meters and heating controls it is possible to automatically track the peak pricing hours and avoid use of your heat pump during these periods, increasing potential savings.

If the heat loss from the home is reduced through fabric measures and an ASHP is not operating during peak pricing hours then, depending on weather conditions, it can take several hours for the internal temperature of the house to drop noticeably before the 'off-peak' pricing hours and return to ASHP heating. Provision of a hot-water storage cylinder will allow hot water to be produced during 'off-peak' hours and stored for use throughout the day.

Alternately, if a battery is added to the household electrical system then this can exploit the very low electricity costs at night to charge the battery and then use this to run the heat pump, and other domestic systems through the off-peak and peak hours.

If retrofit measures are completed before replacing a typical boiler with a heat pump, then it is likely that a lower capacity, and cheaper, heat pump can be used, rather than simply replacing the boiler with a heat pump of comparable output.

Net zero (carbon emissions)

Achieving net zero domestically implies that the carbon emissions from the energy used to heat, light, ventilate, and provide hot water to the home, are reduced to a minimum by balancing the demand of your home with your own sources of renewable energy generation.

Reducing a home's carbon emissions to net zero or below might be achievable but very difficult.

The remaining emissions can be *offset* through certified schemes that will plant trees, remediate soil, or invest in zero-carbon energy generation or other schemes, or through 100% renewable energy supply tariffs. However, direct investment in energy reduction strategies and renewable generation are the most effective means to reaching net zero.

Implicit in this is the reduction of demand; the use of highly efficient systems (heating, lighting, ventilation) to meet that demand and the reduction of the carbon in the energy supply to those systems. While energy usage and bills will be significantly reduced, the costs of the works and of accredited carbon offsetting may be significant.

Grid decarbonisation

The carbon content of the electrical supply from the National Grid is becoming progressively decarbonised as it switches to renewable sources of generation, such as wind, solar etc. This trend suggests that the power from the electric grid that powers heat pumps will become increasingly decarbonised, reducing the carbon impact of this form of heating.

Support

Upgrading your boiler

The replacement of domestic fossil fuel burning boilers (i.e. oil or gas) to air source and ground source heat pumps is currently being promoted by Government – and by installers and suppliers of heat pumps.

From February 2024, government subsidies became available for people in England and Wales for boiler upgrades of up to:

- £7,500 towards the cost of an air source heat pump (ASHP).
- £7,500 towards the cost of a ground source heat pump (GSHP) – including water source heat pumps and those on shared ground loops.
- £5,000 towards the cost of a biomass boiler.

If you live in Northern Ireland you might be able to get a grant to replace your boiler, and it you live in Scotland you might be able to get an interest-free loan or a grant to make your home more energy efficient.

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

Insulating your home

Between (approx.) April 2023 and March 2026 the government will oblige energy companies to help low-income and vulnerable households to reduce energy demand and costs by delivering single insulation measures to homes. This will also be available to those living in homes with an Energy Performance Certificate rating of D-G, and within Council Tax bands A-D in England and A-E in Scotland and Wales.

See the websites below for details of this scheme. Further information will be made available through you energy supplier in due course.

https://www.ofgem.gov.uk/environmental-and-social-schemes/great-british-insulation-scheme

https://www.gov.uk/government/consultations/design-of-the-energy-company-obligation-eco-2023-2026

Further advice and guidance

Links to further guidance on retrofit and home-energy saving from non-profit organisations and local authorities are set out on page 119.

VAT

There are also reductions in VAT when certain energy-saving products are installed in your home. These include draught strips, insulation, photovoltaic panels, batteries and heat pumps, and the cost of the building work required to install these. See VAT Notice 708/6 or the website below for more information.

https://www.gov.uk/tax-on-shopping/energy-saving-products

The UK's wide range of homes

There is an enormous variety of homes in the UK. Different approaches to retrofitting a home are needed depending on the size, type, and age of the building's fabric.

This edition of the Retrofit Pattern Book focuses on the **Victorian Terraced house** – in addition to this, key types include:

Terraced housing

Bungalow

Semi-detached house

Detached house

Purpose Built Low-Rise Flats

These types of home represent c.95% of the UK, with other types such as purpose built high rise flats making up smaller proportions, and having less typical design approaches.

3

The type

Flat-fronted Victorian terraced house

The terraced homes built between 1837 and today and constitute over 28% of the current UK housing stock.[1]

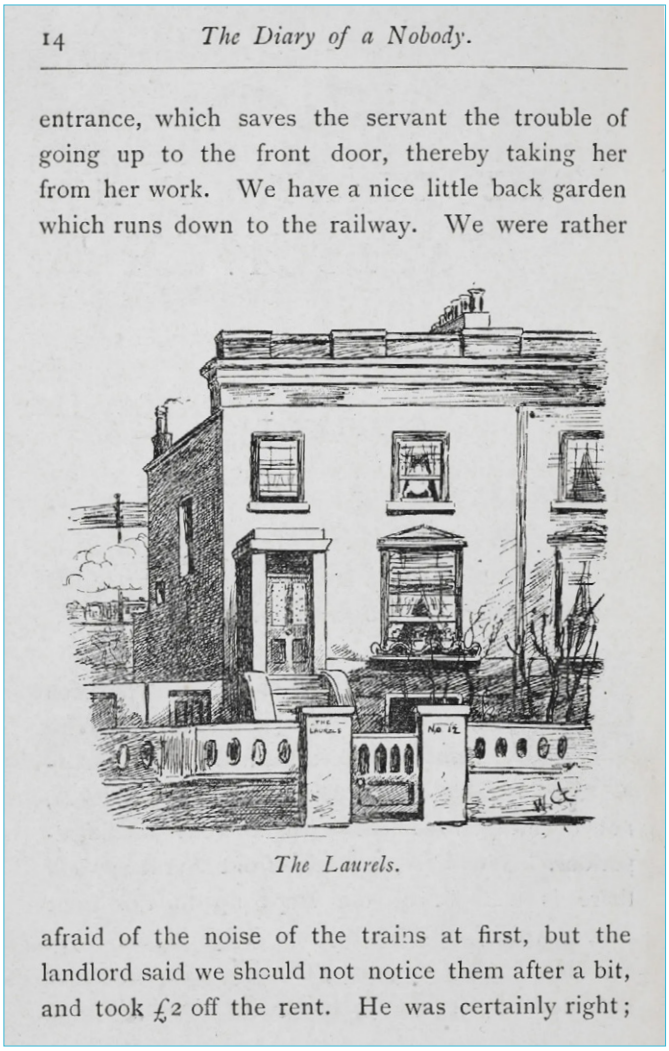
There are nearly 3 million existing Victorian (and earlier) terraced homes, representing over a third of terraced houses. These are one of the UK's most common housing types.

1. English Housing Survey. 2001. https://webarchive.nationalarchives.gov.uk/ukgwa/20120919165908/http://www.communities.gov.uk/archived/general-content/housing/224506/englishhouse/

History & culture

The historic evolution of this type has been described in great detail in books such as 'The English Terraced House'[1]. The character and pre-occupations of the lives within some of this new form of housing are captured in the new forms of household manual contemporary to their construction in books such as 'Mrs Beeton's Book of Household Management'[2] and in the comic novel 'The Diary of a Nobody'[3].

The Victorian 'two-up-two-down' terraced house with a garden has come to represent, in the UK, the typical family home. This type of house has, over time, informed different space standards and sizes used in the design of new homes.



14 *The Diary of a Nobody.*

entrance, which saves the servant the trouble of going up to the front door, thereby taking her from her work. We have a nice little back garden which runs down to the railway. We were rather

The Laurels.

afraid of the noise of the trains at first, but the landlord said we should not notice them after a bit, and took £2 off the rent. He was certainly right;

Above: The Diary of a Nobody, George and Weedon Grossmith. Image source: British Library.

1. Stefan Muthesius. Yale University Press. 1981. ISBN: 0-300-03176-9 (paper).

2. Mrs Beeton's Book of Household Management. S.O. Beeton 1861.
Now available from Empire Books 2011. ISBN: 1619491400.

3. George and Weedon Grossmith. This originated as an intermittent serial in Punch magazine in 1888–89 and appeared in book form, with extended text and added illustrations, in 1892.
Now available from Penguin Vintage Classics. 2010. ISBN: 9780099540885.

The ‘Victorian’ terraced house type

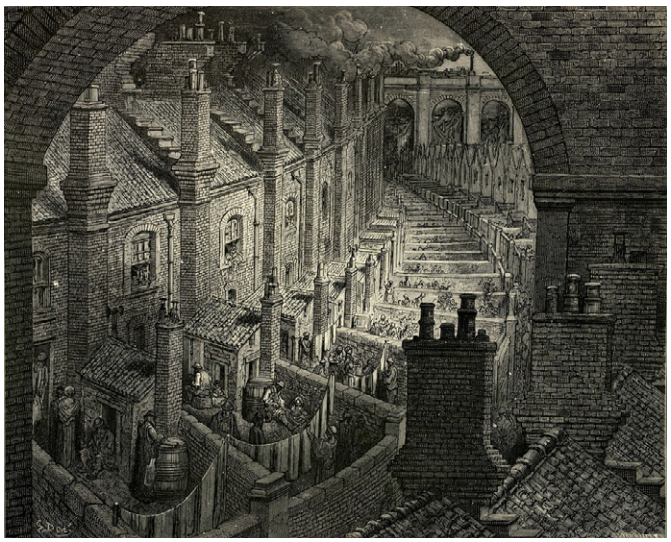
Although there is enormous consistency to the construction of ‘Victorian’ terraced houses, and the issues that arise with these, there is a wide variety of both size and appearance of this type across the UK.

Pattern books and street layout plans were typically established on ‘12-foot’, ‘15-foot’, or ‘18-foot’ plot widths. The width and storey heights depending on affordability and local demand. This ranged from housing for the emerging middle and professional classes (with pretensions but without servants) to the mass-construction of dwellings for workers in close proximity to their employment in factories, on railways, etc (as illustrated by the Gustave Dore engraving below)

The relationship between terraces and streets also varied, with some built directly against pavements while others being set back behind front gardens of varying depths.

House builders did sometimes use local materials (stone and slate) for walls and roofs in building these houses but more often used the most affordable, mass-produced brick, with or without render and clay tile overcladding.

Below: Over London By Rail. Gustave Dore. 1869. Image source: British Library.



Victorian homes were almost certainly not heated to the temperatures (around 21°C) that would meet contemporary expectations of comfort or habitability.

The main rooms of this house type would originally have been heated to provide a background level of comfort. This anecdotally, is a temperature that could reduce the humidity of the air to stave off the chance of developing common diseases of the time, including tuberculosis.

There would be a reduced chance of condensation developing on surfaces heated radiantly to c.13°C and it may be that these temperatures had empirically, rather than scientifically, become ‘normal’. This background heating being made comfortable by the use of many layers of clothing, and thick, heavy blankets for bedding.

Bathrooms and other amenities were not, typically, provided within the body of the main house and, if at all, were usually provided at the far, garden end of the rear extension.

The following link to an Historic England blog provides more insight into the development of this housing type:
https://heritagecalling.com/2019/11/15/a-brief-introduction-to-terraced-housing/

As the basis for this Retrofit Pattern Book we have adopted a ‘15-foot’, two-storey, mid-terrace home, set back from the street with a shallow front garden and a rear extension and garden.

Example flat-fronted ‘Victorian’ terraced houses from across the UK illustrating the nationwide distribution of this type of housing

How did it work for the Victorians?

19th century

The house could be described as operating as an integrated 'system' with the building fabric (walls, roofs, floors, etc), the heating, lighting, ventilation, and the occupants all working together to produce a habitable environment.

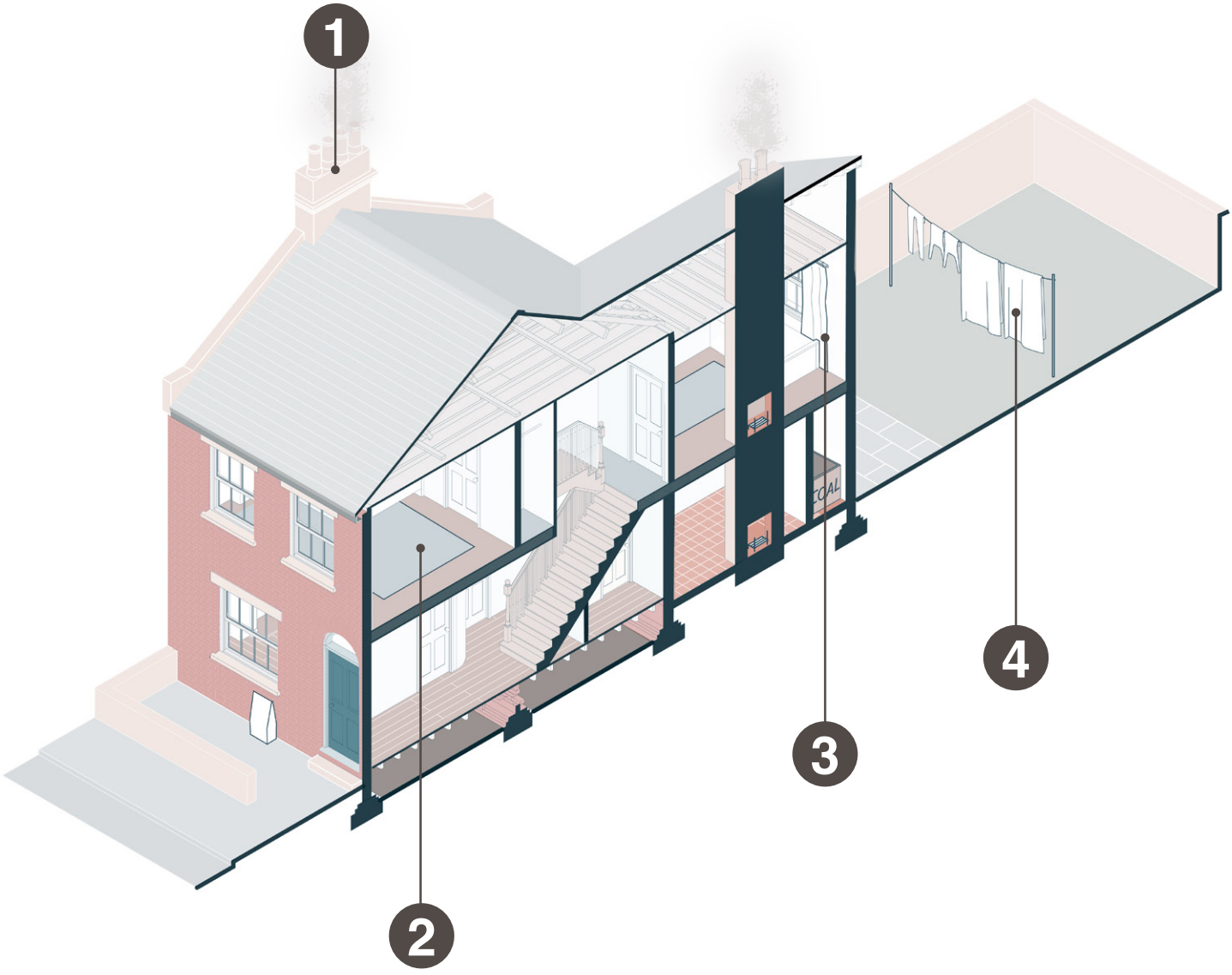
The design of the house had evolved through trial and error, responding to the demands for home ownership and providing comfort, amenity, and privacy in line with emerging social mores, habits, and expectations.

1. Fireplaces heated the chimney stacks which slowly radiated heat into the main ground floor rooms and the principle bedrooms above.

2. Non-fitted carpets and rugs left floorboards exposed at room perimeters – allowing ventilation from below.

3. Heavy curtains provided insulation against radiant heat loss from windows and some airtightness to the draughts through and around the frames.

4. Laundry mainly dried on outside line and by the outdoor – rather than the indoor – environment.



How spaces were typically heated and ventilated

Heat was provided by open fires. The open fires heated the key rooms, directly heating surfaces and people at the level of the fire.

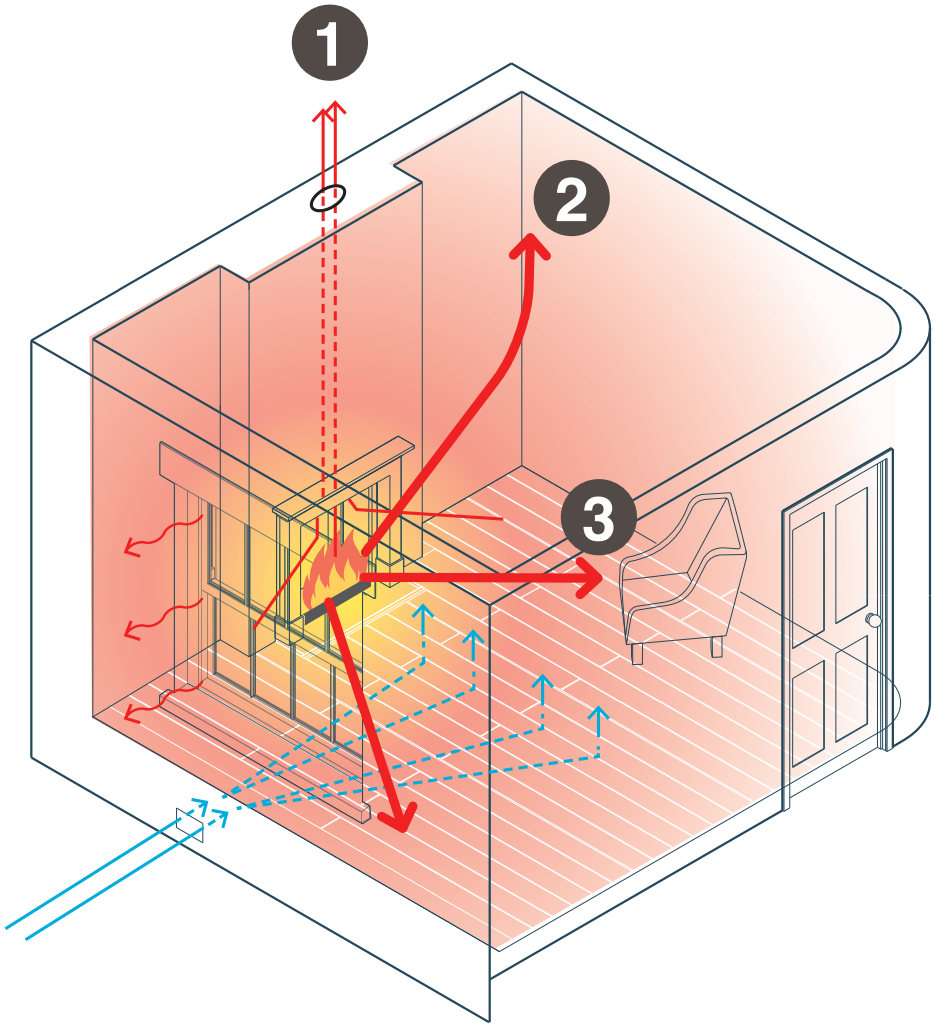
The fresh air required by the fires was provided by ventilation between the floor boards in the rooms, fed from air bricks in external walls, via the voids running beneath the ground floor.

Room temperatures were typically kept between 13°C and 16°C (depending on the external weather conditions) by constant maintenance and fuelling of the fires.

1. Updraughts in the chimneys and opening windows provided fresh air and controlled smoke and dust from fires.

2. The height of rooms, and lack of airtightness, in Victorian terraced houses allowed for the ventilation of the hot and potentially humid air upwards and away from the level of the inhabitants below.

3. Radiant heat warmed surfaces, rather than just the air through convection.



How has the house changed?

Mid to late 20th century

The transition from open fires to central heating began at the end of the 1940s.

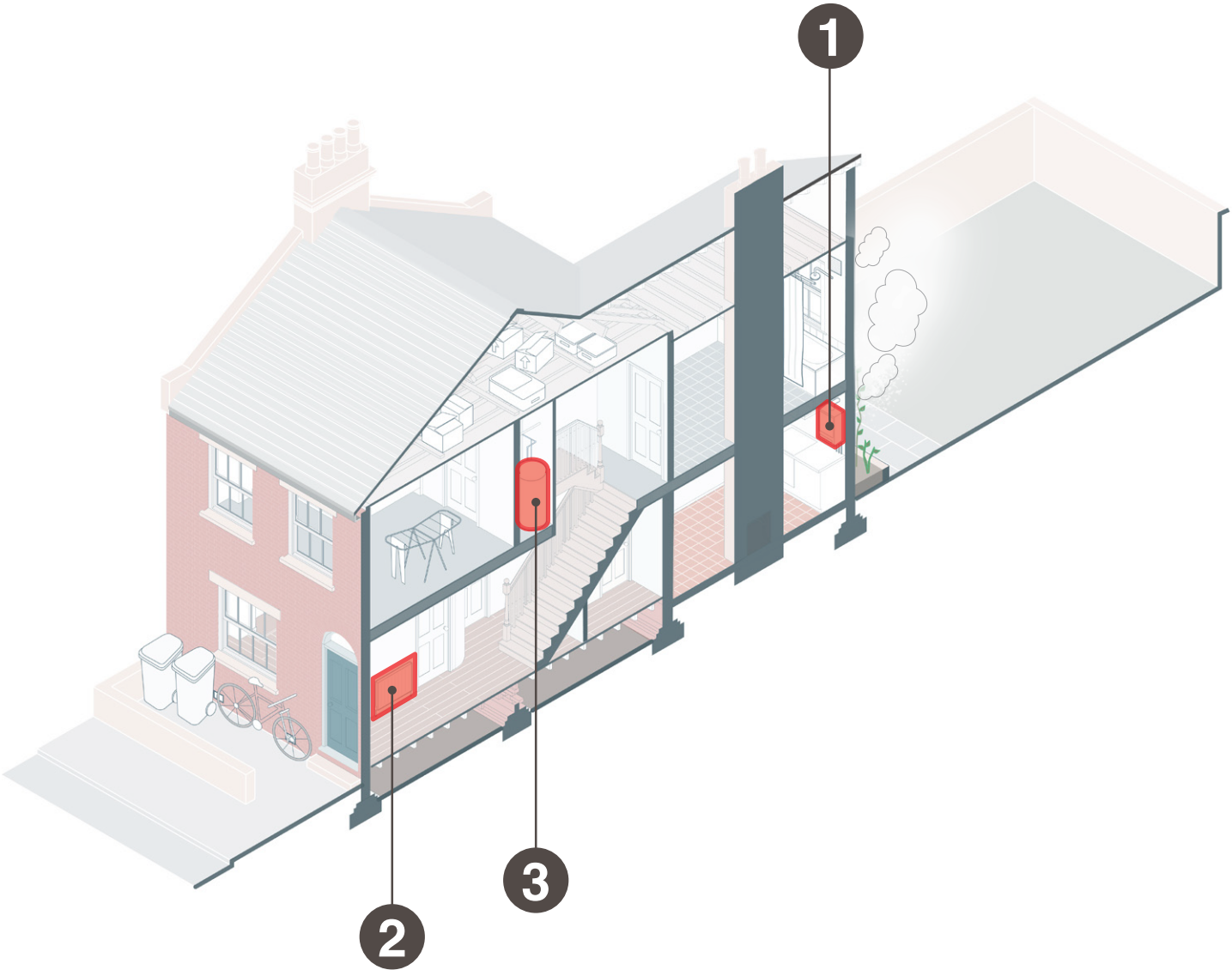
Where open fires were perhaps only in the principle rooms, there was a new potential of evenly provided, highly controllable, heat in every room of the house.

The hot water provided to radiators was heated by central gas or oil boilers or by solid fuel (coke or coal) fires with back-boilers.

1. Fossil fuelled boilers supplying hot water to both taps and to the central heating system.

2. Convection radiators and heating rooms largely by heating air.

3. The installation of hot water cylinders and the ability to store hot water lead to the provision of plumbed in hot baths.



How spaces were typically heated and ventilated

A radiator, generally placed on an external wall beneath a window, heats the cold air above and with the help of draughts from the window a convection current is created that transfers the heat around the room.

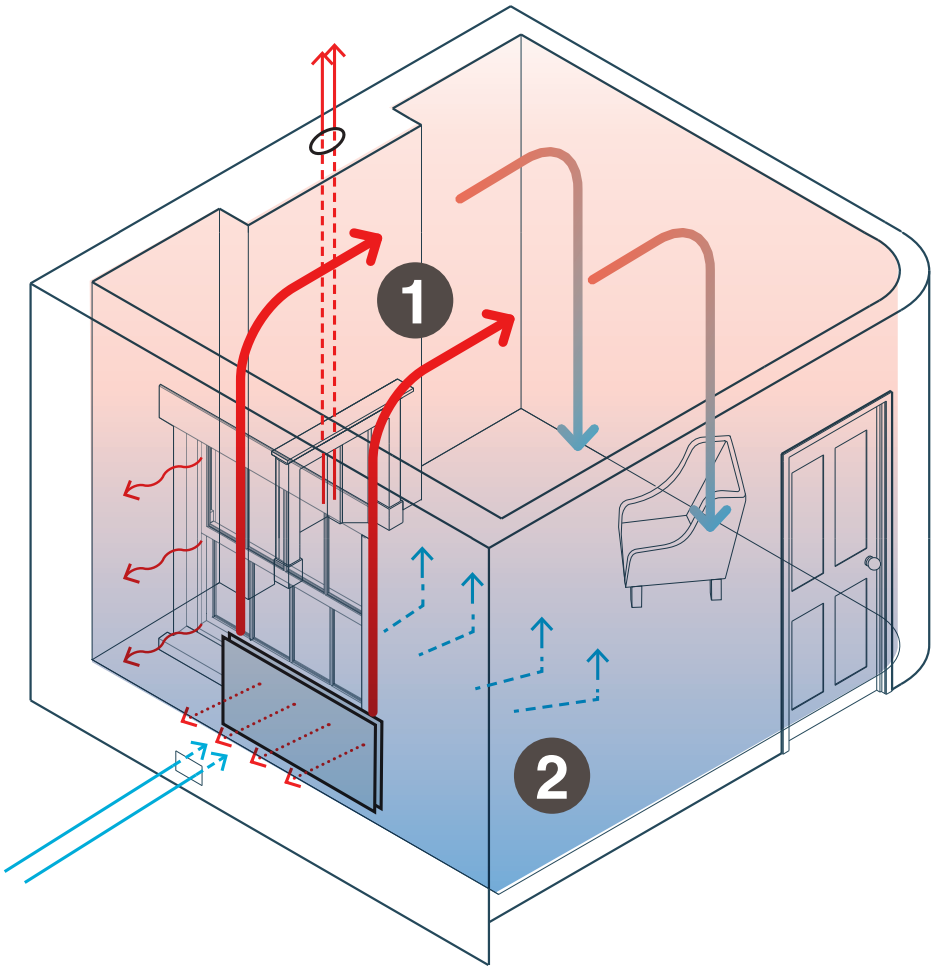
Whilst internal temperatures were not necessarily improved significantly by the transition to radiators, the ability to continuously heat the home without the need to maintain a fire led to warmer and more comfortable, and perhaps more healthy homes.

Humidity and damp was kept under a degree of control as some level of ventilation was obtained through floor voids and around ill-fitting and draughty, windows

Heating the taller rooms in Victorian houses by air has two consequences:

1. The heated air rises to the top of the rooms; a stratification which keeps the floor level and occupants colder.

2. The uncontrolled ventilation of cold air through windows and floor voids counters the heating of the air in the room. Warm air is rapidly replaced by cooler air from outside which can become a source of uncomfortable draughts.



How has the house changed?

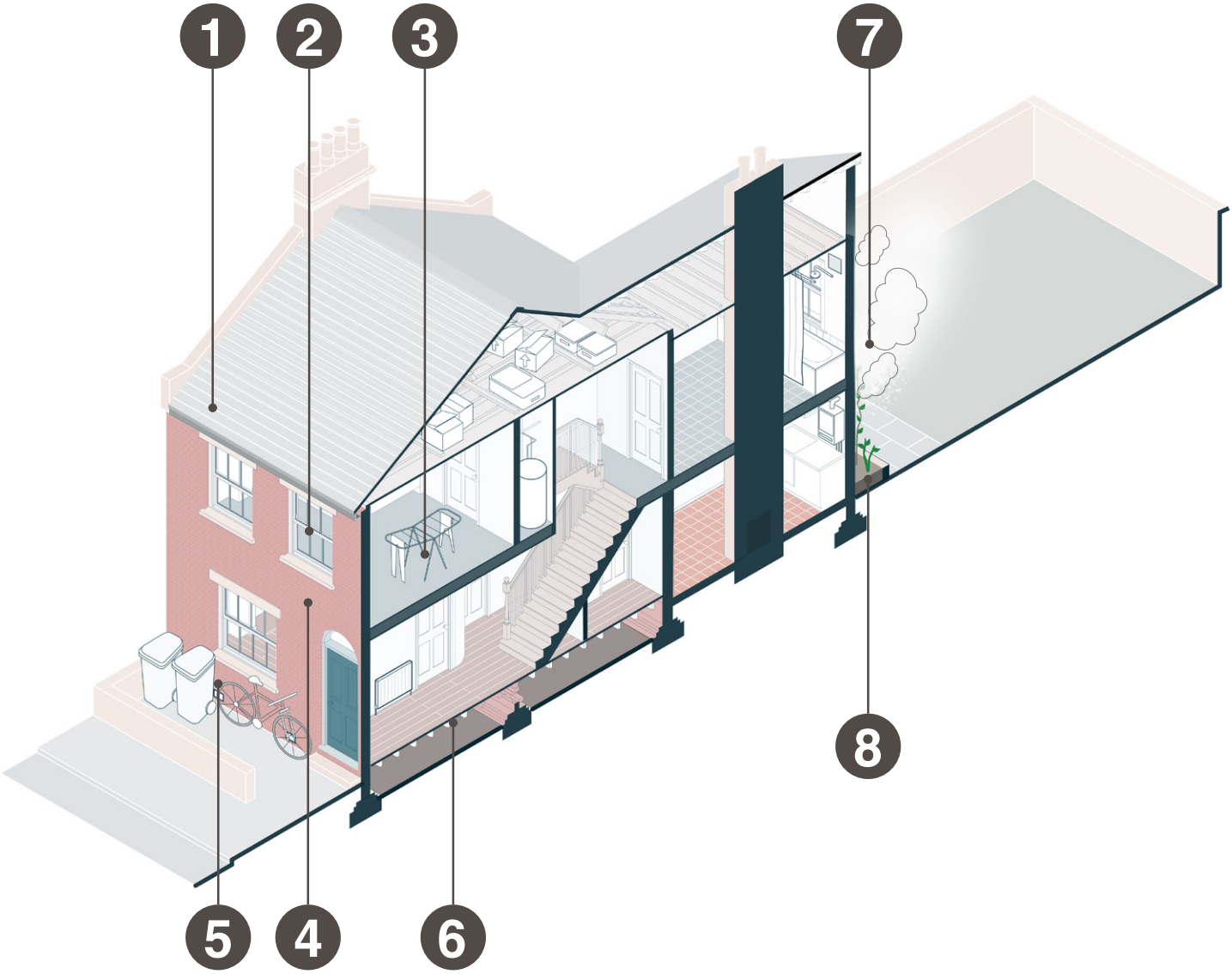
21st century

As we entered the 21st century our expectations of comfort increased and the Victorian terraced house was further adapted in an attempt to meet them.

However, with heating systems designed to meet higher expectations of comfort, the typical response to draughts was to paint up windows, block air bricks and lay fitted carpets. Whilst this had the effect of improving comfort it also drastically reduced the ability for the home to regulate humidity and damp. Infrequent or poor maintenance to this ageing house type has also seen its fabric deteriorate, risking the home's long-term stability.

The issues of trapped moisture and damp were further exacerbated by the introduction of showers and additional bathrooms, and more frequent drying of clothes inside on racks or in tumble driers. These modern comforts all contribute to increased internal humidity levels.

Climate change has increased the intensity and regularity of severe weather events affecting the physical fabric of the house. Severe storms and rainfall can overwhelm rainwater systems and strong winds can damage roofs and cause chilling draughts.



Lack of maintenance of ageing materials, windows, etc as well as of newer systems (boilers, extractor fans, etc) include:

1 Damaged roof tiles and flashing.

2 100+ year old windows becoming draughty through age due to timber shrinkage and infrequent maintenance.

3 Clothes more frequently dried inside.

4 Damaged or eroded pointing – or resilient lime mortar replaced with hard cement mortar pointing.

5 Ventilating air bricks blocked or obstructed by raised ground or planting bed levels.

6 Damp floor joists.

7 Showers and extractor fans.

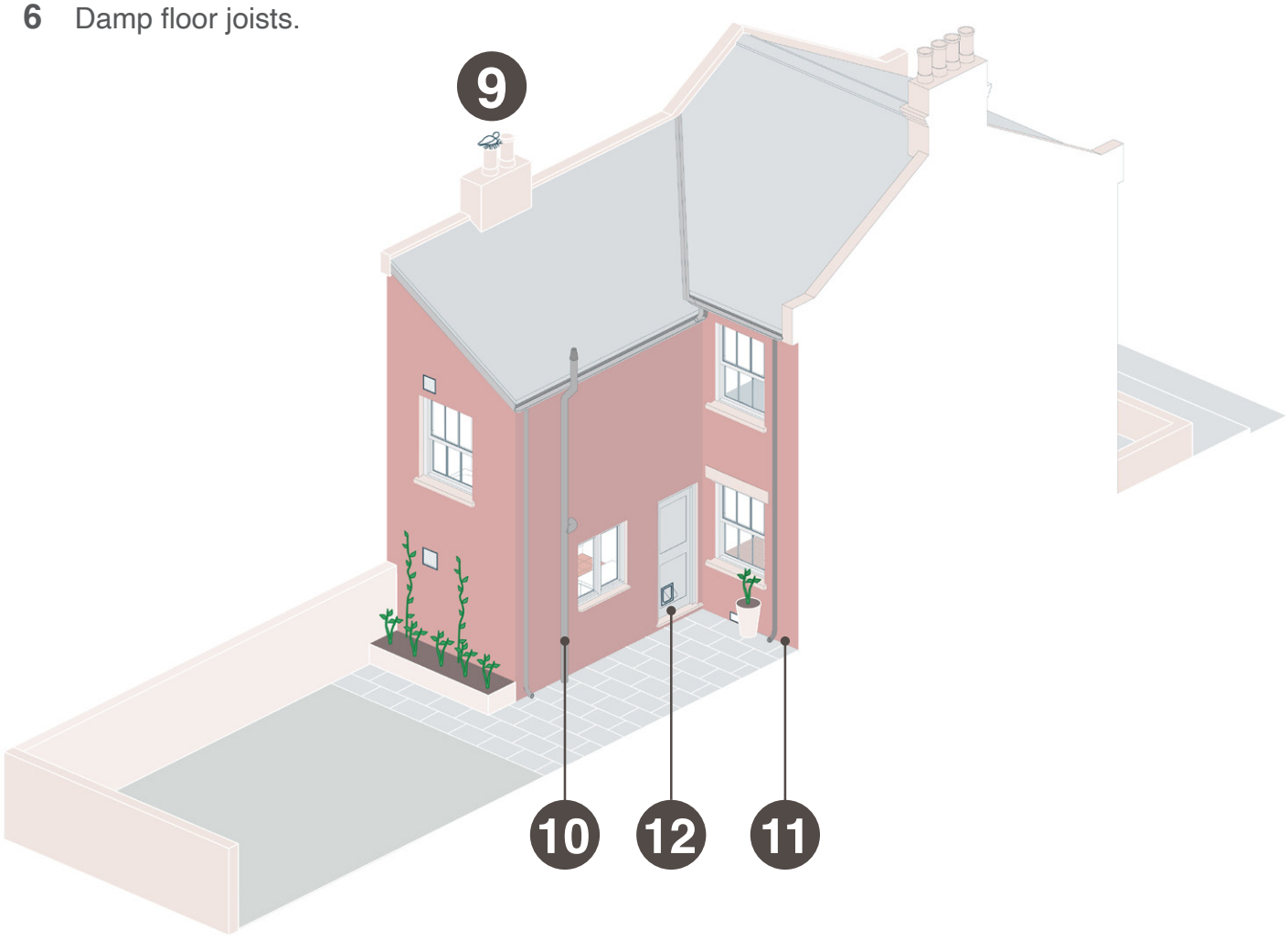
8 Raised external ground levels.

9 Obstructions to chimneys and flues, such as bird nests.

10 Overspill from blocked or leaking gutters and drainpipes causing long-term damp.

11 Waterproof paint trapping moisture inside external walls.

12 Changes to doors and windows.



What does that mean?

Impact on the fabric of the house

The consequences of changing heating systems, increased humidity (showers, more frequent laundry drying etc.) infrequent maintenance and sealing up ways that air can get into and out of the building have been significant for both building fabric and inhabitants.

An increase in timber rot and decay (in floor and roof joists, wall plates, etc.) arises from defects in the construction or lack of maintenance of the house. Leaking gutters, split drainpipes, rising moisture from raised external ground levels or storm events, etc. allow the fabric of the house to become damp.

Reduced levels of ventilation throughout the home, combined with more widespread heat provides the warm and humid/moist conditions in which dry and wet-rot fungi can propagate.

These conditions are also beneficial to the growth of mite and bug populations – leading to a rise in the diagnosis of respiratory complaints such as asthma over the last 50 years of the 21st century that can be seen to coincide with the mass installation of central heating.

Mould

Rising damp

Service openings through external walls are inadequately sealed

Evidence of damp in brickwork that has been pointed with Portland cement mortar

Inadequately insulated loft

Damp

4

What to do?

Over the last 70 years there have been significant changes in domestic expectations of comfort. Alterations to heating and poor maintenance mean many homes no longer operate as the system they were designed to. This risks causing harm to the building and its inhabitants.

Retrofit offers the opportunity to rebalance the operation of these homes, supporting improved domestic comfort and the building's long-term stability. Understanding how the home operates as a balanced system is key to ensuring there are no further unintended consequences.

If you only make a few upgrades to your house, you should consider the benefits of:

1. Complete any **maintenance tasks** that are undermining the thermal performance of your house – leaks, blocked vents, etc.

2. Insulate your **loft**.

3. Address heat losses from **draughts** (draught seal windows and doors) while making sure that your kitchen and bathroom extract ventilation fans work efficiently.

4. Install an **air source heat pump** (and possibly a battery) using smart tariffs to reduce the costs and carbon emissions of your energy.

Components of retrofit

The retrofit of any house will typically involve three kinds of change:

Improvement of the **thermal performance of the building fabric** to reduce the amount of heat and energy required to maintain the same levels of internal temperature and comfort. This will be in the form of insulation (of floors, walls, windows, doors, and roof) or improved airtightness.

Improving the **efficiency of the services** – the way that the house is heated, ventilated, and lit, to reduce the amount of energy used by fittings and appliances. This will be in the form of LED lamps and improving heat source efficiency – replacing gas-fired boilers with air source heat pumps, recovering heat from ventilation fans, etc.

Adding **renewable supplies of energy** to generate clean, fossil-fuel-free energy that can directly power the home, reducing the amount of energy which needs to bought from the electrical grid. This includes electricity from photovoltaic panels and batteries etc.

These are considered in this order in the following measures and levels of retrofit.

A note on 'comfort taking':

It is possible that installing the first components of retrofit do not achieve savings in energy use or costs but do deliver increases in internal temperature and comfort (health etc) within the same levels of energy use and cost.

The phenomenon of 'comfort taking' is well-recognised and discussed in this Summary of Analysis of the National Energy Efficiency Data-Framework (NEED): 2021

https://assets.publishing.service.gov.uk/media/610aa4bae90e0706d8a27712/need-report-2021.pdf

Where to start?

Retrofitting our homes offers the opportunity to reinstate a holistic approach to the health of occupants and the building fabric, levels of comfort and energy efficiency.

Poorly designed and/or installed insulation or airtightness measures can be ineffective and risks damage to the health of the building and its occupants. When planning any works:

1 It is important that damp problems caused by lack of maintenance or inadequate ventilation are sorted out before new measures are undertaken. Damp brickwork and plaster are much worse at insulating than dry brickwork or plaster. Damp timbers may be susceptible to mould and decay.

2 It is crucial to maintain good ventilation throughout the year to ensure occupant health and maintain the building fabric. Over insulating your home without ensuring adequate ventilation through windows, trickle vents or ventilation systems can result in high humidity, condensation and, potentially, damp and mould forming within the building fabric.

3 Try to use materials that are 'breathable' and retain the characteristics of the original construction. Natural materials such as wood-fibre involve less carbon in their manufacture and give off fewer Volatile Organic Compounds (VOCs) within the house.

4 Heritage features – like cornices, architraves, window surrounds and staircase details – are important historically and add significantly to the character and ongoing value of the home. If practically possible, retrofit measures should be planned so that these are retained or reinstated.

5 Materials which are known to pose a risk to health are present in many older buildings including lead paint and asbestos. Asbestos was frequently used in the 20th century as an insulating material and within decorative plaster finishes. There are significant health risks associated with disturbing or handling asbestos. Before embarking on DIY works, it is advisable to get technical advice from a surveyor on any asbestos risks that may exist in your home.

Common misconceptions

Heat goes upwards

Hot air rises through **convection** and that is the basis of this myth. Heat is a form of **energy** and travels in every direction from warmer to colder bodies by **radiation** or **conduction**. Uninsulated, solid floors feel cold as heat is being radiated or conducted from feet into the cold floor. This is also why it feels cold to stand close to a single-glazed window in the winter. Just as we feel this heat loss, our houses lose their heat through radiation not just upwards but in **all directions** through walls, floors and windows etc.

You're not allowed to do works to listed buildings or those in conservation areas

You **can** undertake almost any **retrofit** measure to a listed building or one in a conservation area. You just need more detailed consents and will need to take more consideration of the aspects of the house that contribute to its listing or the character of the conservation area. Conservation Officers can often have a more educated and holistic view of sustainability, but will be keen to see that proposals are sensitive to the heritage character of the property.

You can't insulate the inside of a solid brick wall

There are many accepted wisdoms about this but, if you (and your adviser) are careful to use **vapour-permeable insulation** and **not** to **over-insulate**, it has been shown that it is possible to **internally insulate** the solid walls of even Grade 1 listed buildings. Over insulating or vapour impermeable insulation can risk creating conditions for interstitial condensation and mould growth harming building fabric and occupants.

An air source heat pump will save you money without having to take any measures to reduce your heating demand

An air source heat pump (ASHP) will – because of its efficiency – **reduce the amount of energy needed** to heat your home and, as the electricity grid is decarbonised, will dramatically reduce the associated carbon emissions. An ASHP with a performance coefficient (COP) of 3 will reduce the energy needed to heat your home by 66% to 33%. However, as **electricity is currently ~3x more expensive than gas**, this reduced amount of energy might cost no less.

If you make your home airtight it means that you can't (ever) open the windows

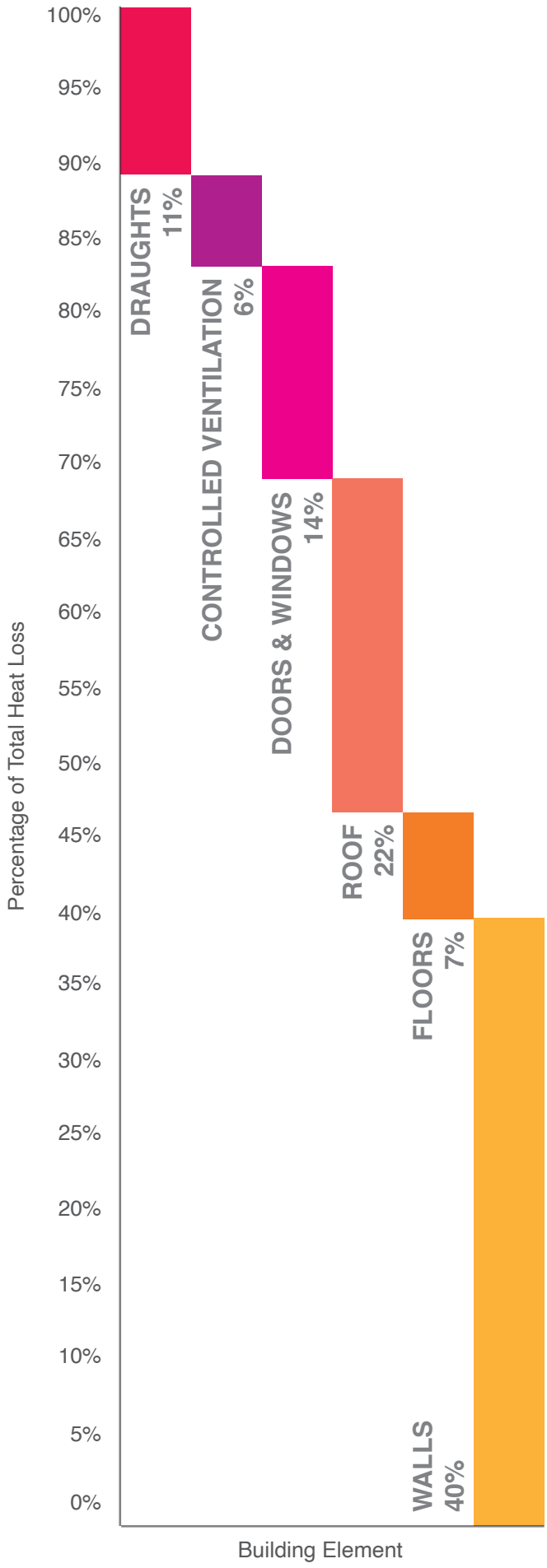
Making a house airtight aims to reduce the amount of heat that is lost by **draughts (uncontrolled ventilation)**, NOT the proportion of heat that is lost through the **controlled ventilation** that is needed to maintain your health – through controlling the humidity and VOCs levels in your home. Unless you have a mechanical ventilation system with heat recovery you will still need to open windows (or keep any trickle vents open) in order to maintain the health of your house and family.

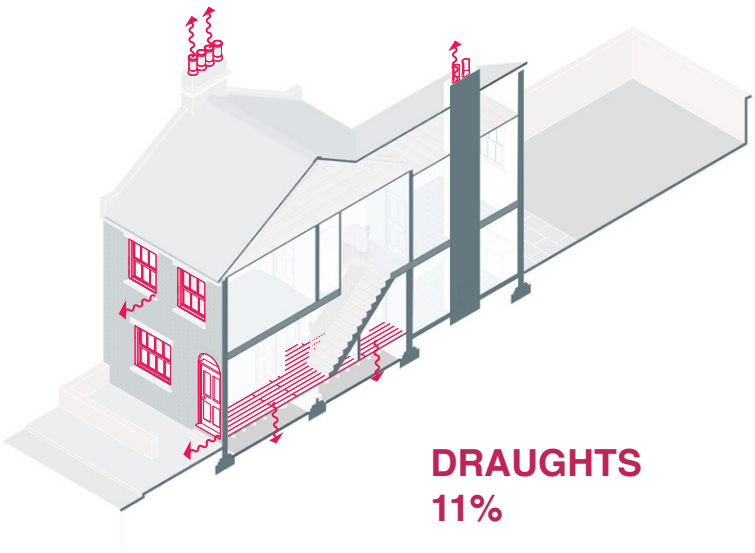
Baseline heat loss

The ‘baseline’ Victorian terraced house loses heat across multiple building elements – in particular through large uninsulated surfaces i.e. mainly the roof and walls, and through draughts (uncontrolled ventilation). The likely % of peak heat loss is illustrated by building element (shown opposite).

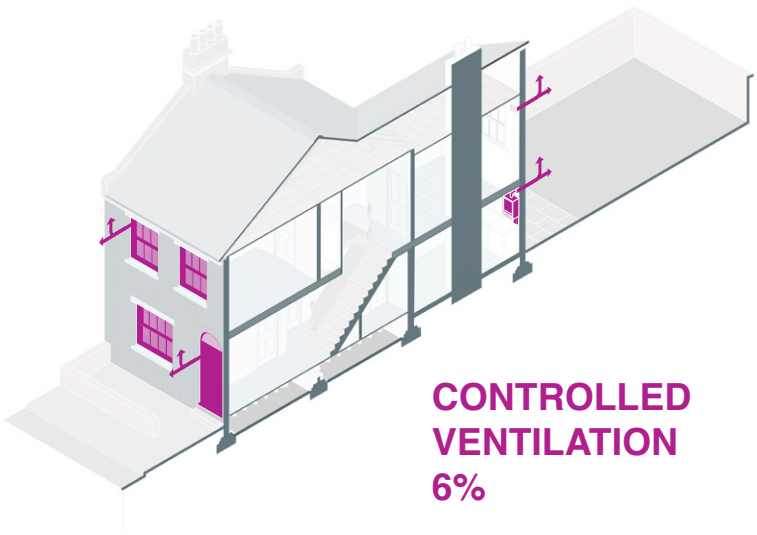
The baseline peak heat loss shown in this pattern book is based on a house with a target temperature of 21ºC for occupied spaces, and 18ºC in hallways, stairs, and landings. To calculate the ‘peak’ heat loss an external temperature of -3ºC has been used.

Climate also impacts building heat loss. The default home illustrated is based in Norwich.



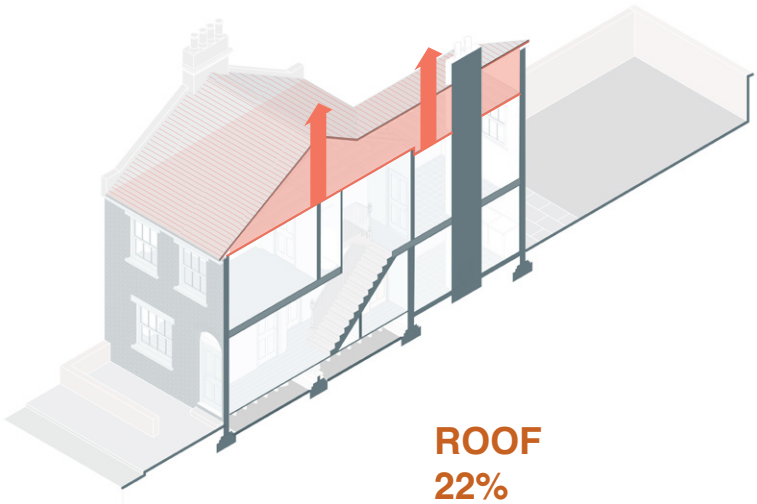


DRAUGHTS
11%

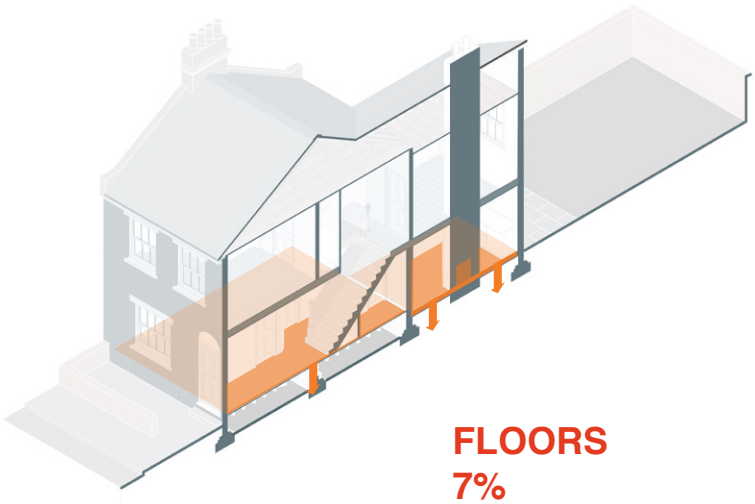


CONTROLLED VENTILATION
6%

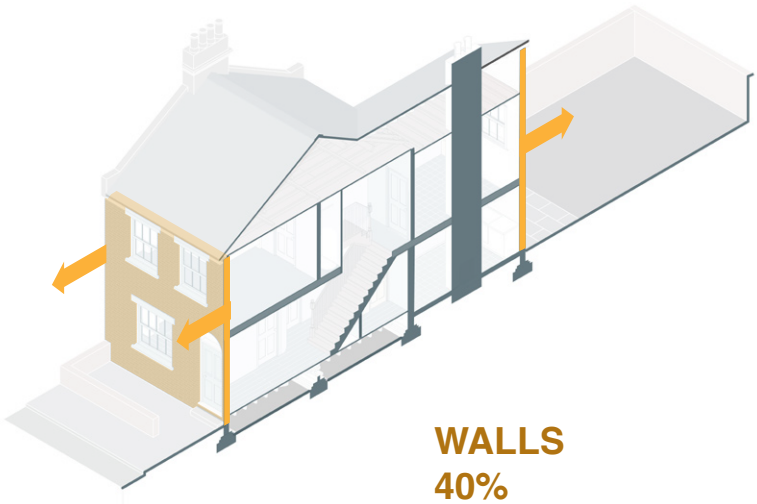
DOORS & WINDOWS
14%



ROOF
22%



FLOORS
7%



WALLS
40%

Levels of fabric retrofit

Levels

As all homeowners will have different financial situations, DIY capabilities, and lifestyle priorities, this Retrofit Pattern Book sets out three 'levels' of fabric improvements. Each of these levels suggest different degrees of:

- Time
- Delivery (who is doing the works)
- Disruption
- Installation Cost
  N.B. Due to the high degree of variation in costs related to region, season, and individual installers, costs are suggested by orders of magnitude only.

EPCs

Energy Performance Certificates (EPCs) are currently used by government, landlords, and during house sales as a way of assessing the environmental performance of houses. They form the basis for implementing the Energy Act legislation which determines whether, or not, a premise can be leased or rented. EPC ratings range from A (very efficient) to G (inefficient).

Baseline

'Baseline' describes a house that is completely uninsulated – as would have been the case when it was built.

This condition is used to understand where retrofit works to your **existing house** might be starting from, and to calculate approximations on the potential energy, costs, and carbon you might save.

We have used these assumptions to calculate the figures included in this Retrofit Pattern Book. These assumptions are listed in the Fabric Measures section.

Baseline+

We appreciate that every house is different and that some improvement may well have been made to the insulation and comfort of your home.

'Baseline+' is included to recognise that some homes may have some energy-efficiency measure installed already and identifies the effects of the improvements that may have been made by the installation of some loft insulation, wall-to-wall carpets, heavy curtains etc.

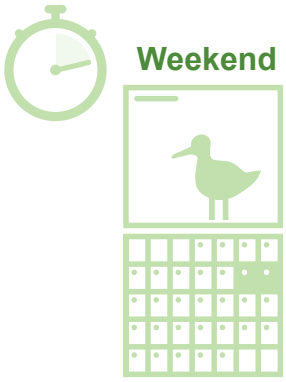
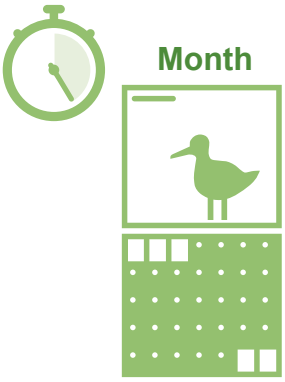
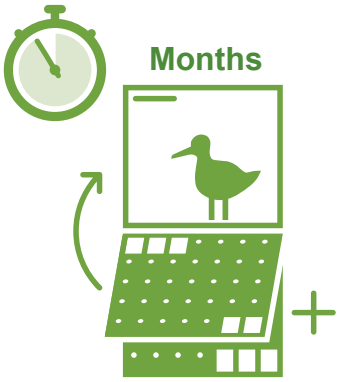
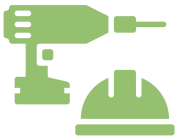
In the later chapter exploring services and renewable energy improvements, it has been assumed that the home is likely being heated through a gas-fired combi boiler arrangement, providing hot water for heating and domestic uses (taps).

The methodology for determining EPCs is based on Standard Assessment Procedure (SAP) calculations. These are abstract, generalised measures of cost (rather than energy) efficiency of heating, and not truly representative of how a building performs.

It is possible, for example, for a deeply-sustainable Passivhaus standard dwelling, despite extraordinarily low energy consumptions, to achieve an EPC of only B through SAP analysis.

The improvement measures and energy savings presented here are based on detailed modelling of the building materials, construction and patterns of occupancy behaviour. They more accurately represent the actual performance of your home, improvement measures, and savings of energy, cost, and carbon.

This version of the Retrofit Pattern Book is unable to relate the Levels and Measures it proposes to the output of SAP calculations or to EPC ratings.

	Level 1	Level 2	Level 3
Timescale	 Weekend	 Month	 Months
Delivery	DIY	 Small builder	 Small builder + professional advice
Disruption	Minimal	 Room by room	 Phased room by room, or one-hit whole house
Cost	£	££	£££

Impact of retrofit

The following pages provide a summary of the impact of fabric retrofit measures.

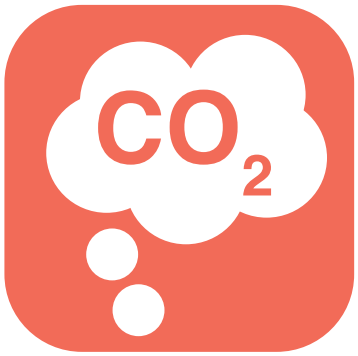
BASELINE

100%

Percentage representative of the Baseline total of annual bills*

100%

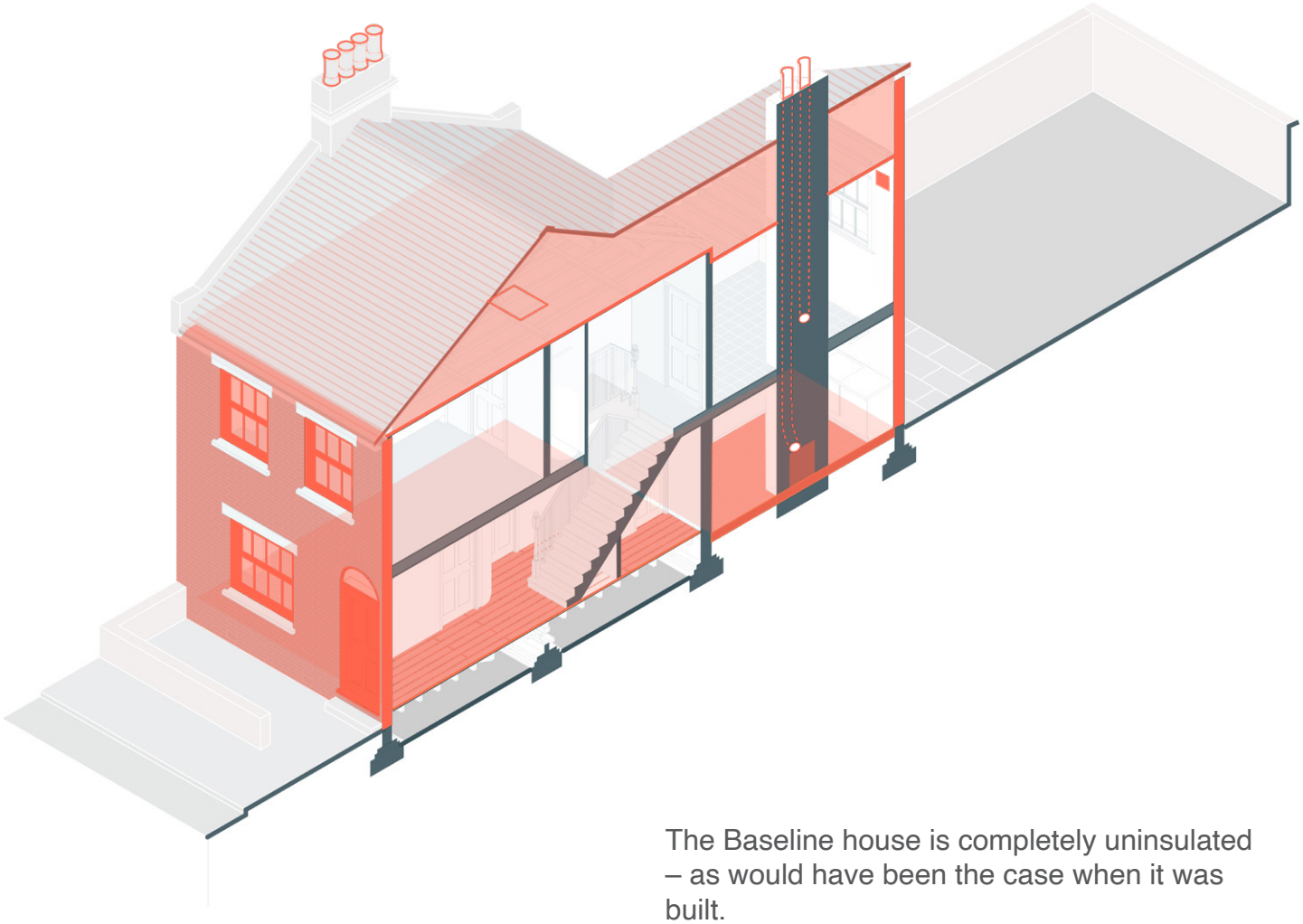
Percentage representative of the Baseline total of annual energy consumption



100%

Percentage representative of the Baseline total of annual carbon emissions

***figures based on mixed gas and electricity energy usage**



The Baseline house is completely uninsulated – as would have been the case when it was built.

Potential benefits

BASELINE+

£

88%

Percentage of annual bills compared to Baseline*

kWH

83%

Percentage of total annual energy consumption compared to Baseline

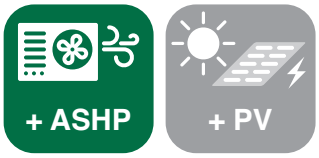
CO_2

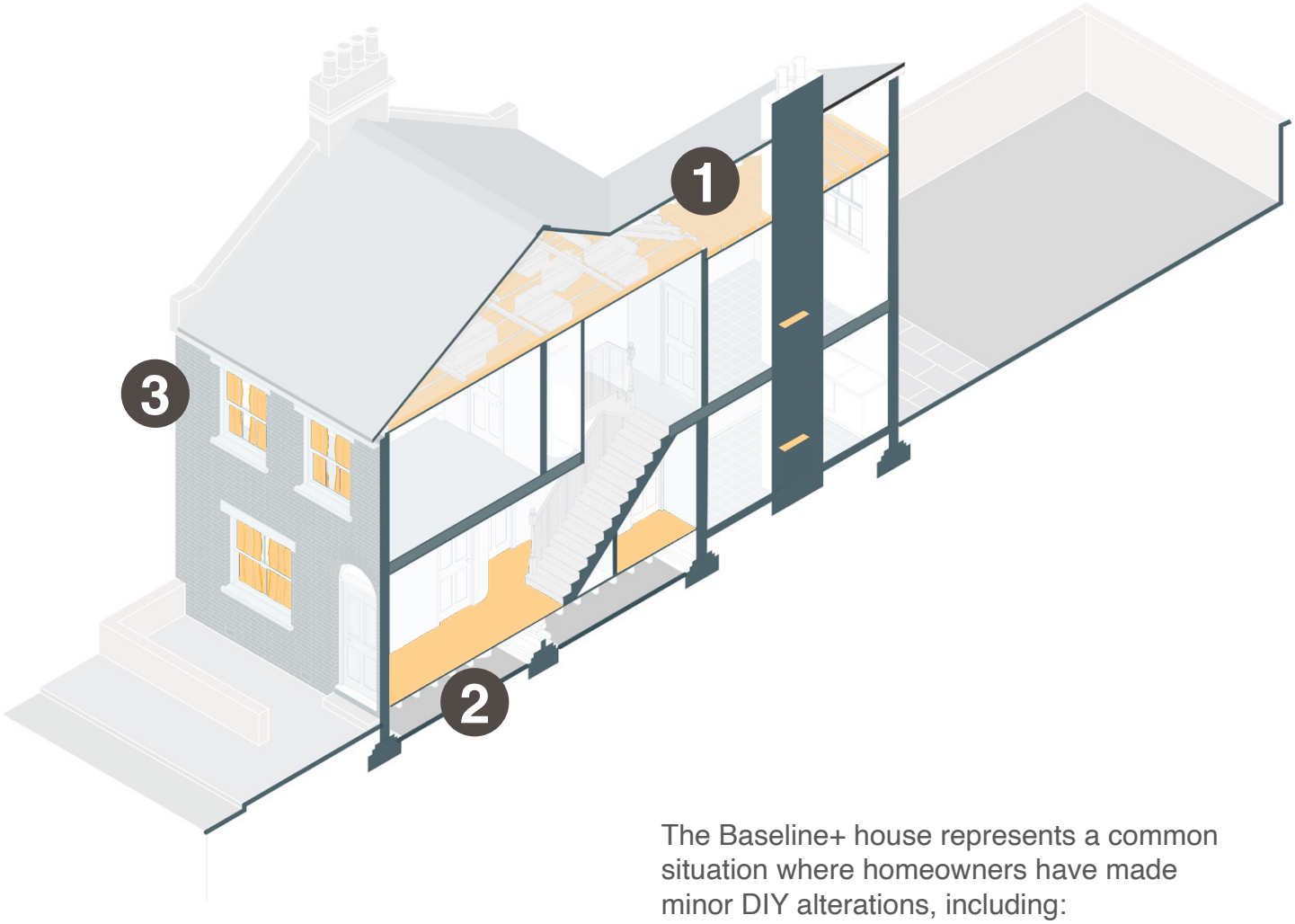
82%

Percentage of annual carbon emissions compared to Baseline

*figures based on mixed gas and electricity energy usage

Opportunity to combine with services measures - *Refer to later chapter*





The Baseline+ house represents a common situation where homeowners have made minor DIY alterations, including:

1 Some roof insulation installed

2 Carpet over suspended timber floors

3 Heavy curtains installed

Refer to pages 55-57 for a full breakdown of Baseline+.

Potential benefits

LEVEL 1

£

86%

Percentage of annual bills compared to Baseline*

kWH

80%

Percentage of total annual energy consumption compared to Baseline

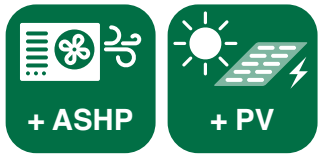
CO_2

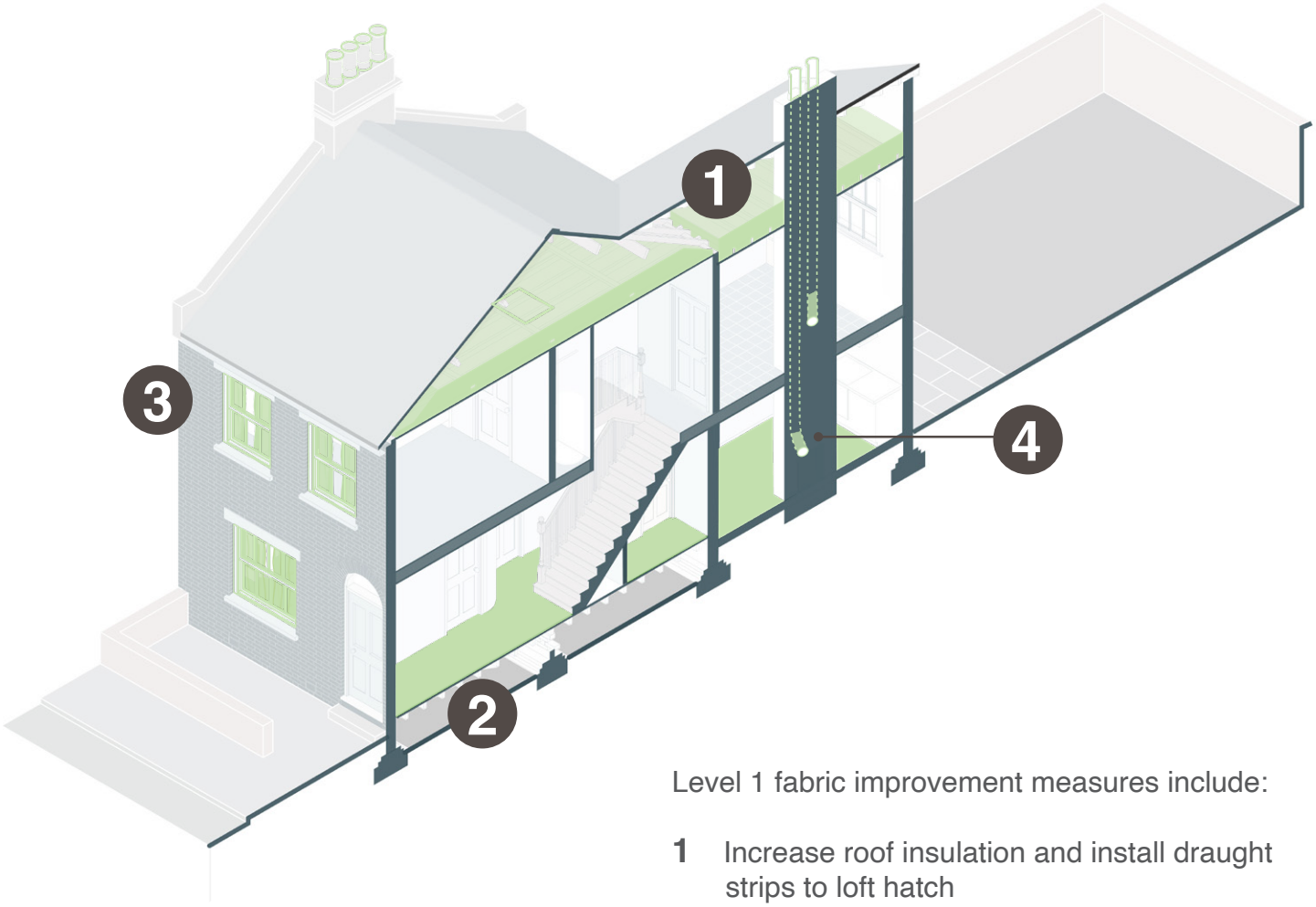
79%

Percentage of annual carbon emissions compared to Baseline

*figures based on mixed gas and electricity energy usage

Opportunity to combine with services + renewable energy measures - *Refer to later chapter*





Level 1 fabric improvement measures include:

1 Increase roof insulation and install draught strips to loft hatch

2 Fit carpet or covering over suspended and solid floors

3 Install draught and weather strips to windows and draught excluders to doors

4 Install chimney draught excluders

Refer to pages 55-57 for a full breakdown of Level 1 measures.

Potential benefits

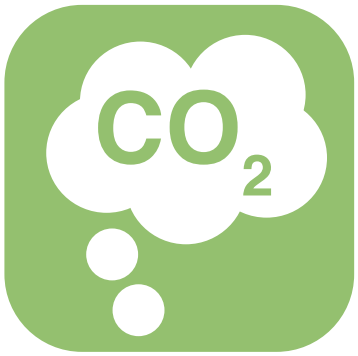
LEVEL 2

82%

Percentage of annual bills compared to Baseline*

74%

Percentage of total energy consumption compared to Baseline

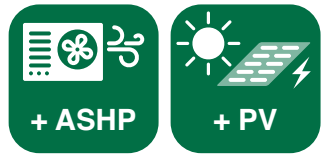


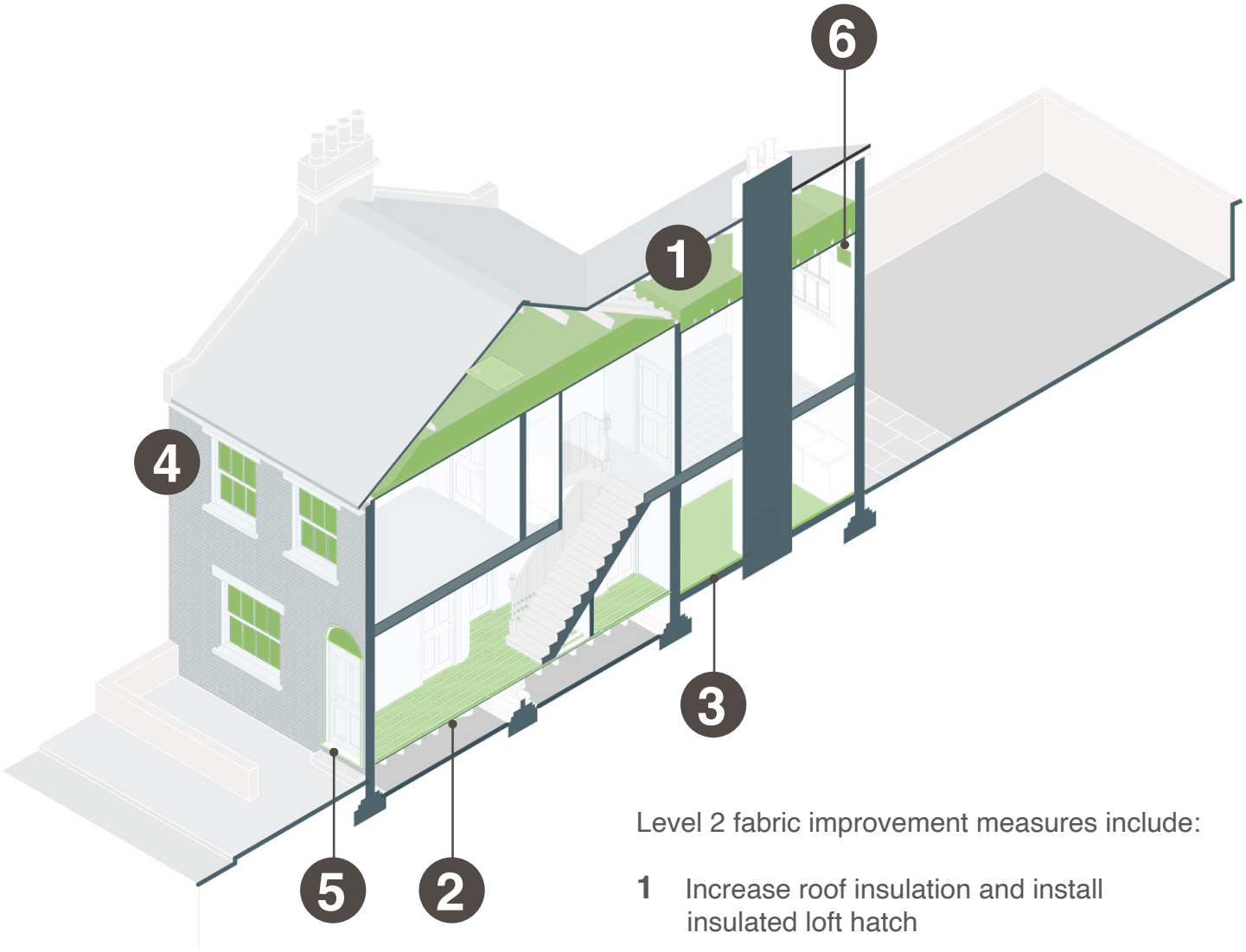
73%

Percentage of annual carbon emissions compared to Baseline

*figures based on mixed gas and electricity energy usage

Opportunity to combine with services + renewable energy measures - *Refer to later chapter*





Level 2 fabric improvement measures include:

1 Increase roof insulation and install insulated loft hatch

2 Re-lay timber floorboards to close up gaps

3 Install insulation and new flooring over existing solid floor

4 Reglaze existing windows with double or vacuum glazing

5 Install draught proofing measures to doors

6 Install room-by-room MVHR units

Refer to pages 55-57 for a full breakdown of Level 2 measures.

Potential benefits

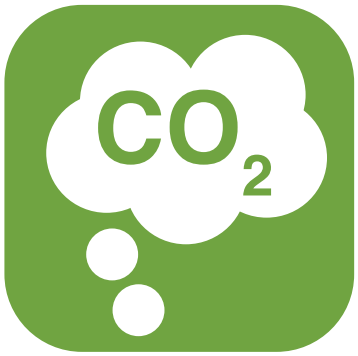
LEVEL 3

45%

Percentage of annual bills compared to Baseline*

50%

Percentage of total energy consumption compared to Baseline

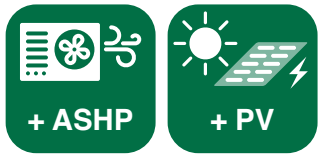


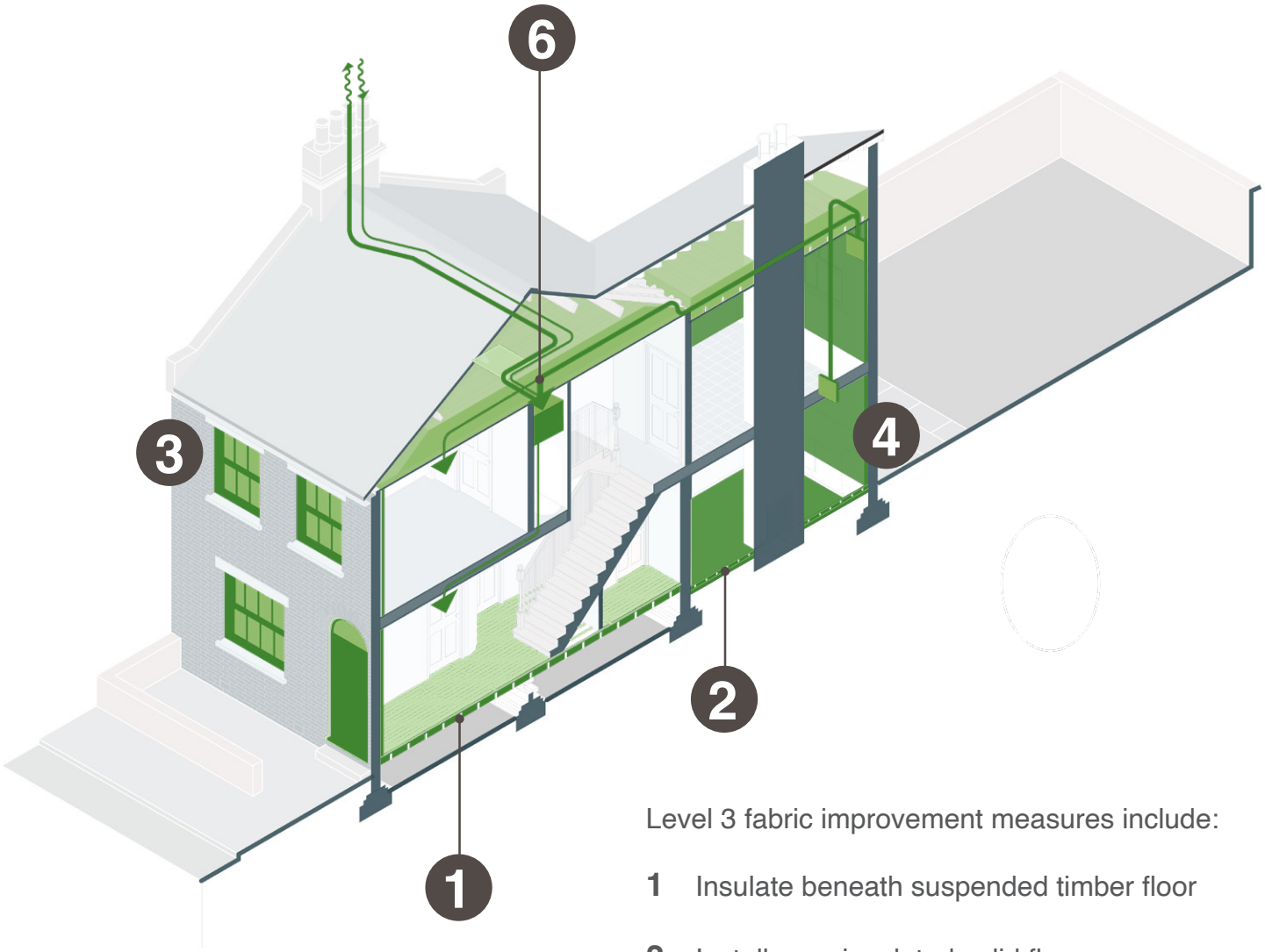
48%

Percentage of annual carbon emissions compared to Baseline

***figures based on mixed gas and electricity energy usage**

Opportunity to combine with services + renewable energy measures - *Refer to later chapter*





Level 3 fabric improvement measures include:

1 Insulate beneath suspended timber floor

2 Install new, insulated solid floor

3 Replace existing windows with thermally-broken frames and double or vacuum glazing

4 Replace existing doors with insulated doors and double or vacuum glazing

5 Insulate walls externally or internally where appropriate

6 Install MVHR using chimney flues

Refer to pages 55-57 for a full breakdown of Level 3 measures.

Fabric measures

Summary

This section outlines detailed measures to improve the physical 'fabric' of your house, including guidance for retrofitting.

The table on the following pages outlines our baseline assumptions about the physical fabric of the typical Victorian terraced house. Using these assumptions we have calculated the potential figures provided throughout this document. The various fabric measures are organised by building element and the different levels of retrofit.

The figures given on the following table are the estimated percentage reduction which may be achievable in your homes peak heat loss. It is the peak heat loss, i.e. the amount of heating energy it takes to maintain your home at a comfortable temperature, that are used when determining the capacity of your heating system, be it a gas boiler or heat pump.

How to use this table?

'As Baseline' used when no measures for that level are advised.

'-' used when no additional measures from the previous level are advised.

Building element e.g. roof, floors, walls etc.	*Baseline assumptions about existing fabric of your house*	As Baseline	*Description of Level 1 fabric measures*	*Description of Level 2 fabric measures*	-
		-	**-5%**	**-10%**	-

Note:
Whilst a reduction in peak heat loss will broadly translate into a similar reduction in annual heating energy and therefore your bills, the two concepts – peak heat loss and annual heating energy are separate and distinct. The amount of heating energy your home will use in a year will depend not only on the peak heat loss but the outside temperature and how you use your home, what temperature you maintain it at, etc.

Fabric measures and potential % of peak heat loss reduction from Baseline

Building element	Baseline	Baseline+	Level 1	Level 2	Level 3
Roof	Slate roof • 25mm slates • 40mm timber battens • 100mm timber rafters • No insulation • 100mm ceiling joists • 35mm timber lathes and lime plaster • Simple boarded access hatch	Existing 100mm fibreglass quilt insulation between ceiling joists	Increase insulation between and over ceiling joists 400mm	Increase insulation between and over ceiling joists 600mm Install insulated and airtight loft access hatch	-
		-18%	**-21%**	**-22%**	**-22%**
Floors	Suspended floors • 20mm exposed timber floorboards – painted • 130mm timber joists on dwarf walls • 590mm ventilation gap	Existing carpet and underlay	Install fitted carpet and underlay	Lift and re-lay (or lay new) boards (to close up gaps)	Insulate beneath boards • Insulation in mesh hammocks between joists • Spray insulation to underside of boards Install underfloor heating
		-1%	**-1%**	**-1%**	**-4%**
	Solid floors • 20mm quarry tiles • 30mm concrete screed • 150mm concrete slab	As Baseline	Install carpet or insulated (cork or foam) vinyl sheet flooring	Install new flooring. • Thin insulation above existing slab/screed (waterproof painted) • Laminated board or thin tile floor finish	Install new floor • Break out existing screed/ slab • Install new insulated slab and screed (with underfloor heating)
		-	**< -1%**	**< -1%**	**-1%**

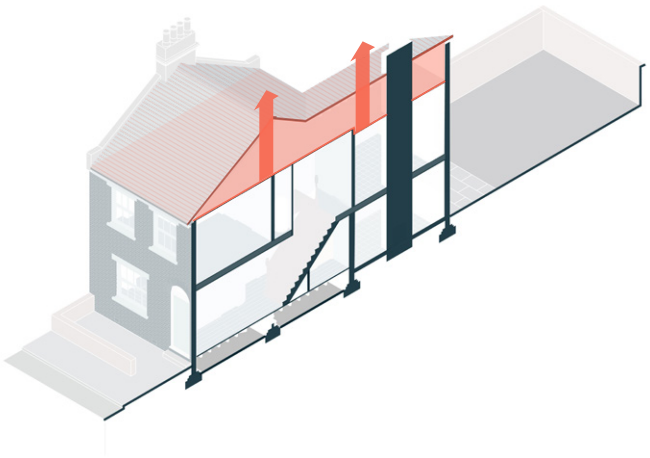
Table continued overleaf...

Building element	Baseline	Baseline+	Level 1	Level 2	Level 3
Walls	Brick external wall • 215mm solid brickwork with lime mortar • 25mm internal lime plaster	As Baseline	As Baseline	As Baseline	Internally insulate with 60mm wood fibre and fermacell or lime plaster
	Brick external wall / no heritage value • 215mm solid brickwork with lime mortar • 25mm internal lime plaster	As Baseline	As Baseline	As Baseline	Externally Insulate with 80mm insulation with render, brick, or board finish
		-	-	-	**-23%**
Windows	Sliding sash windows • 4mm glass in softwood sashes • Softwood frame and cill	Existing heavy curtains installed	Install draught and weather strips to existing sashes and frames	Reglaze existing sashes with slimline double or vacuum glazing and install draught and weather beads	Replace existing window frames and sashes with thermally-broken frames and sashes with double or vacuum glazing
	Hinged casement windows • 4mm glass in softwood sashes • Softwood frame and cill	Existing heavy curtains installed	Install draught and weather strips to existing casements and frames	Reglaze existing casements with slimline double or vacuum glazing and install draught and weather beads	Replace existing window frames and casements with thermally-broken frames and casements with double or vacuum glazing
		-3%	**-3%**	**-5%**	**-9%**

Table continued opposite...

Building element	Baseline	Baseline+	Level 1	Level 2	Level 3
Doors	Softwood front door • Panelled softwood door • Softwood frame • Stone cill	As Baseline	Buy or make draught excluders	Install draught and weather strips to existing doors, frames. Install insulated inner flap to letter box and escutcheon to keyhole	Replace existing door and frame with insulated door and frame with double or vacuum glazing
	Part-glazed softwood back door • 4mm glass in panelled softwood door • Softwood frame • Stone cill	As Baseline	Buy or make draught excluders	Install draught and weather strips to existing doors, frames. Install insulated inner flap to letter box and escutcheon to keyhole	Replace existing door and frame with insulated door and frame with double or vacuum glazing
		-	**< -1%**	**< -1%**	**-1%**
Ventilation and infiltration	Badly-fitting loft access hatch	As Baseline	Add draught strips to existing hatch	Install insulated and airtight loft access hatch	As Level 2
	Gaps between floor boards of suspended floors / draughts	Existing carpets to suspended floors	Install fitted carpet and underlay	Re-lay floorboards to close gaps	As Level 2
	Open chimney flues to all fireplaces	Fireplaces closed off with hardboard	Install chimney sheep	As Level 1	Install Mechanical Ventilation with heat recovery system (MVHR) using chimney flues as atmosphere connections and for supply air to rooms. Stair and hall forms return air plenum with extract through landing ceiling
	Badly fitting doors and windows / draughts	Existing heavy curtains installed	Install heavy curtains	Install room-by-room MVHR units to kitchens and bathroom	
	Extract vents from Kitchens and bathrooms	As Baseline	As Baseline		
	Windows open for fresh air	As Baseline	As Baseline		
		-	**-2%**	**-8%**	**-10%**
Total reduction in peak heat loss from Baseline		**-23%**	**-28%**	**-38%**	**-70%**

Roofs



Insulating your roof is one of the most effective ways to reduce heat loss at home. Here are some general tips:

Where to insulate?

Ideally, roof insulation would be installed between the sloping rafters. As this is awkward to do in practice and requires provision of ventilation above the insulation, insulation is rarely installed here unless as part of a complete re-roofing project. Roof insulation is most commonly and easily installed between and above the ceiling joists.

Install Roof insulation in layers.

The first layer should lie between the ceiling joists and be of the same depth, with subsequent layers at right angles, to limit formation of gaps.

It is important that the insulation does not block ventilation of the roof space

Normally the vapour generated in the rooms below passes into the roof space through the ceilings where it can condense on the underside of the roof structure. This moisture is usually carried away to the outside by air movement within the roof space. If this ventilation is blocked there is a risk that the timber structure will become damp and lead to the formation of mould and wet/dry rot.
Insulation should be installed to maintain ventilation gaps at the eaves.

Insulate pipework and tanks

Where pipework from below passes through the layer of insulation and where there are cold-water storage tanks within the roof space, installing insulation above the ceiling will mean that these will be in a colder space than before and might be at risk of freezing.
Pipes and tanks in the roof space – above the insulation layer – should be lagged with pre-formed insulation and insulated jackets.

Insulation sags and compresses with time

– so if a roof had 200mm insulation installed a few years ago – this might now only be between 100-150mm thick with a corresponding reduction in performance.

Insulate loft access hatch

Badly-fitted or uninsulated loft access hatches can be a significant route for the leakage of warm air from the house and for cold down-draughts.
Ensure that the loft hatch fits tightly and add draught strips to the hatch and frame. Placing insulation within a bag that is taped or glued to the top of the hatch can ensure that this stays in place when the hatch is opened. Alternatively, fit a high-performance insulated and airtight loft hatch.

Create a storage platform

If the roof space is used for storage, it may be necessary to move this onto a platform that sits above the insulation. ‘Loft packs’ – essentially chip board flooring on stilts or cross-bearers – are available from most DIY stores and can be used to create a storage area whilst not compressing the insulation beneath it.
Always leave a ventilation gap (50mm) between the chip board surface of a storage platform and the top of the insulation, to allow the ventilation of any moisture that forms.

Protect recessed downlights

Modern downlights that are set into the ceiling below will intrude into the zone of insulation, bringing potentially hot lamps into close contact with insulating materials.
To ensure that these do not overheat and risk damaging the insulation (fire) install fire-hoods over all downlights.

Carefully consider risks to health & safety

The ceilings of Victorian terraced houses were often made of lime plaster and split, or sawn, lathes – small strips of timber spanning between ceiling joists – between which the plaster was pressed, projecting to form a key.

Neither this lathe and plaster, or the modern plasterboard that may have replaced it, are capable of supporting human weight. To avoid injury from falling and damage to ceilings and the rooms below it is very important not to stand on this.
Always tread carefully across the tops of the ceiling joists or onto a piece of ply or chipboard that can be moved to span a number of joists and allow safe movement over a wider area.

Be wary of insect or vermin nests & infestations – have these professionally removed.

Infestation by vermin, insects, birds (particularly pigeons) and their faeces can be a health risk (wasp stings etc). They can reduce the effectiveness of insulation (by moving it around to make nests) and be a source of moisture and dangerous pollution. It is best to have any infestations professionally removed.
Ensure that you are wearing appropriate protection, including gloves and a mask if working near an infestation.

Flat roofs to extensions

It is often only possible to increase the insulation of flat roofs through more intensive construction.

Insulating from above requires removing and replacing the waterproof layer and often the timber board beneath which sits over insulation installed between the roof joists. Insulating from below requires removing and replacing the plaster ceiling below insulation installed between the roof joists.

In each case, a ventilated gap of 20mm should be maintained between the insulation and the timber boarding that supports the waterproofing, with ventilation openings and grills at opposite sides of the roof to allow air flow.

Some modern roofing materials include insulation within a make up that includes vapour barriers (stopping moisture entering the roof build-up from below) and waterproofing. If one of these is used, there is no need to install ventilation.

Rooms in the roof

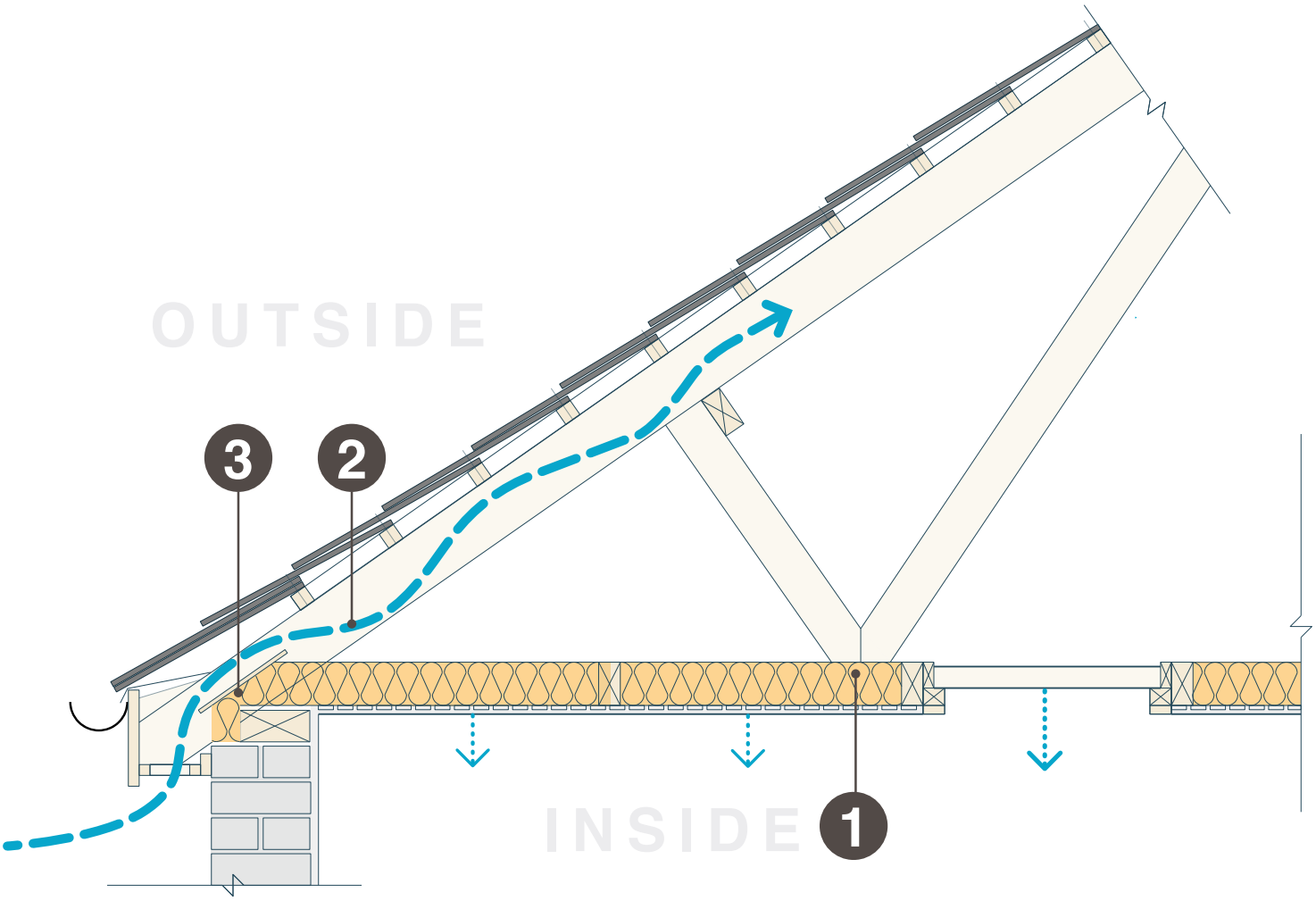
It is often only possible to insulate the roof over the sloping ceiling of an attic room by removing and replacing the plaster ceiling below insulation installed between the roof joists. If there is enough head room in the attic room, it is good to space the new plaster ceiling on battens 25mm below the undersides of the sloping rafters to allow insulation to be installed in this gap.

A ventilated gap of 50mm should be maintained between the insulation and the timber battens or boarding that supports the tile or slate roof.

Roofs

BASELINE+

18%
energy saving from Baseline



1 100mm fibreglass quilt insulation between ceiling joists

2 Insulation installed to maintain ventilation gap at eaves

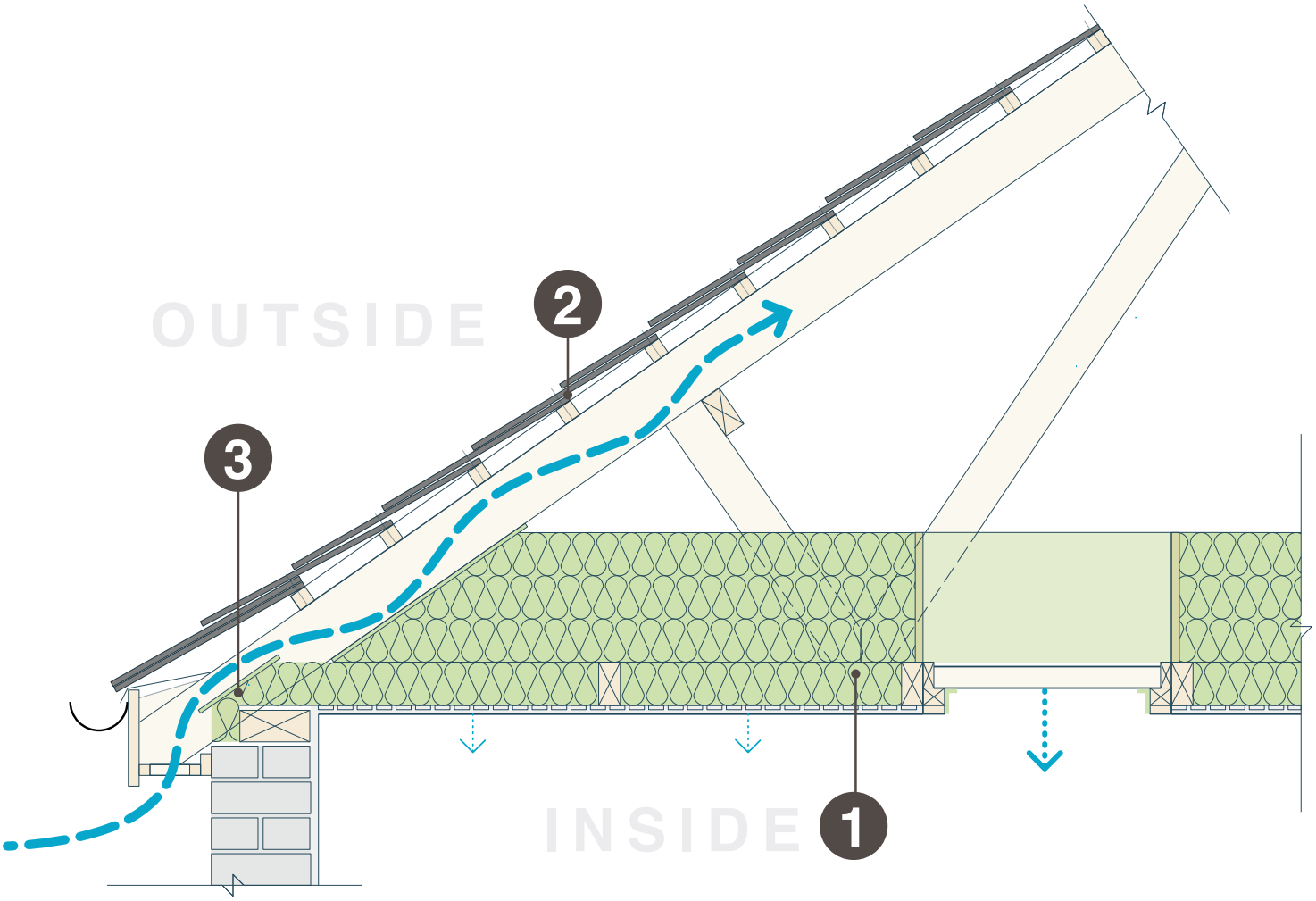
3 Ideally extend insulation over the wall plate

Roofs

LEVEL 1

21%

energy saving from Baseline



Ideally insulate over the wall plate

1 Increase insulation between and over ceiling joists 400mm

2 Insulation installed to maintain ventilation gap at eaves

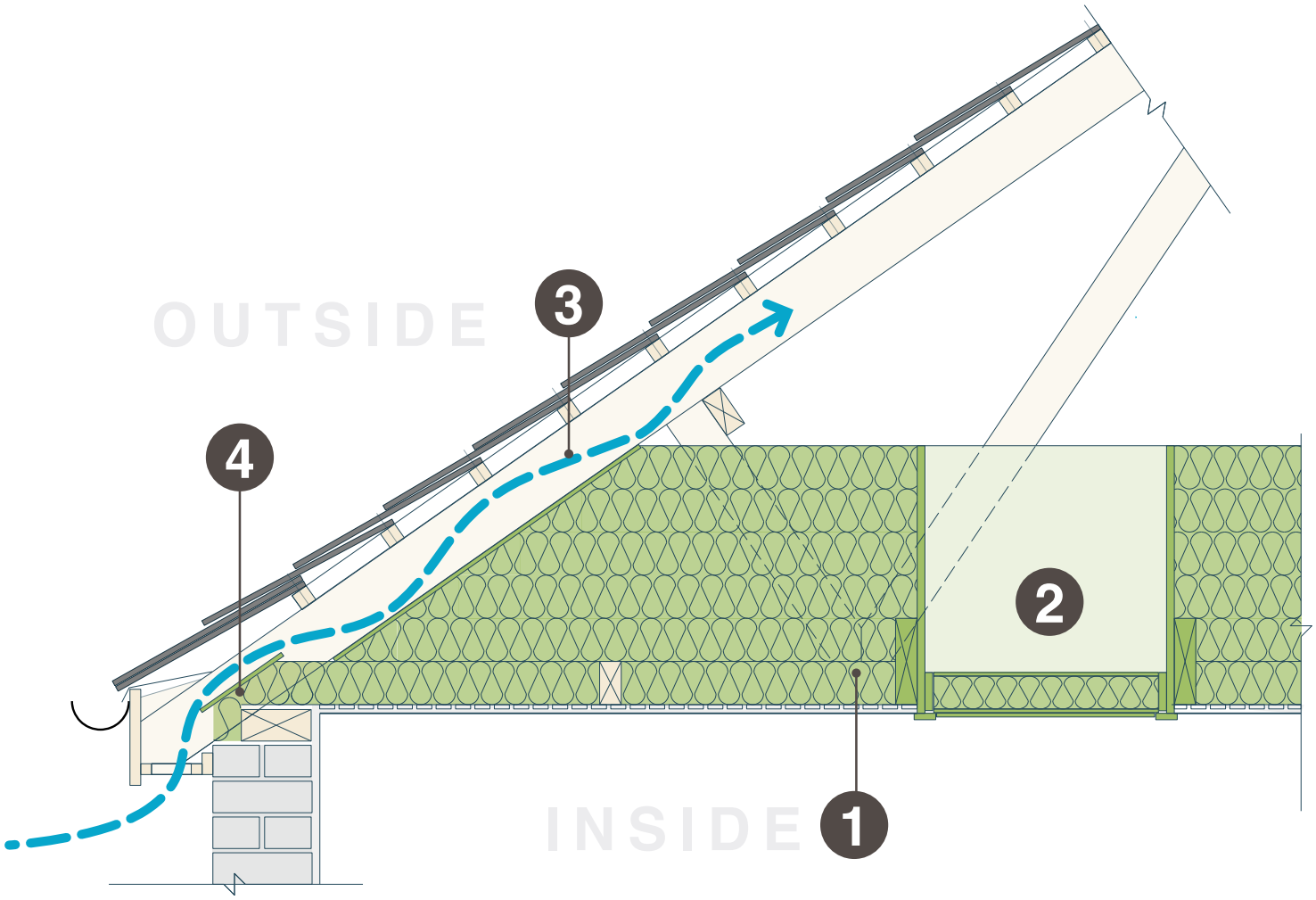
3 Ideally extend insulation over the wall plate

Roofs

LEVEL 2

N.B. As these works are relatively straightforward, and can have a significant impact on heat loss and energy use, it has been suggested that the maximum level of improvement can be reached at Level 2 (in terms of timescale, cost, and disruption)

22%
energy saving from Baseline



1 Increase insulation between and over ceiling joists 600mm

2 Install proprietary insulated and airtight loft access hatch

3 Insulation installed to maintain ventilation gap at eaves

4 Ideally extend insulation over the wall plate

Floors

Background

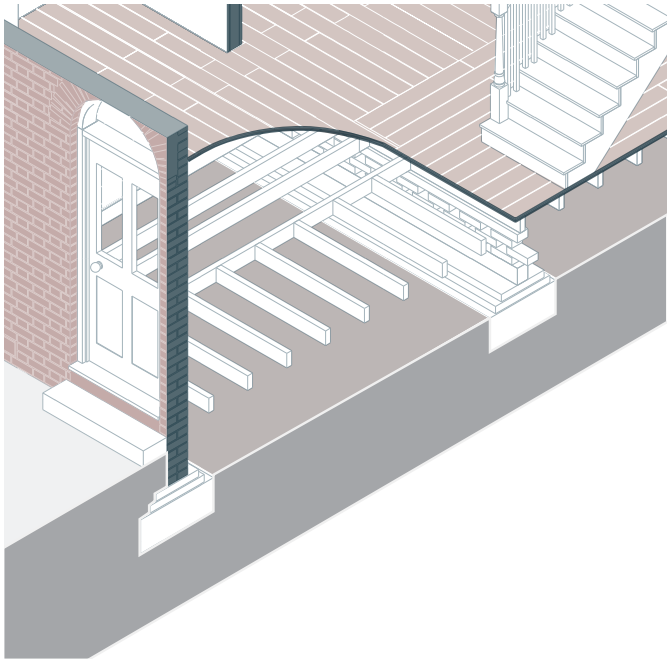
Victorian terraced houses traditionally have suspended timber floors to ground floor rooms in the main house. Timber joists span between the front and back walls of the house with intermediate supports in the central room-dividing wall and, sometimes, brick pillars at mid-points.

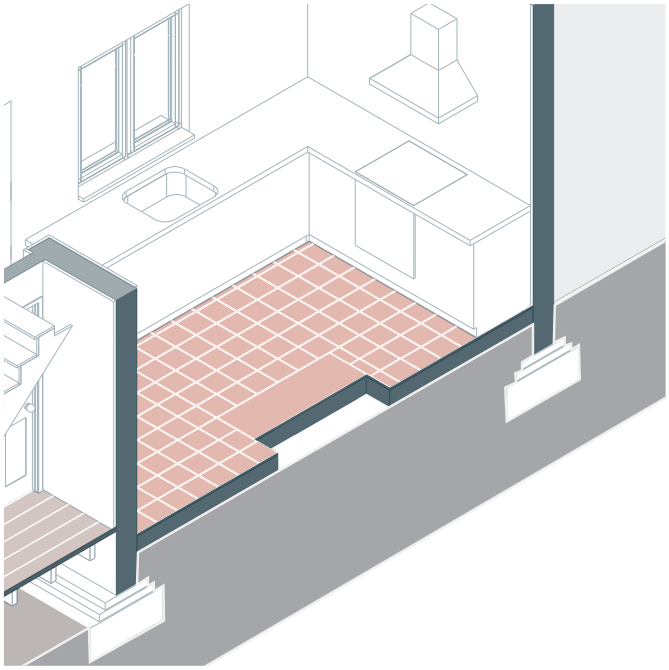
The floor boards sit above the joists, spanning side to side. They were usually exposed, painted, or partially covered with a central carpet / rug.

The ground surface below this floor is often simply the original site soil covering although sometimes a thin concrete slab or screed was installed over this.

The void between this floor is ventilated by air-bricks built into the front and back walls. Air movement through this floor traditionally provided some of the combustion air for the fireplaces and kept the timber structure dry. With the change to convection heating, this air movement is now experienced as cold-draughts and adds discomfort to the cost of heat loss.

By comparison, the floors in the rear extensions, where the wet kitchen, scullery and laundry activities were carried out, are frequently solid with a concrete slab or screed laid directly onto the site ground level. Sometimes these floors were quarry tiled. These floors were never insulated and now feel cold underfoot.





The approach for the two types of floors are separated because they require different measures and considerations:

Suspended floors

There are a range of materials and ways of increasing the thermal performance of suspended timber-boarded floors and of reducing the draughts that can come up through these floors.

Solid floors

Improving the thermal performance of solid floors has a much greater impact on comfort than on energy usage but can often be worth doing for that reason alone.

Maintain ventilation

In order to avoid the build up of moisture (from the ground below – or from the floor above) and the risk of mould growth or decay, it is important that the space beneath the floor is as unobstructed and well-ventilated as possible:

- Ensure that air-bricks in the outside walls are clear and above the surrounding ground level.
- Ensure that any insulation installed does not block the ventilation of the void beneath the floor.

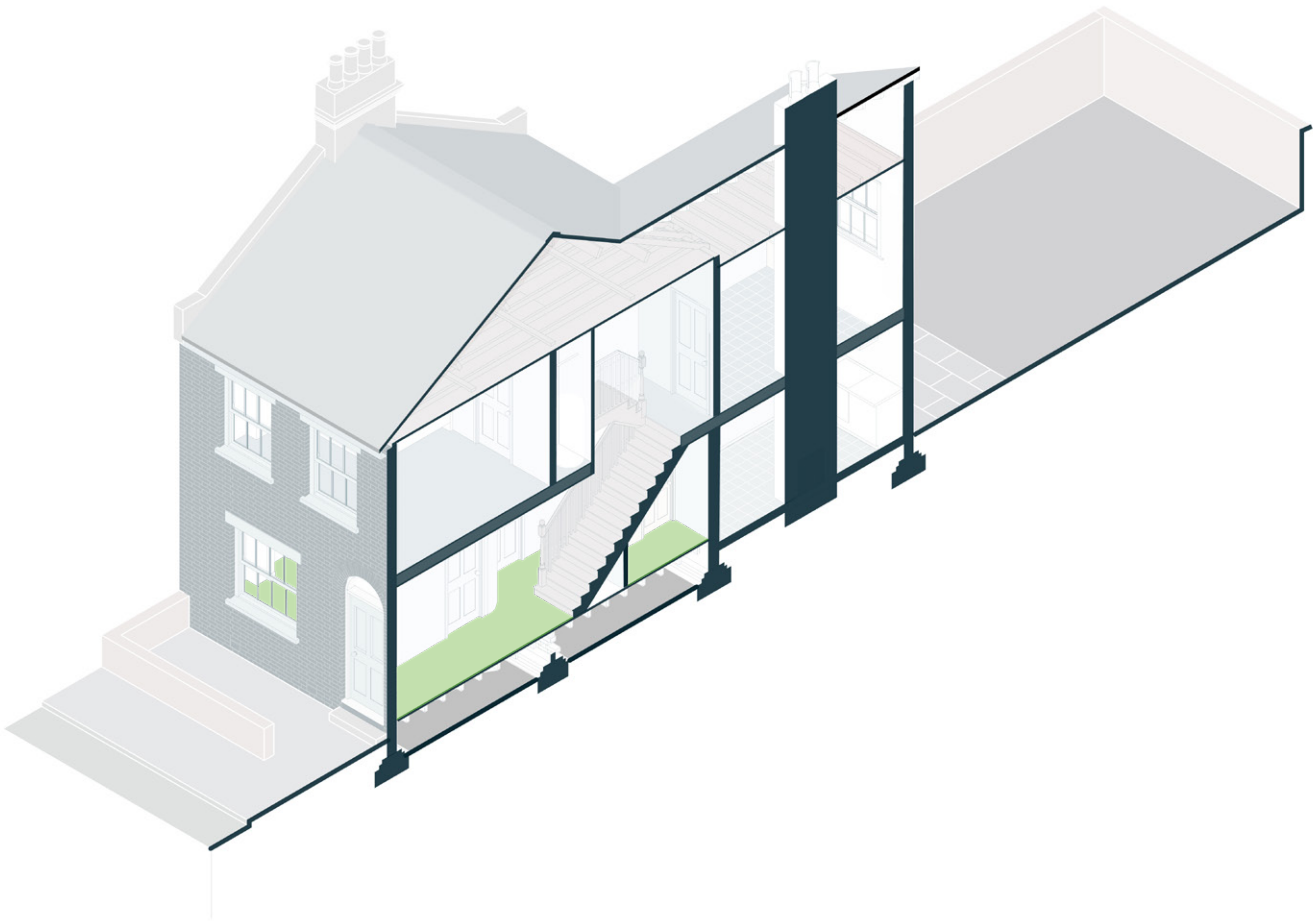
Damp

Solid ground floors are frequently at or below external ground level and can be susceptible to damp movement from the adjacent external planting or paved areas.

Any dampness will exacerbate the sensation of cold so, if possible, external ground levels should be reduced below the floor level.

Floors

LEVEL 1

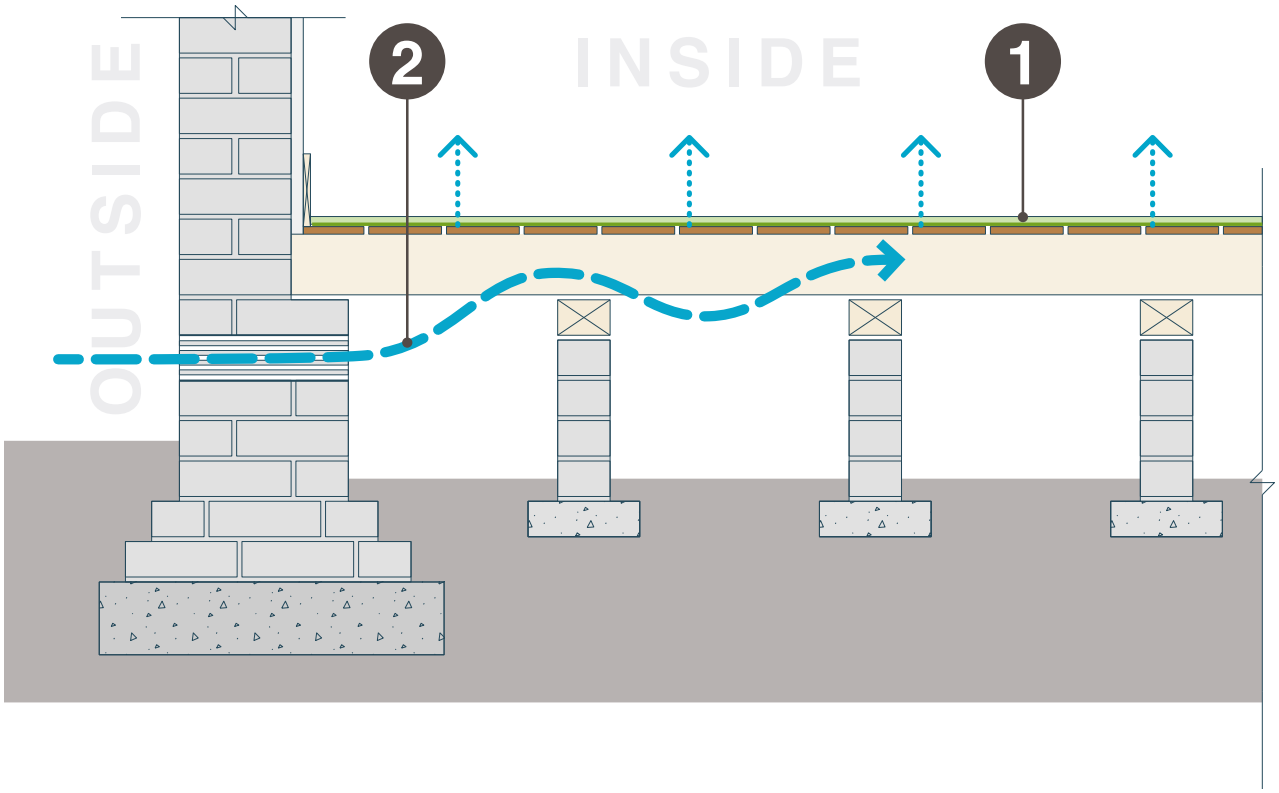


Suspended floors

Timber shrinks over time (mainly across the grain) and so an original over 100-year old floor probably has significant gaps in the joints between boards. These gaps can be the source of drafts, so laying carpets over the boards to cover the gaps can improve thermal comfort.

1%

Suspended floor energy saving from Baseline



1 **Lay carpet and underlay**

2 **Maintain ventilation gap**

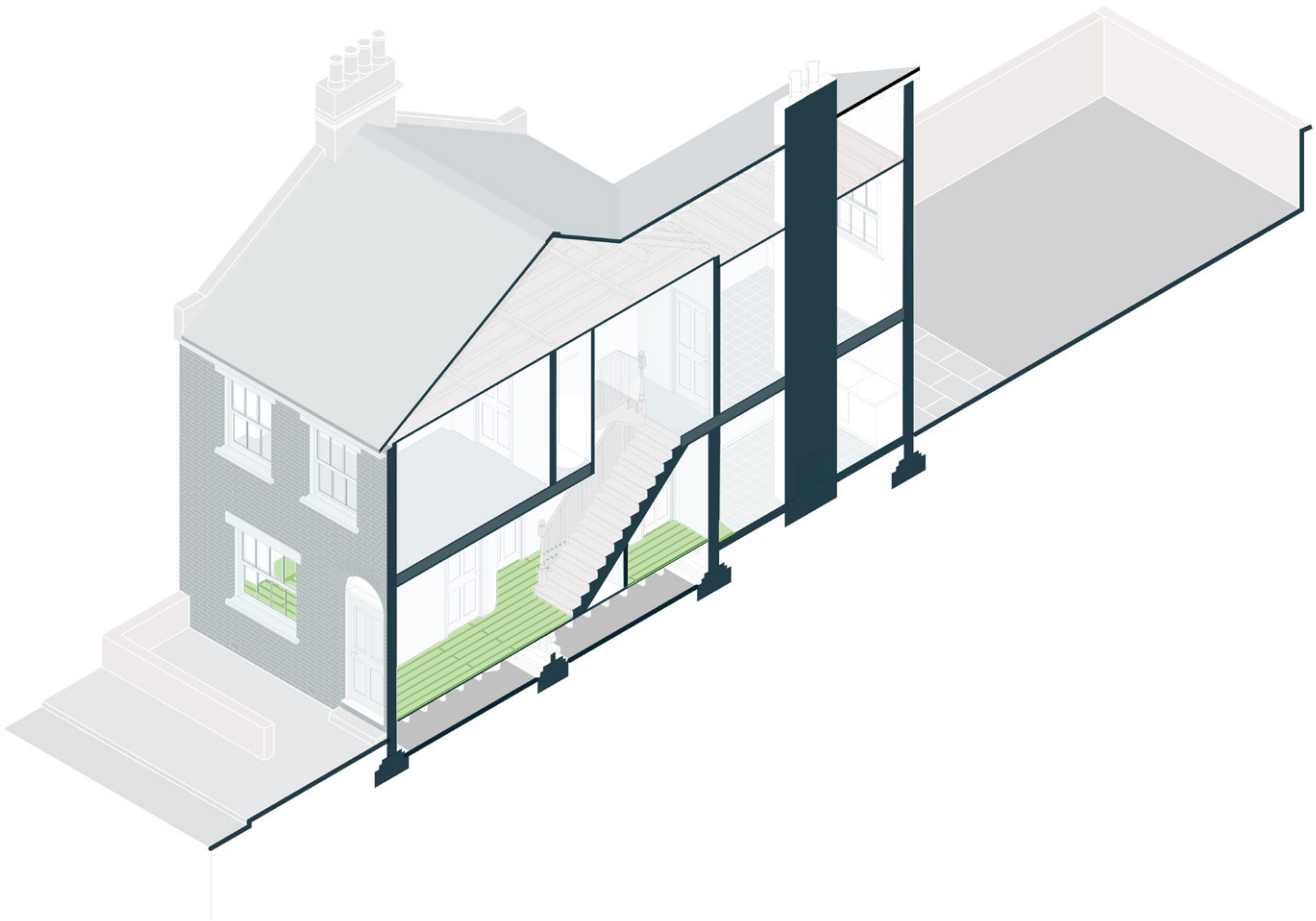
Note

Carpets and sheet flooring can be laid directly onto existing boarding although unevenness in the boards, or gaps between them, may well show up in the future as dark marks in the carpet. Ideally carpet would be laid on an underlay and / or 3mm hardboard sheeting tacked to the floor boards.

Carpet should be laid tight to the skirting boards but, if the existing floor boards have not been overlaid or made airtight, there may be a draught through the skirting junction which forms a line of dirt at the junction of carpet and skirting.

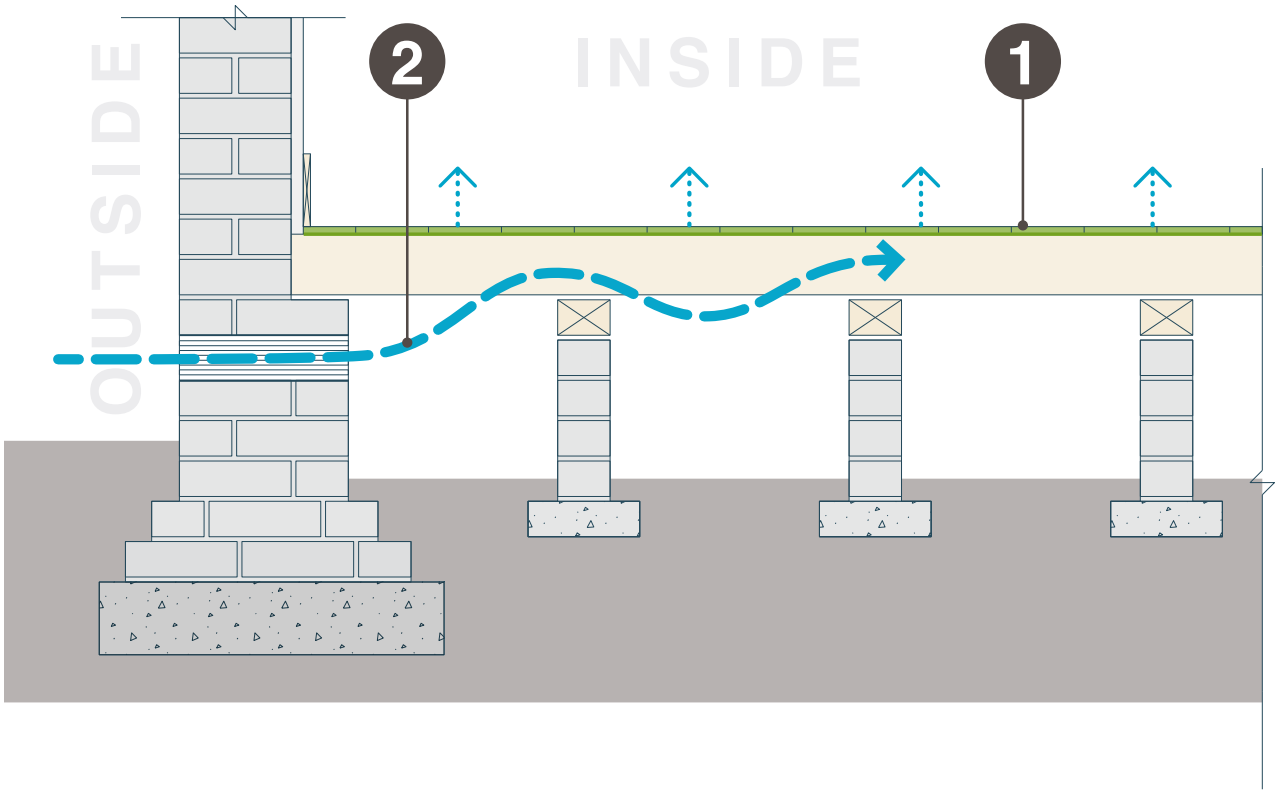
Floors

LEVEL 2



1%

Suspended floor energy saving from Baseline



1 Lift and re-lay (or lay new) boards (to close up gaps)

2 Maintain ventilation gap

Note

Existing boards can be filled with a proprietary filler paste, or by installing a long tapered fillet of timber which is glued and fixed into these gaps and then cut down and sanded flush with the boards.

Alternatively, if the boards are lifted and their edges cleaned, they can be cramped up and re-laid with much tighter joints. This usually results in the formation of a single, larger, gap between the last board and the wall, which can be filled with a new board or a reclaimed Victorian board.

If boards are lifted then it may be worth considering the additional effort and cost of installing insulation below before these are relaid. As Level 3.

Broken or defective boards can be replaced with either new boards or reclaimed Victorian boards from an architectural salvage yard.

N.B. While reclaimed boards are unlikely to move or shrink, a new softwood board will shrink and may need filling, filleting, or re-laying after a period of years.

Floors

LEVEL 3

Suspended floors

There are proprietary ways of insulating the underside of suspended floorings including by a remote controlled ‘robot’ that is installed in the sub-floor void (by forming a small opening in a couple of floor boards) and which sprays foam insulation up against the boards to the desired depth.

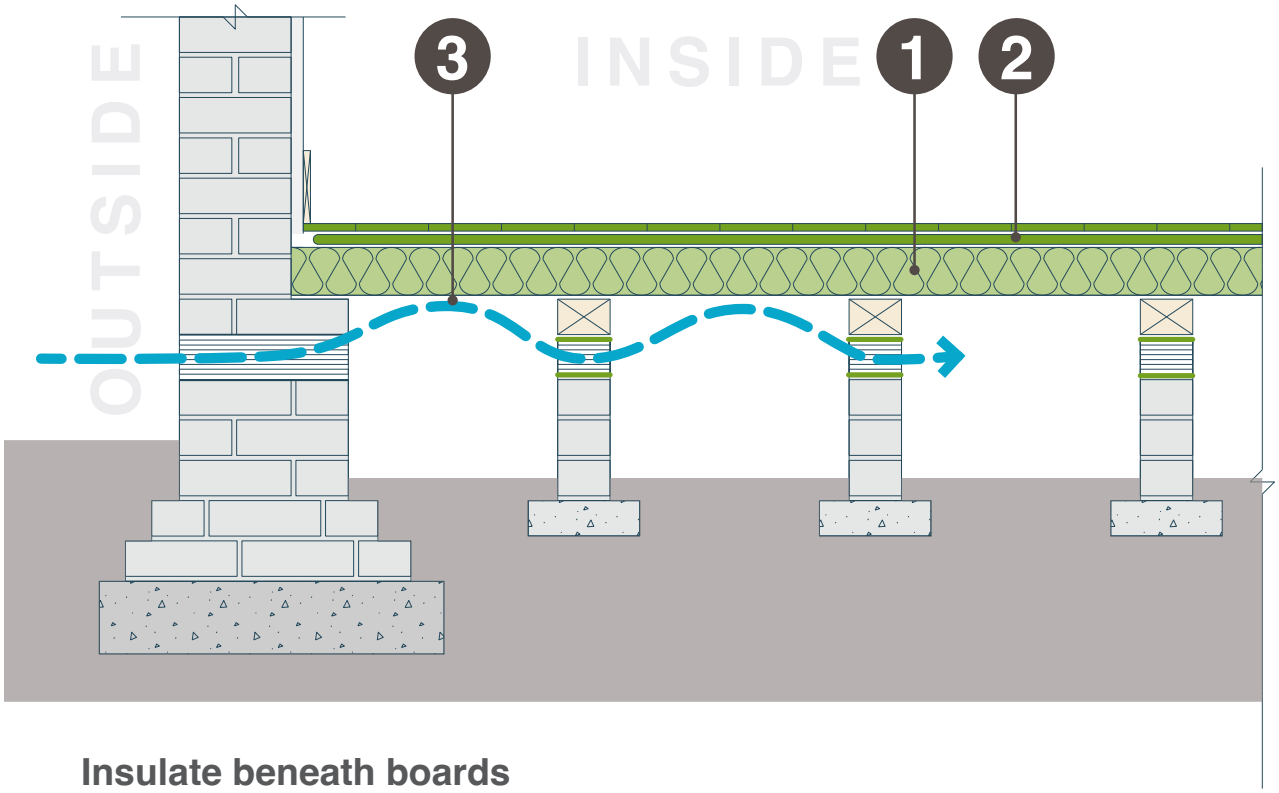
More normally, mineral fibre quilt is laid in nylon mesh ‘hammocks’ formed between, and fixed to, the floor joists. This involves lifting and re-laying all of the floor boards (and, ideally, also fixing an insulation board below the joists – to protect these from moisture in an unventilated sub-floor cavity, although this can be awkward to install).

As part of an insulated floor build up it would be possible to install underfloor heating beneath the floor boards.

This would consist of water-filled pipework in profiled metal carrier plates, installed above the insulation and between the floor joists before the floor is relaid. The pipework carries low-temperature water providing highly efficient, comfortable and, critically, radiant heating to the room. This would be fed from a manifold (typically in a cupboard under the stairs) which takes water, at a max c.30°C temperature, from the heating system.

4%

Suspended floor energy saving from Baseline



1 Insulate beneath boards

- Insulation in mesh hammocks between joists OR
- Spray insulation to underside of boards

2 Install underfloor heating

3 Maintain ventilation route

Note

Underfloor heating

To avoid leaks it is important that this pipework is jointless and laid in single runs from and to the manifold. Enormous care should be taken not to puncture this pipework when re-laying the floor.

N.B. There are concerns that timber flooring can move and shrink if laid over underfloor heating. This is very unlikely to happen with a well designed system and properly seasoned or over 100-year old floor boards.

The space beneath suspended floors can contain **electrical, data and telephone cables and sometimes old iron (or modern copper) gas pipes.**

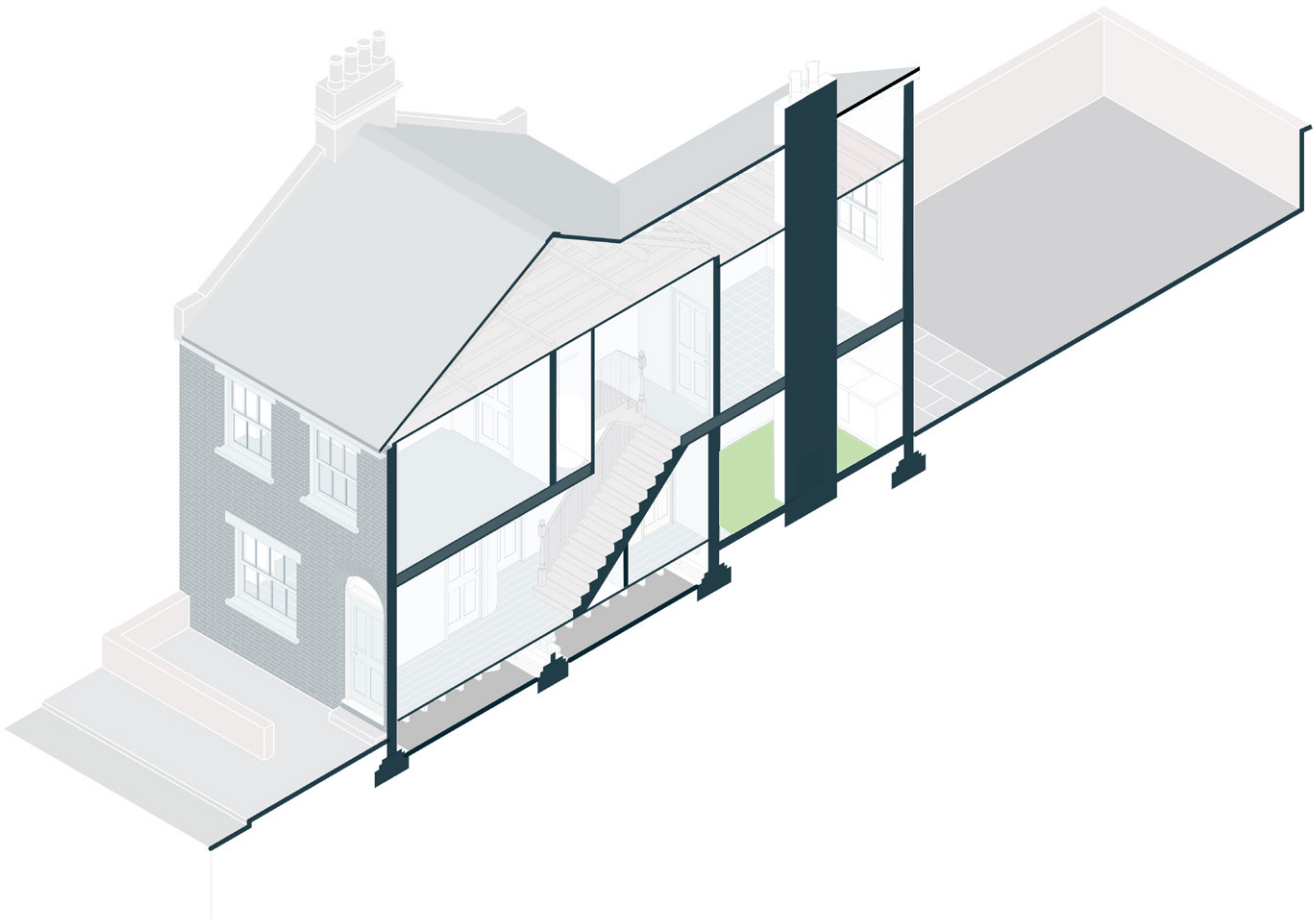
These should be carefully identified and redundant cables and pipework professionally removed. Pipes and cables that are live should, if possible, be fixed to floor joists to make sure that they are not moved, stretched, or damaged during the insulation works. Water or central heating pipework should be kept on the warm side of the insulation or provided with an insulating lagging. If a QBot system is used, pipework can be given a 10-15mm coat of spray insulation.

Before installing insulation, it would be wise to inspect the condition of the floor boards and the timber plates on which these are supported. These plates are either embedded within the external wall or span between small brickwork support pillars under the room.

Indications of damp or decay should be addressed before the floor is insulated or covered up. Consult a professional adviser about the causes of the moisture in the wall or sub-floor. If these are addressed and the sub-floor properly ventilated then any mould growth will probably diminish or disappear without the need for toxic anti-fungal treatments.

Floors

LEVEL 1

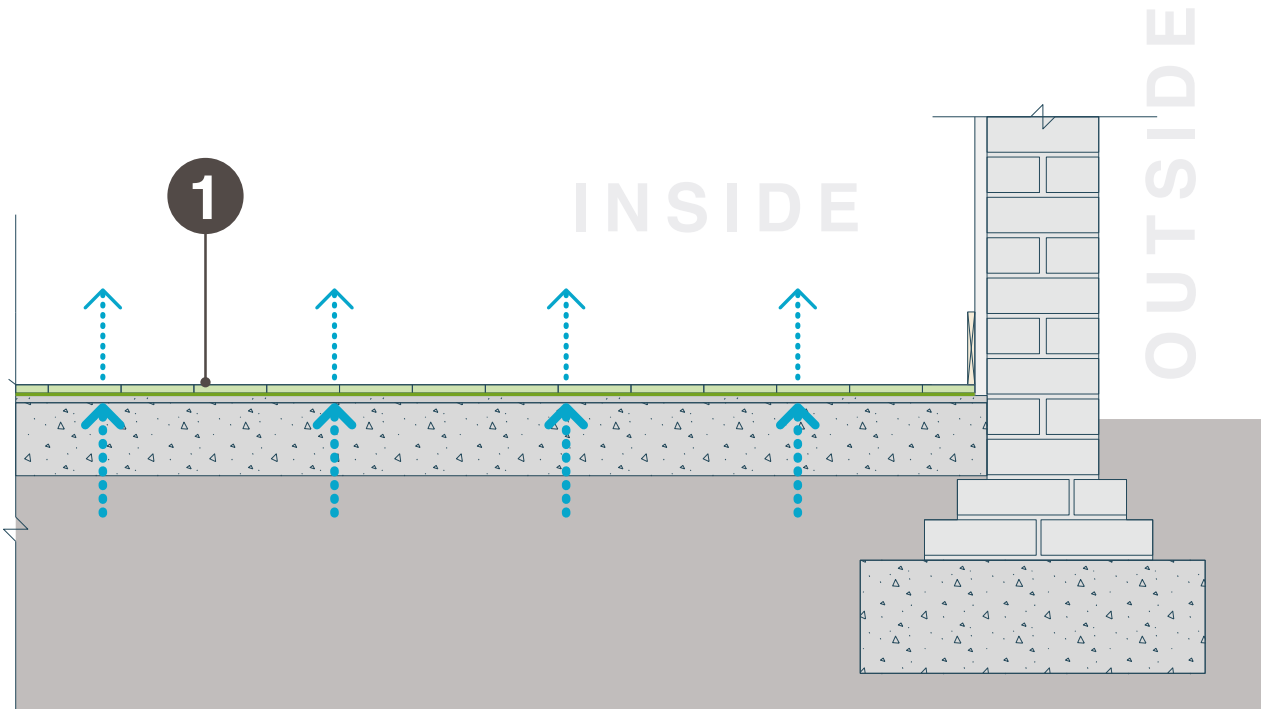


Solid floors

Although not delivering a significant energy saving, simply installing an insulated floor covering over the existing slab can increase the comfort levels in the space. Feet radiate less heat to an (even quite thin) insulated surface.

<1%

Solid floor energy saving from Baseline



1 Install carpet or insulated (cork or foam) vinyl sheet flooring

Note

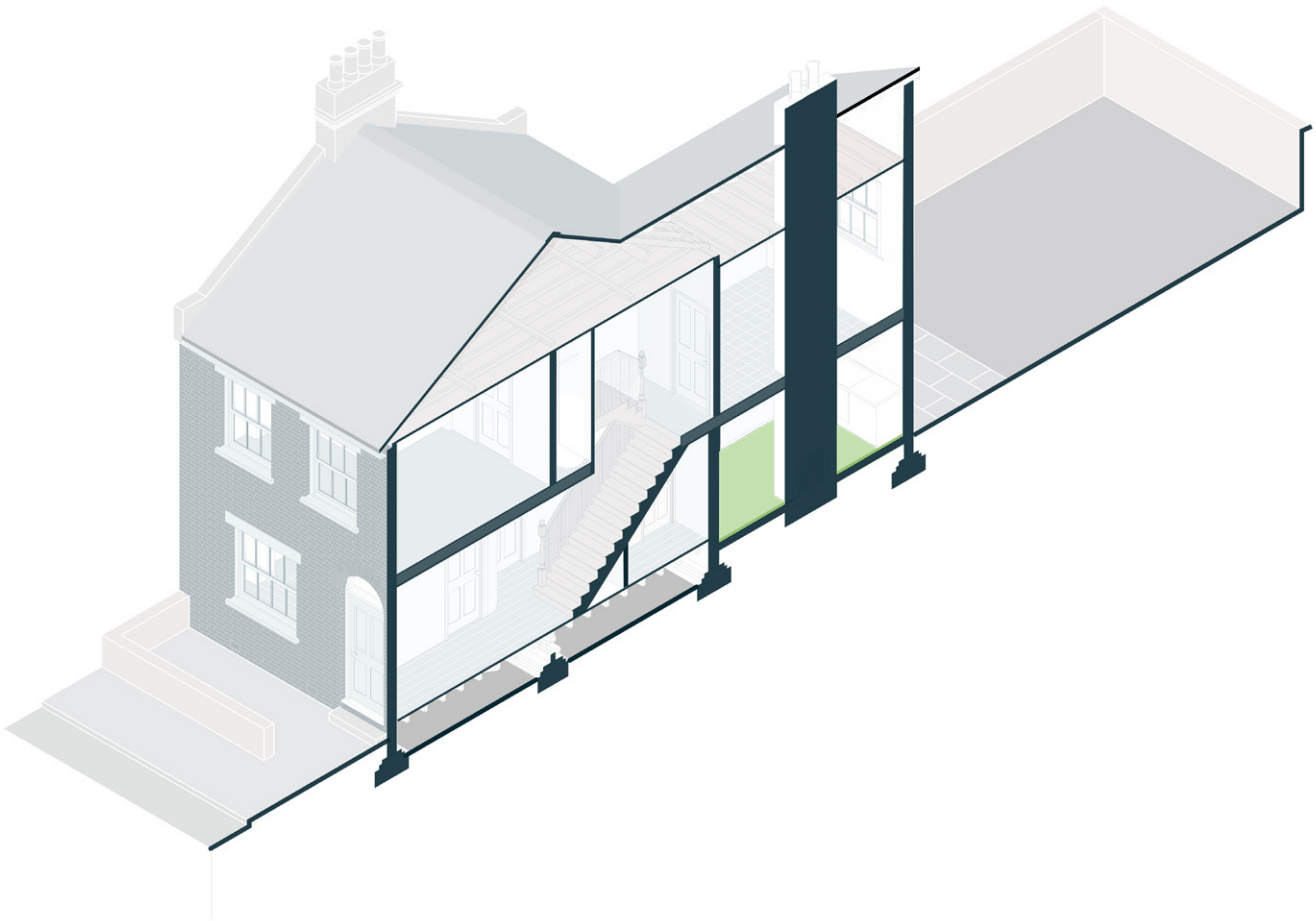
If there are wet uses (kitchen, utility, bathroom, etc.) the new covering would ideally be a non-slip cork or vinyl waterproof covering.

For other rooms, an insulated carpet or one with a thick underlay, would be ideal.

The finished floor will be higher than the existing floor, so there will likely be knock on impacts in terms of steps at doors and removing and removing and replacing the skirting boards. Any fixed furniture (like kitchen units) will need to be removed and replaced

Floors

LEVEL 2

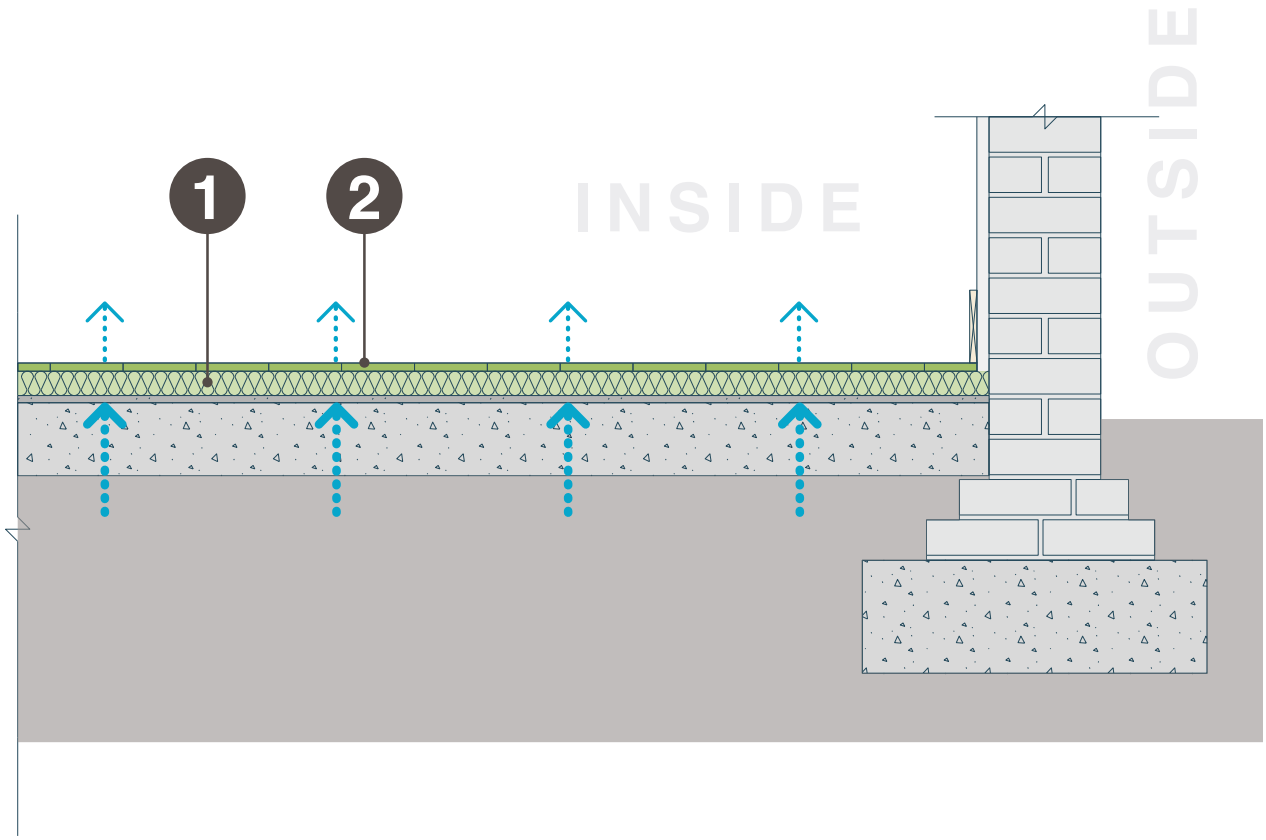


Solid floors

A more extensive improvement can be made – at the expense of reducing the floor to ceiling height in these spaces – by installing a layer of insulation and new flooring over the existing floor.

<1%

Solid floor energy saving from Baseline



1 **Install thin layer of insulation above the existing slab / screed (waterproof painted)**

2 **Install new flooring – laminated board or thin tile floor finish**

Note

The existing floor would be cleaned and a painted waterproof or membrane applied under a floor-loaded insulation layer and a laminated floor or tiled finish.

It would be possible to incorporate efficient (and, critically, radiant) underfloor heating system within this build up.

The finished floor will be higher than the existing floor, so there will likely be knock on impacts in terms of steps at doors and removing and removing and replacing the skirting boards. Any fixed furniture (like kitchen units) will need to be removed and replaced

Floors

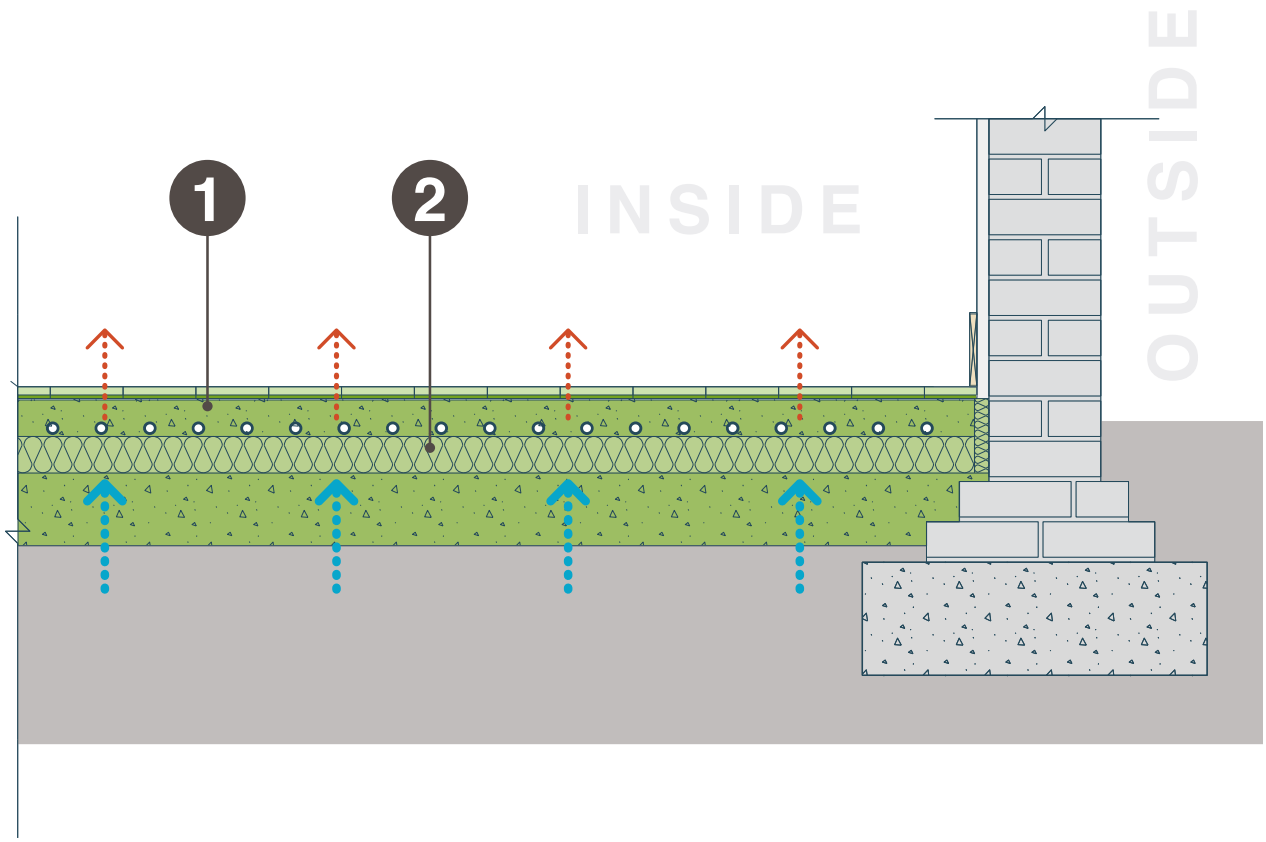
LEVEL 3

Solid floors

The greatest thermal efficiency can be achieved, without reduction in headroom, by removing the historic floor construction and installing a new, fully insulated floor with a new slab – set at a lower level – with insulation and underfloor heating beneath a screed.

4%

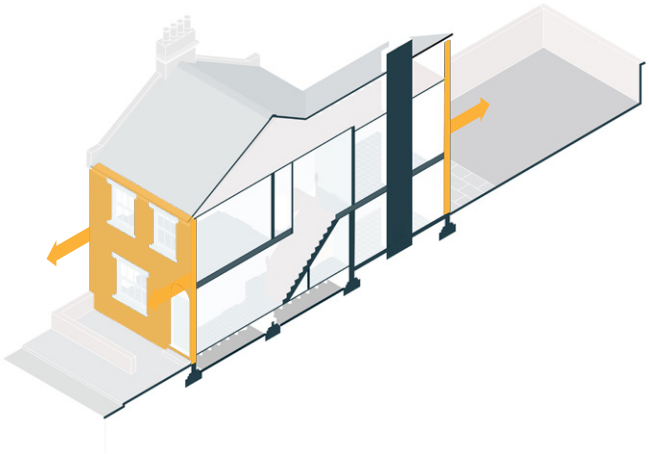
Solid floor energy saving from Baseline



1 Break out existing screed / slab

2 Install new slab, insulation and screed (with underfloor heating)

Walls



Background

Victorian terraced houses have solid brick walls with lime / sand mortar pointing. The walls are usually finished internally with a lime or cement / lime render and a set coat of lime or gypsum plaster.

This form of construction is vapour permeable. It admits the passage of water vapour from outside, through the evaporation of moisture within wet brickwork by the heat of sunlight or the warmer temperatures inside the wall, and water vapour produced inside, from baths, showers, washing machines, etc.

This is normal and healthy for both walls and humans and was part of the whole-house 'system' embodied in the Victorian terraced house.

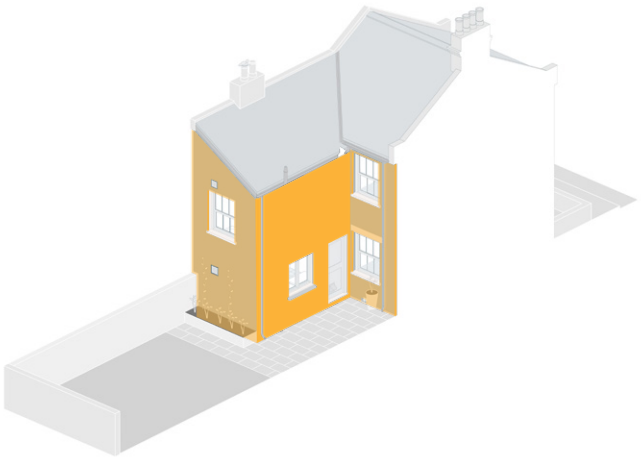
Over the years, two things tend to have happened to these wall:

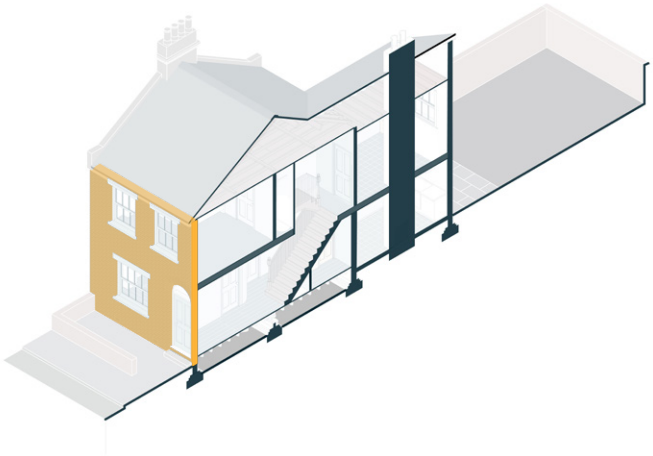
- **The pointing fails** – leading to water passing through the walls and damp forming internally – and has been replaced, usually, with cement / sand mortar which is much less vapour permeable.
- **The internal plaster fails** and is replaced with cement/sand or gypsum plaster – which have reduced vapour permeability.

If a wall is made impermeable to vapour, then the vapour from the outside can condense inside the wall. This risks creating the conditions in which mould can develop endangering timber elements within the wall (floor joists, soft wood grounds to which skirtings etc are fixed).

Similarly vapour then held within the building either creates a humid environment or condenses on colder surfaces. This risks leading to the conditions under which mites and bugs can proliferate along with the formation of mildew and other moulds – all of which are a health risk for occupants.

N.B. The increase in installation of central heating, the occurrence of internal condensation, mildew and other moulds, led in 1962 to the first Building Regulations clauses. These addressed insulation and ventilation and the requirement for mechanical ventilation of bathrooms and kitchens.





In order to maintain the vapour permeability of solid brick walls whilst improving the thermal performance, it is important to adopt one of two approaches:

1. External insulation and cladding

This forms a waterproof coat outside the existing solid wall. The cladding protects the wall from external moisture whilst allowing vapour to pass through the wall from the inside.

There are a number of proprietary systems available for the external insulation of solid wall houses. These comprise a mineral wool or phenolic foam insulation (typically 3” (80mm) deep) and either a thin coat render or timber-board cladding. These claddings are typically ¼” (6mm) thick for render or 1.5” (38mm) thick for timber boarding.

2. Internal insulation

Vapour-permeable internal insulation is required to allow water vapour to continue to pass through the wall from inside to out and vice-versa.

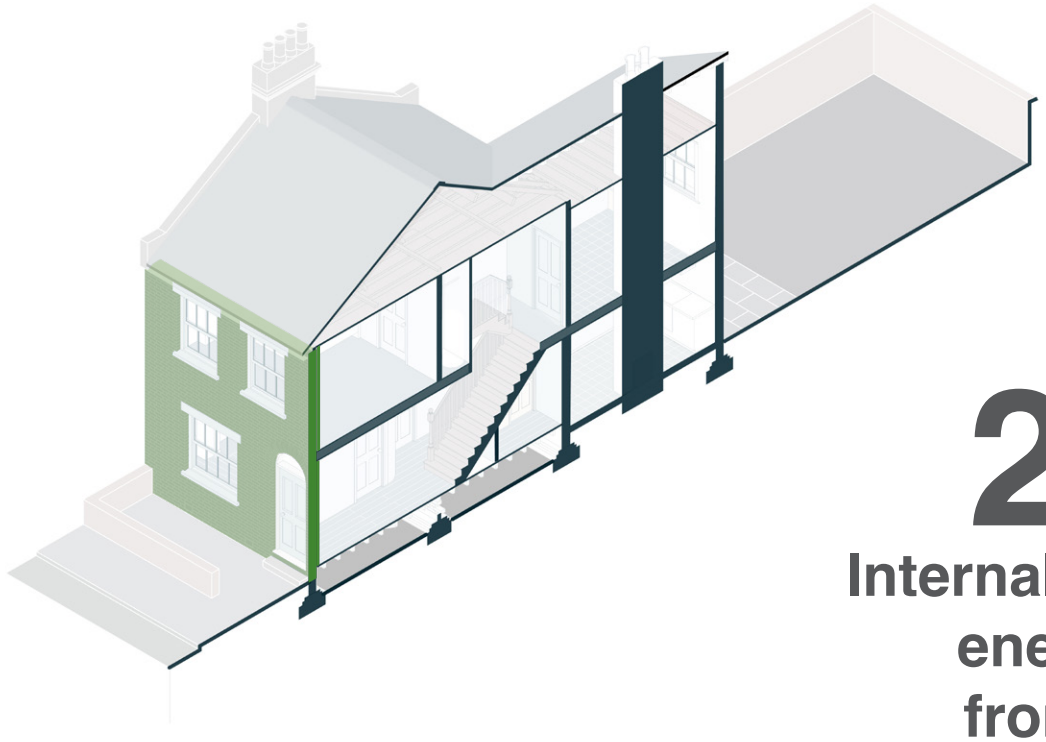
There are a number of proprietary systems for this insulation – comprising either wood-fibre, aerogel (a nano-insulation material), or a composite lime / cork or aerogel mixture – of various thicknesses, costs, and efficiencies.

Note
In either case it is critical that the inside of the house is properly ventilated (see Ventilation) and that vapour is not allowed to accumulate or to condense inside the house with all of the risks to building fabric and occupant health that might involve.

Walls

LEVEL 3

Internal wall insulation



23%

Internal insulation energy saving from Baseline

Note

The advice below relates to the recommended use of vapour-permeable insulation.

Thickening the inside face of a wall may involve alterations to a number of internal features to the wall:

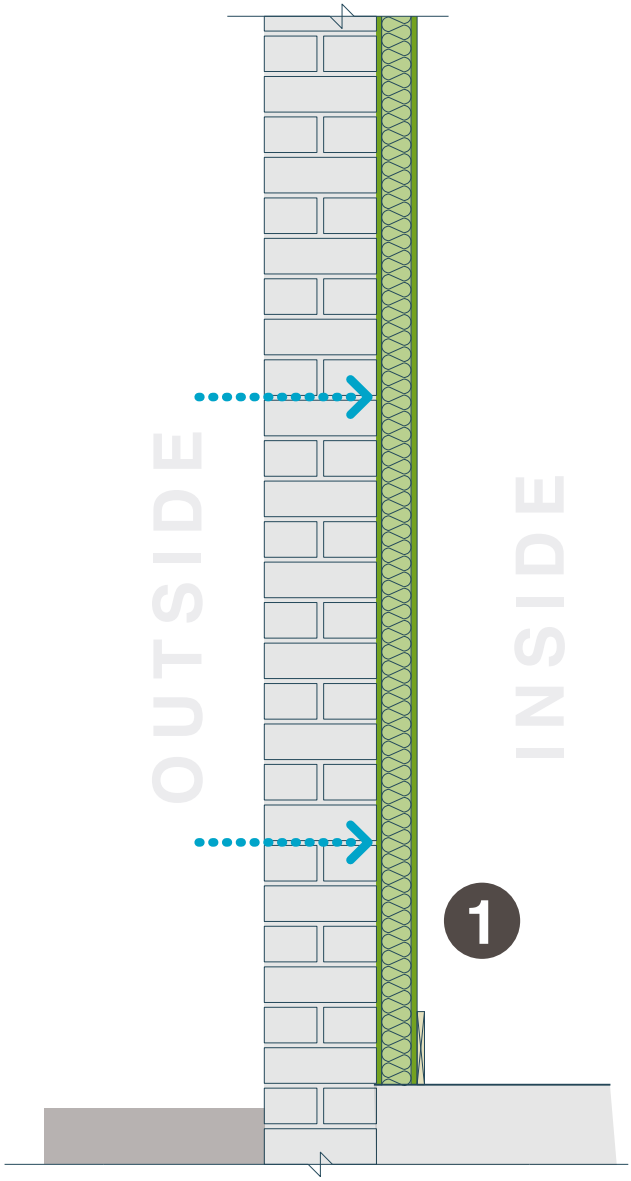
- **Electrical, data, or TV sockets.** These can be temporarily isolated and then re-instated on the new finished surface of the wall.
- **Radiators.** These can be temporarily isolated and then re-instated on the new finished surface of the wall.
- **Historic features** such as cornices, picture rails, dado rails or skirtings.

There are a number of options as to how to manage these historic features:

- Remove these and re-instate them on the finished face of the insulated lining.
- Leave these where they are and cover them with the insulation. The use of vapour-permeable insulation should ensure that these elements are not affected by moisture or mould growth.

Window cills will need to be extended to cover the additional wall thickness and (ideally – to maintain the insulation line) some insulation would be returned into the window reveals.

N.B. It is not necessary to return insulation along the party (or internal junction wall lines). There has, historically, been a theory that the continuous brickwork junction between external and party (and other) walls would cause 'cold bridging' and formation of condensation and mould. Recent modelling and site experience shows that although 'cool bridges' can be formed – these are very unlikely to lead to conditions at which condensation (or mould) will form.

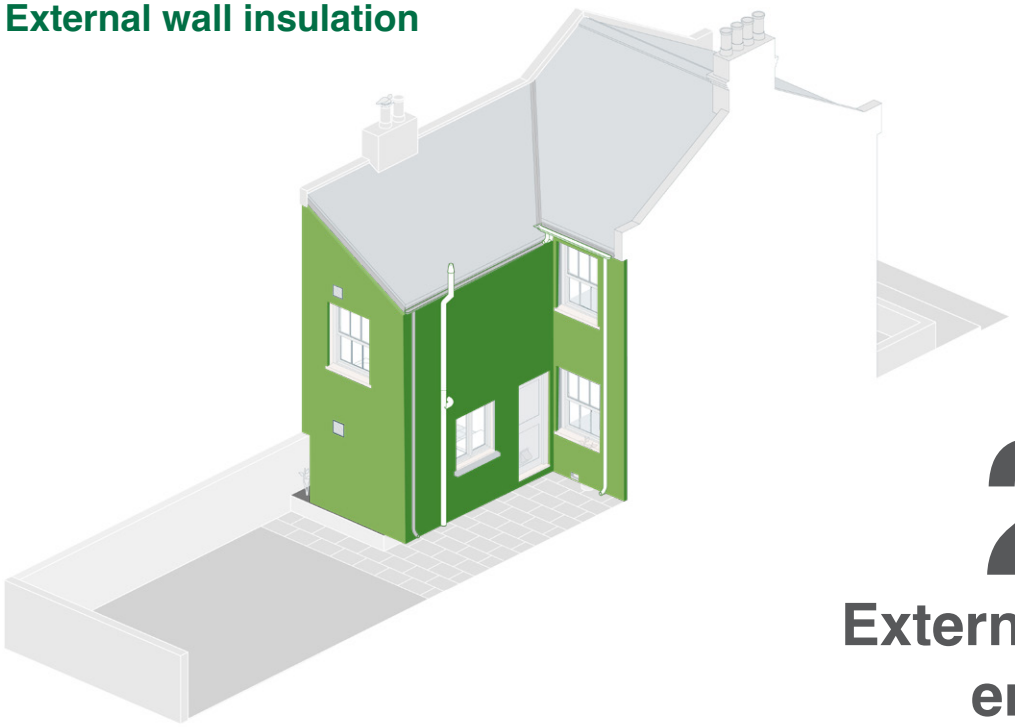


1 Internally insulate with 60mm vapour-permeable insulation (e.g. wood fibre) and fermacell or lime plaster

Walls

LEVEL 3

External wall insulation



23%

External insulation energy saving from Baseline

Note

Thickening the outside of the house walls will probably involve adjusting the rainwater and soil drainage pipework. These are usually clipped close to the face of the brickwork and will need adjusting – together with any connection points at ground level – by the distance required to allow for the insulation and cladding.

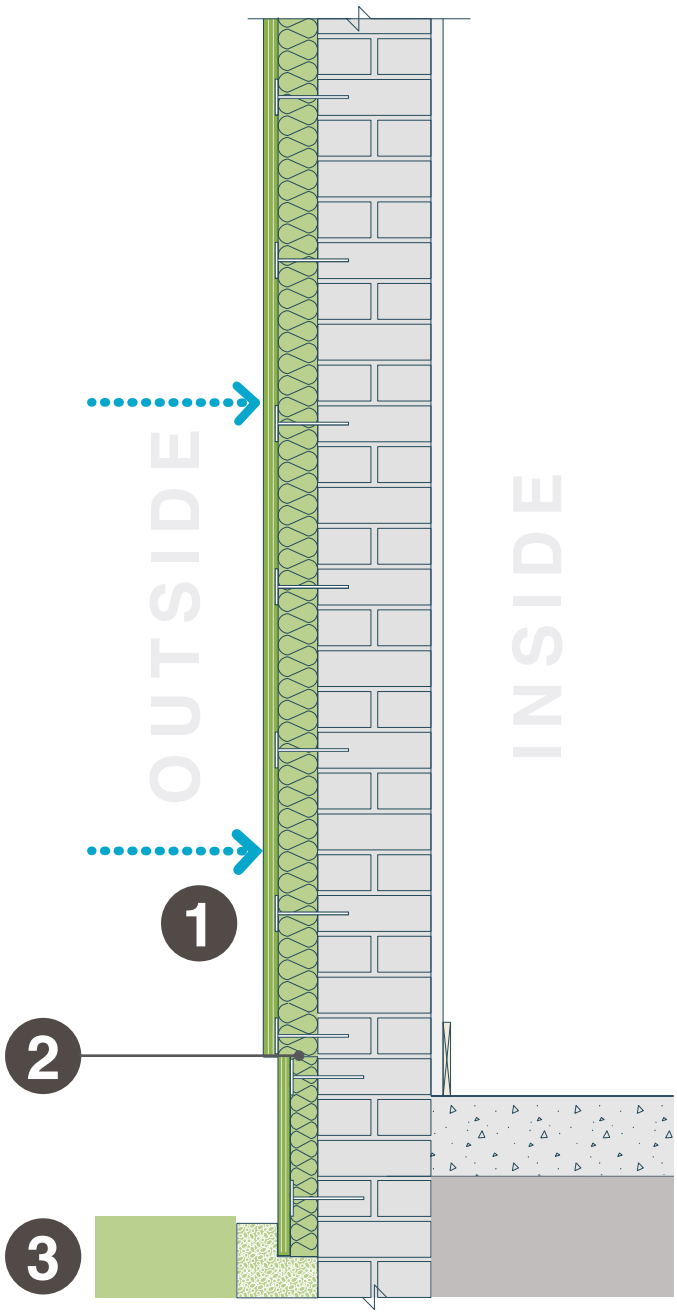
With modern push-fit or solvent plumbing systems this is not a particularly time-consuming or costly process. Even moving ground-level connections and making good ground finishes can be completed quickly and neatly.

Other elements that might be affected by thickening the external wall are the projections of overflows (from WC cisterns, heating systems, etc), window cills and gutters as well as the gable line of any roof elevation.

It is usually possible to leave gable tiling and gutters in their existing positions with a pressed aluminium flashing. This is fixed to the existing wall or eaves board and steps out to waterproof the top of the insulation and cladding. Remember to retain a ventilation route to roof when doing this.

Ideally windows would be replaced with high-performance double-glazed windows as part of the over-insulation project. However, if the existing windows are to stay in position then it will be necessary to add a deep aluminium flashing beneath the existing window cill and (to maintain the insulation line) to return some insulation and cladding into the window reveals.

Straining wires for plants can be installed to the cladding, with fixings to the timber framing or through to the brickwork if necessary.

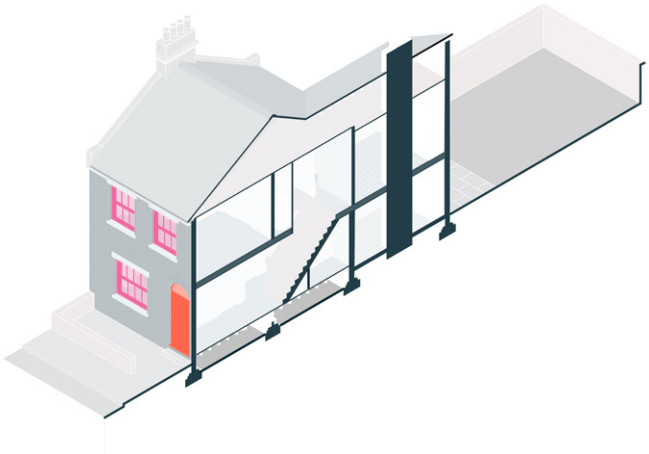


1 **Externally insulate with 80mm insulation with render, brick, or timber board finish.**
Note: ventilation gap required for timber board cladding (not shown in drawing).

2 **Waterproof insulation to be used to a minimum of 300mm from the external ground level**

3 **Where possible, lower external ground levels**

Windows & doors



The same principles apply to improving the thermal efficiency of doors and windows.

There are two elements to the thermal performance of windows and doors – the frame and the glazing:

Frames

The frame elements are both the outer frame that is fixed into the wall and the moving (sliding or hinged) casements that sit within this and hold the glazing / solid infill. The thermal performance of solid timber frame elements is generally good and, as long as these are in a good condition, the timber elements do not usually need to be replaced.

The weakness in all framing usually lies in the gaps between sashes/casements and frames. Historic timber has shrunken or worn with age and no longer fits properly within the frame – allowing draughts and the uncontrolled or uncomfortable loss of heat.

Timber frames, sashes and casements should have modern weather and draught seals added. The metal carriers to these can usually be simply routed into the timber sections and the thickness of the brush seals adjusted to allow the windows to open and close easily without allowing too large a gap for draughts. There are proprietary systems for upgrading sash windows which include improved sash pulleys and a full set of brush seals to all of the sliding and meeting parts.

Type	Thickness (mm)	U-Value (W / m² / °C)	Heat loss reduction from Baseline	Approx. lifespan* (years)
Traditional single glazing	4	5.8	0%	100s
Modern double glazing	24	1.1	81%	15-20
Slimline double glazing	10	1.9	67%	15-20
Modern triple glazing	44	0.7	88%	15-20
Modern vacuum glazing	7.7	0.7	88%	25+

Glazing

The glazing / solid infill usually represents the largest proportion of the area of windows and doors.

The typical thickness and U-values (the lower the better) of glazing are shown in the table above.

It is not usually possible to install double or triple glazing within the historic sash or casement windows in Victorian houses. The most viable options are either slimline double glazing or vacuum glazing which can be installed within wider and deeper routed rebates in the existing timber frames.

Solid infill panels on doors will be easier and cheaper to insulate than glazed areas.

Glazing weight

Double or vacuum glazing can be twice the weight of traditional single glazing. The hinges on casement windows should be upgraded and the sliding weights inside the pockets of a sash window should be adjusted/ increased to allow for this additional weight.

Special materials

Traditional putty quickly degrades the spacing and sealing components of the modern double-glazed units and so installing these requires specific sealants and mastic pointing. Single and vacuum glazing – which comprise only glass – can be glazed with normal putty and beads.

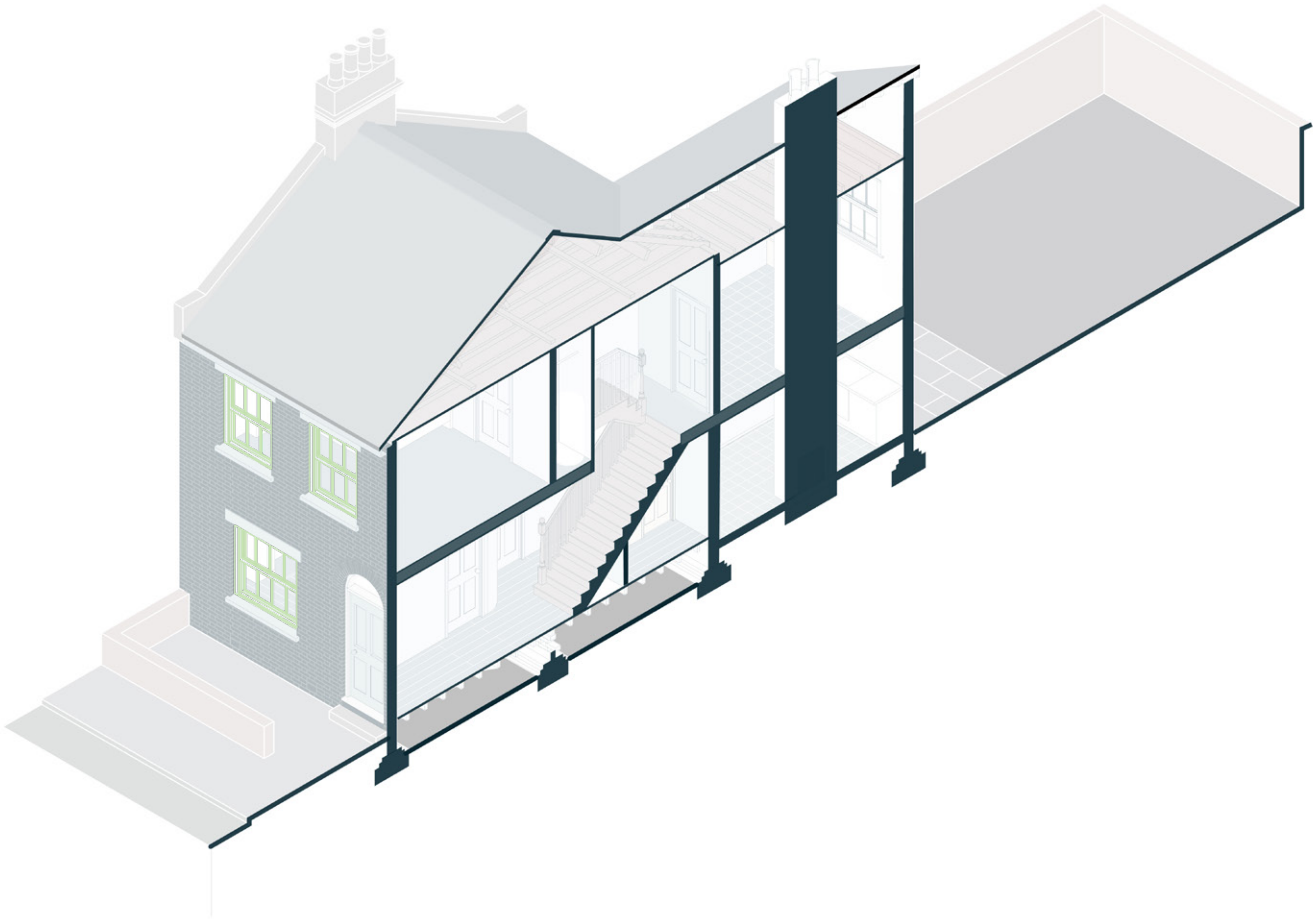
Above table to compare thermal performance and properties of glazing types.
Note -

- *Figures for single glazing sourced from Histoglass. https://chameleon-decorators.co.uk/blog/standard-glass-thickness-and-its-impact-on-window-efficiency/*
- *Figures for modern double glazing, triple glazing and vacuum glazing sourced from Fineo glass. https://www.fineoglass.eu/product/thin-double-glazing/*
- *Figures for slimline double glazing sourced from Histoglass. https://histoglass.co.uk/thin-double-glazing/options-thin-double-glazing/*

**Lifespan figures are an approximate guide.*

Windows

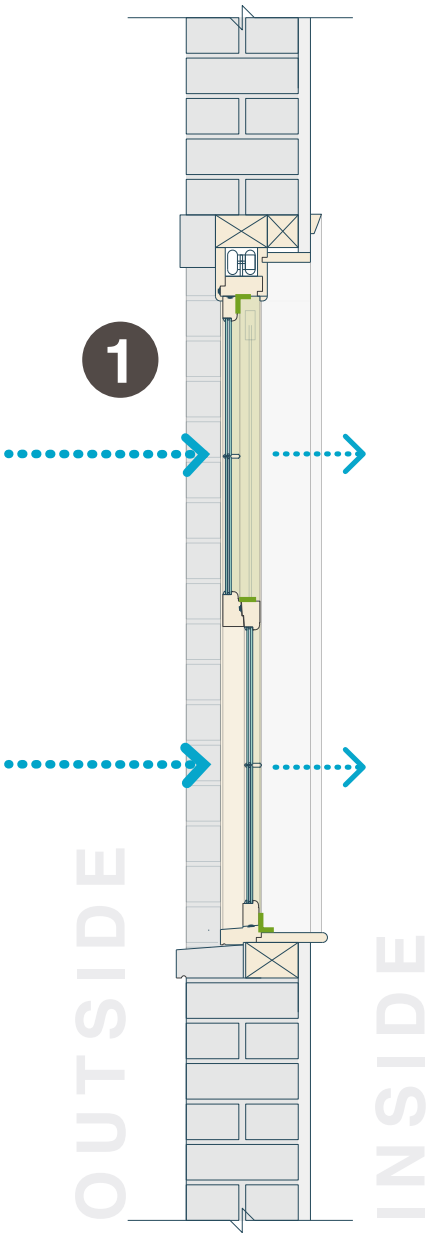
LEVEL 1



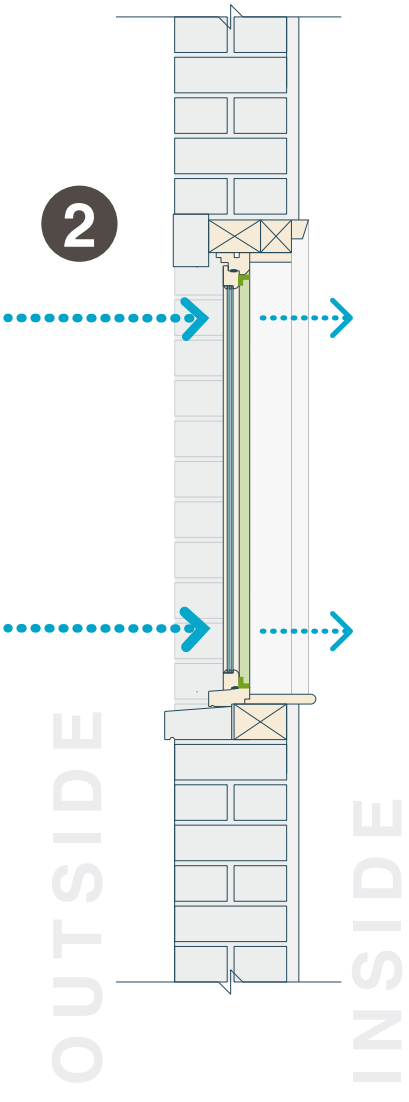
3%

Windows energy saving from Baseline

Sliding sash windows



Hinged casement windows

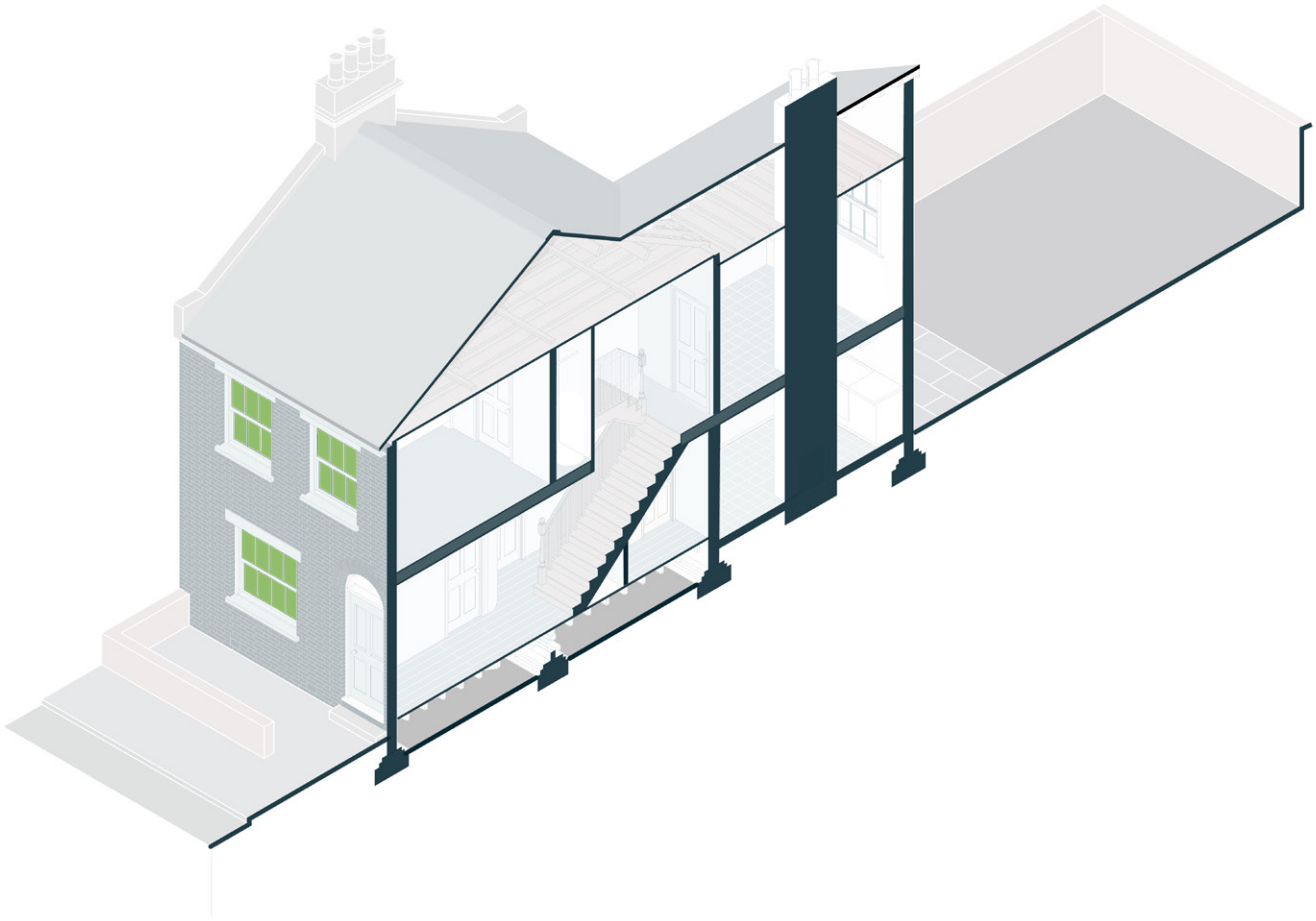


1 Install draught and weather strips to existing timber sashes and frames

2 Install draught and weather strips to existing timber casements and frames

Windows

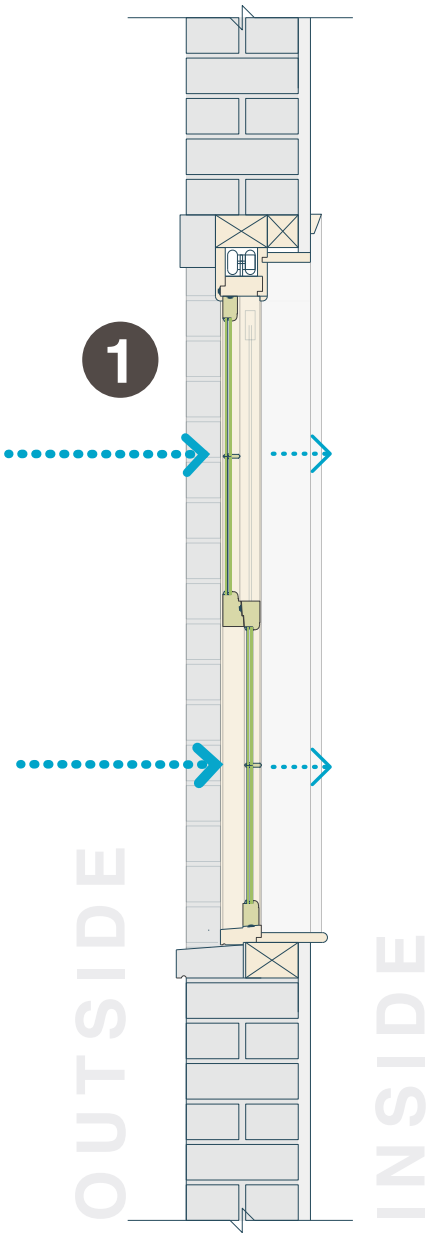
LEVEL 2



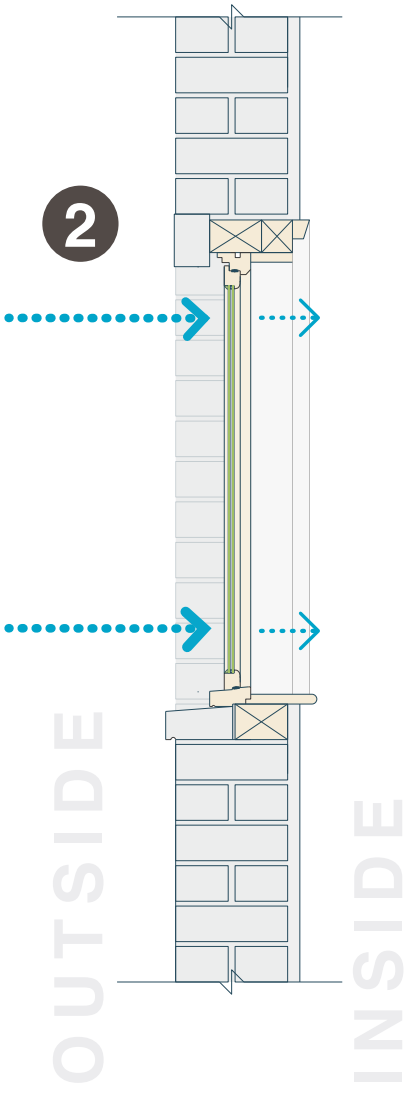
8%

Windows energy saving from Baseline

Sliding sash windows



Hinged casement windows



1 Reglaze existing sashes with slimline double or vacuum glazing and install draught and weather beads

2 Reglaze existing casement with slimline double of vacuum glazing and install draught and weather beads

Note

Ensure that the timber of existing windows is sound – or repaired – before installing new glazing.

It is possible to get vacuum glazing with a historic, rippled finish which may be appropriate for use on particularly sensitive historic properties.

Work may be required to adjust the glazing bars and the frame to accommodate the new glazing, as the thickness of the new double glazing will be greater than the single glazing and weigh more. A carpenter will be able to advise on this.

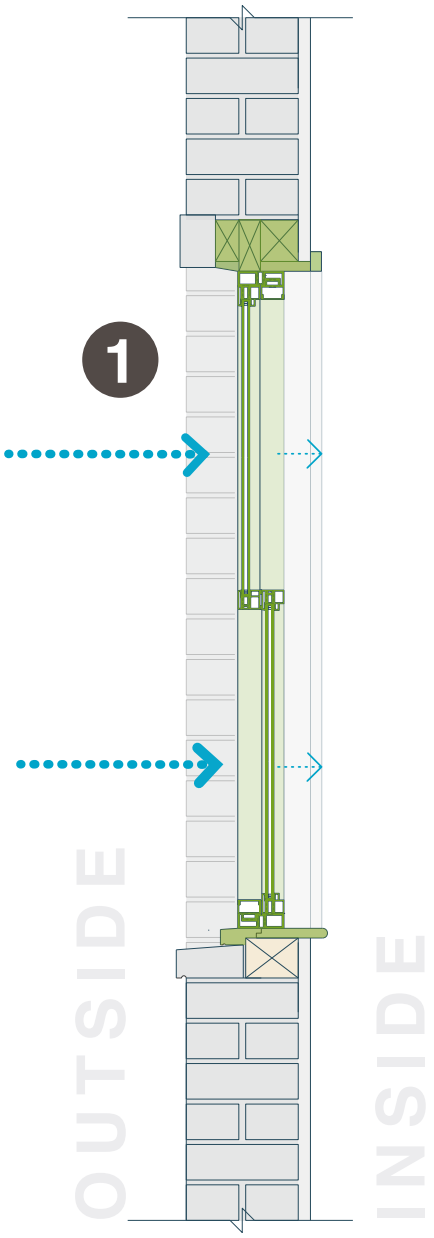
Windows

LEVEL 3

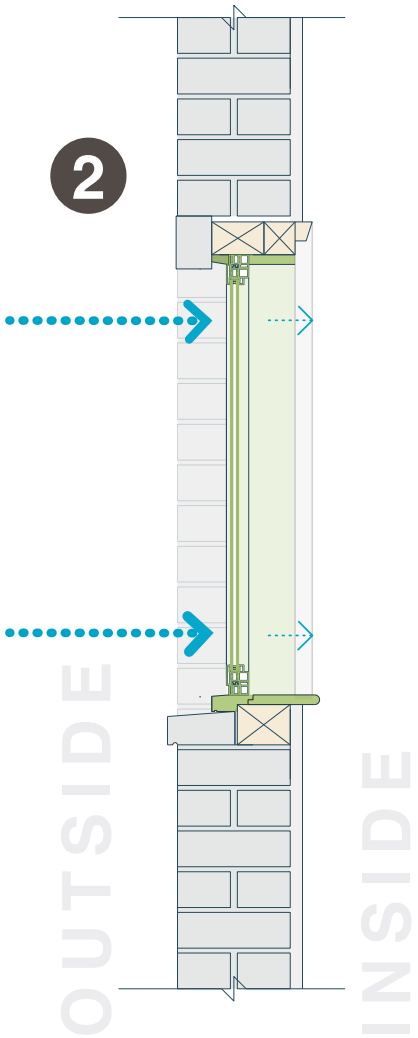
9%

Windows energy saving from Baseline

Sliding sash windows



Hinged casement windows

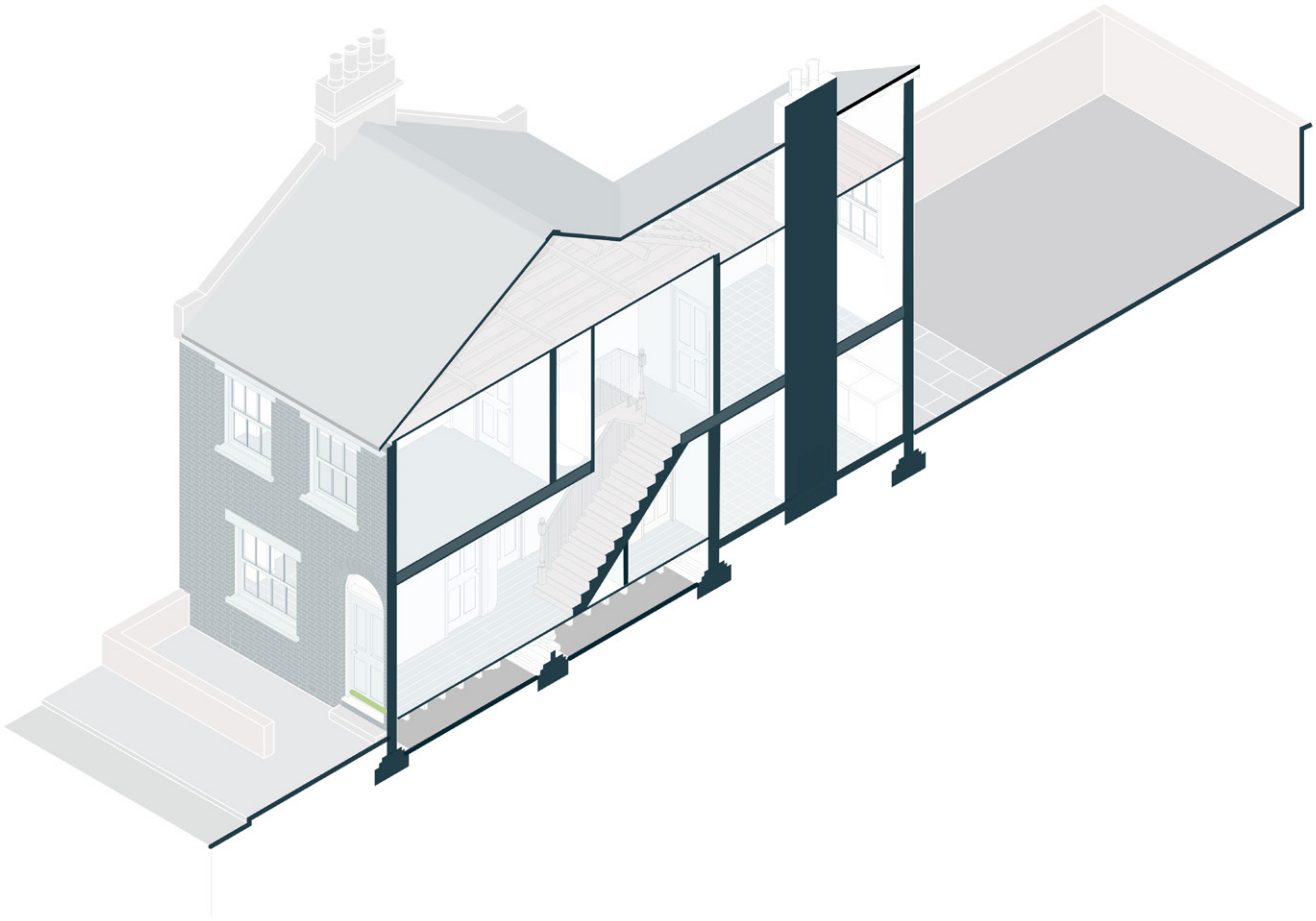


1 Replace existing window frame and sashes with thermally-broken frames and sashes with double or vacuum glazing

2 Replace existing window frames and casements with thermally-broken frames and casement with double or vacuum glazing

Doors

LEVEL 1



<1%

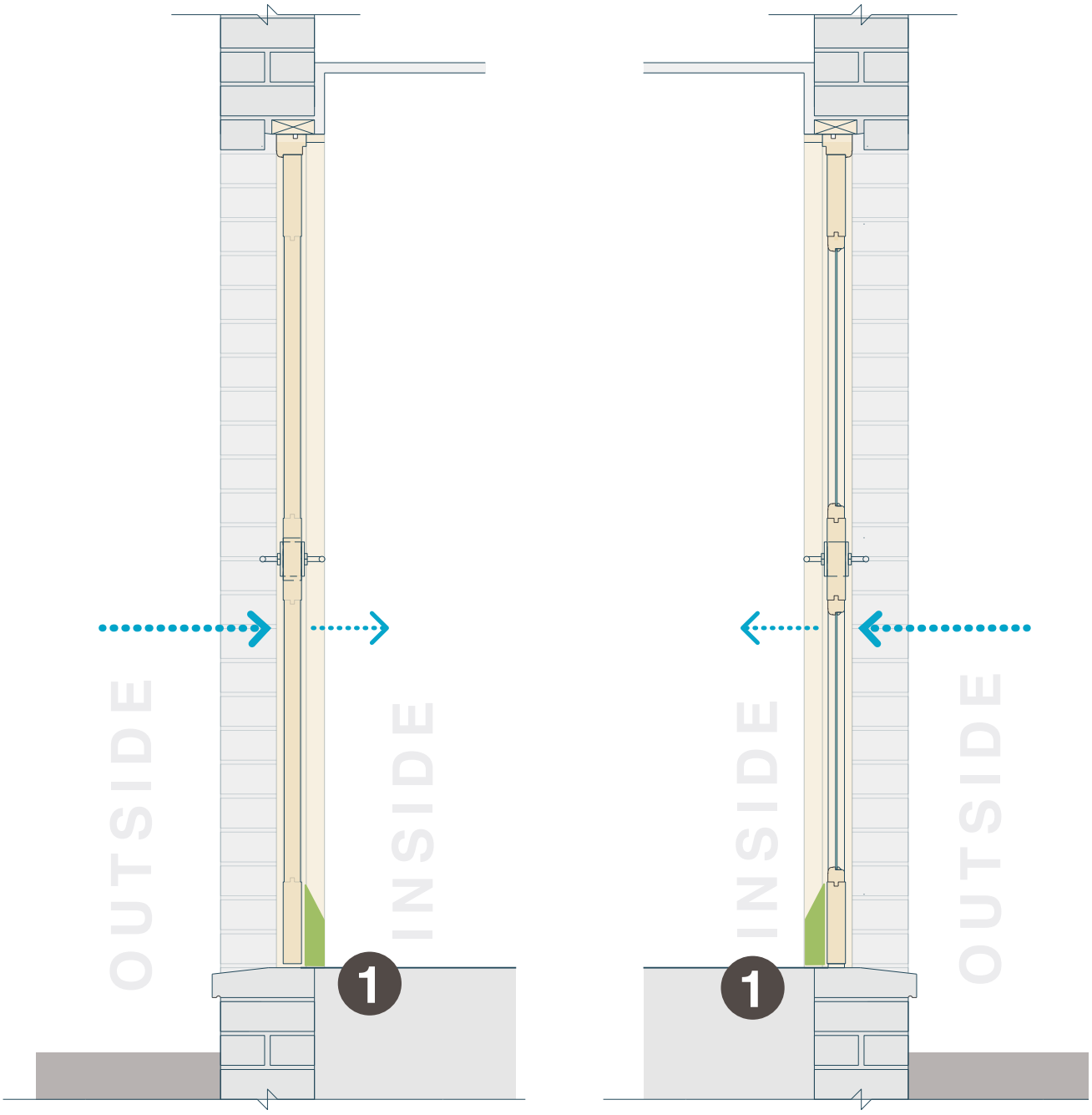
Front door energy saving from Baseline

<1%

Back door energy saving from Baseline

Softwood front door

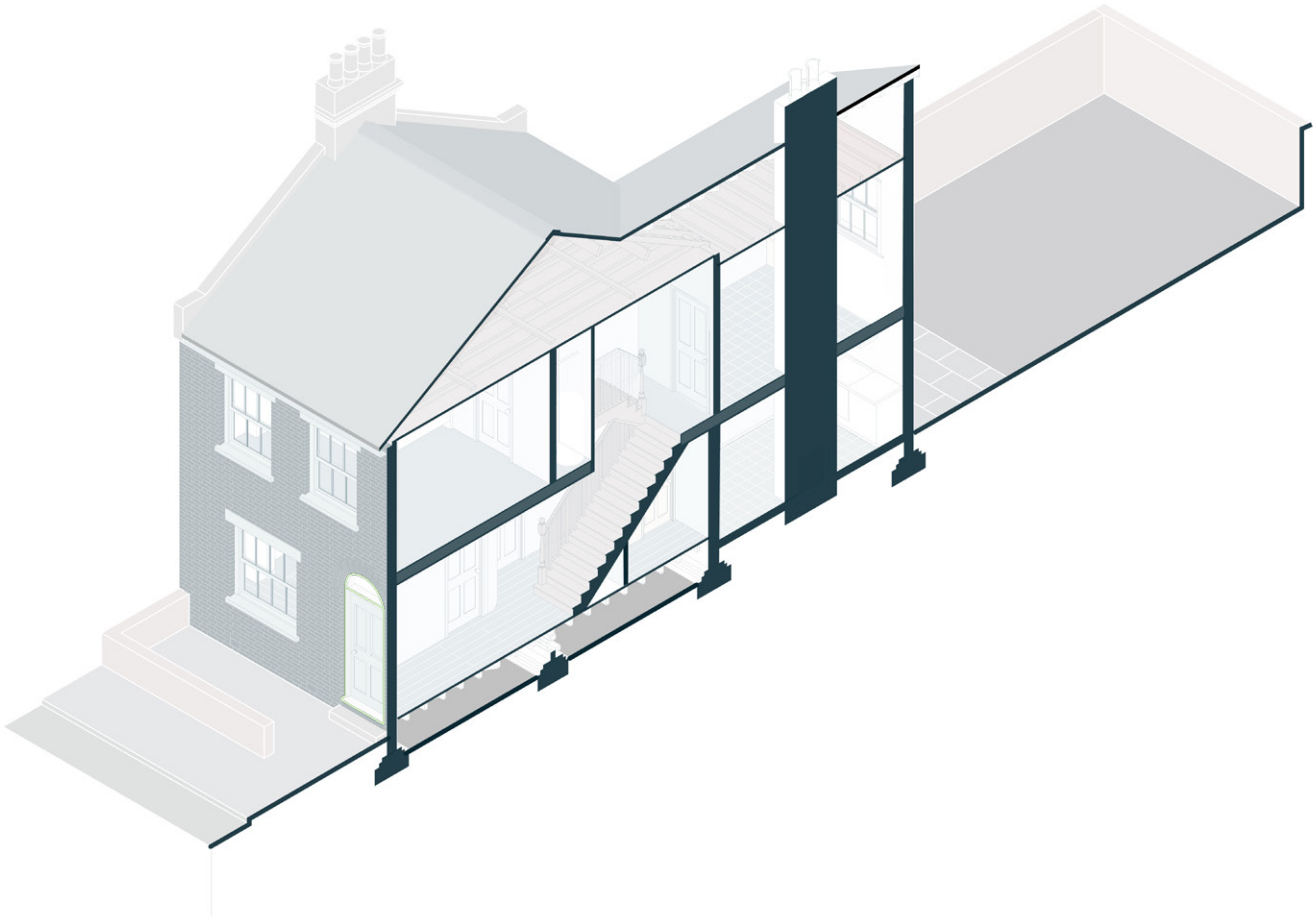
Part-glazed softwood back door



1 Buy or make draught excluders

Doors

LEVEL 2



<1%

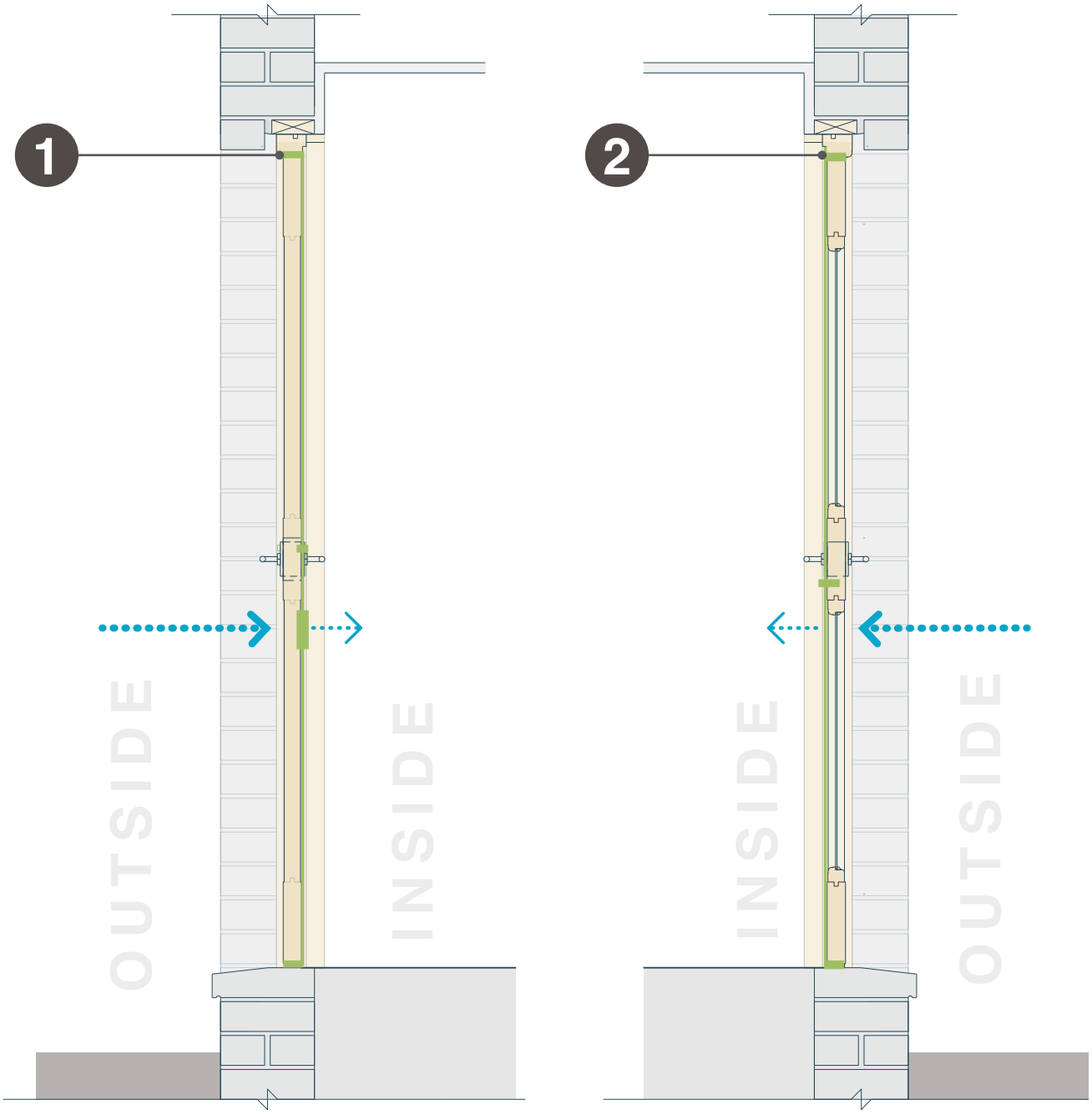
Front door energy saving from Baseline

<1%

Back door energy saving from Baseline

Softwood front door

Part-glazed softwood back door



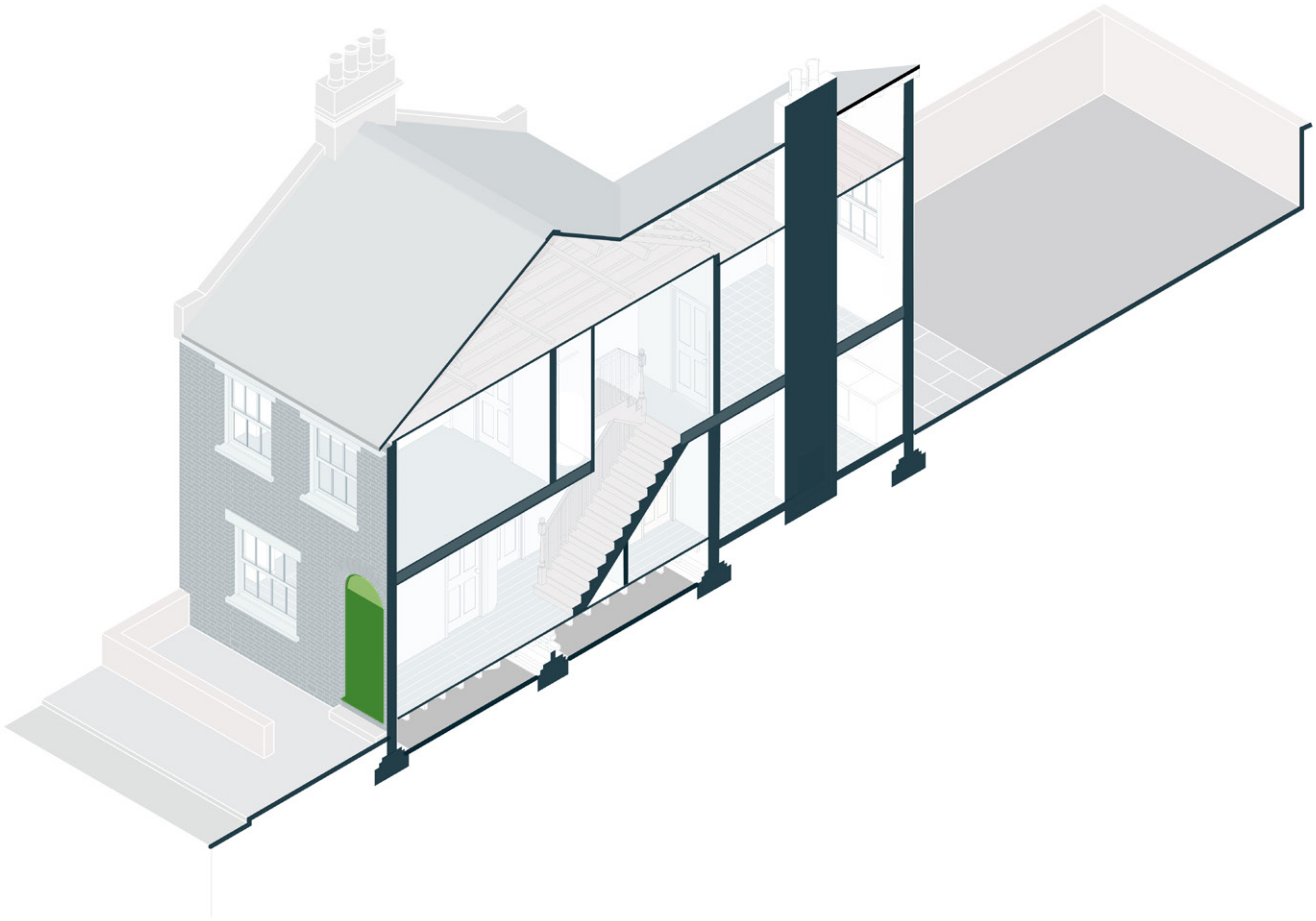
1 **Install draught and weather strips to existing doors & frames. Install insulated inner flap to letter box and escutcheon to keyhole**

2 **Install draught and weather strips to existing doors & frames. Install insulated inner flap to letter box and escutcheon to keyhole**

Note
Ensure the timber of existing doors is sound – or repaired – before installing new glazing.

Doors

LEVEL 3



1%

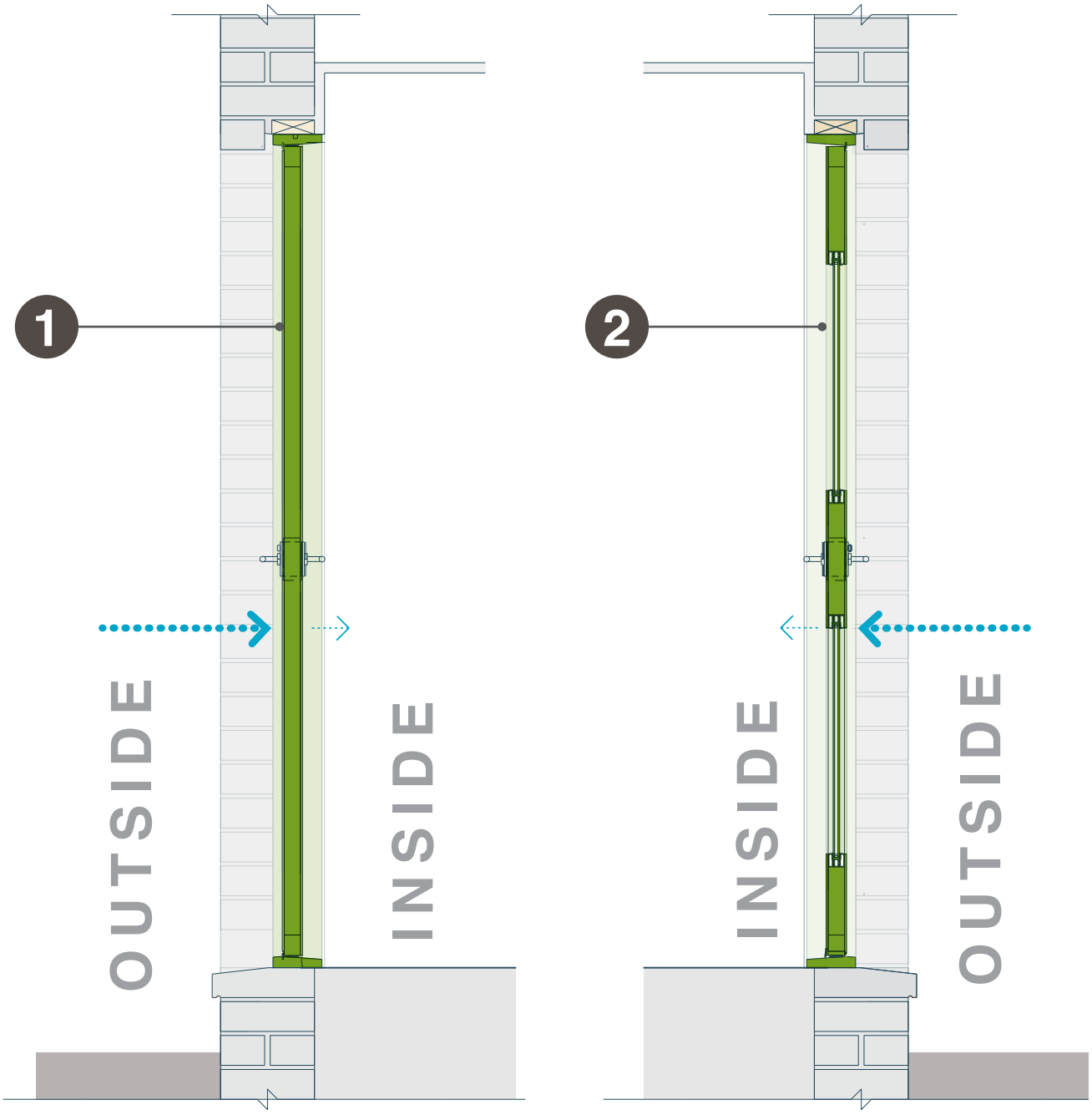
Front door energy saving from Baseline

1%

Back door energy saving from Baseline

Softwood front door

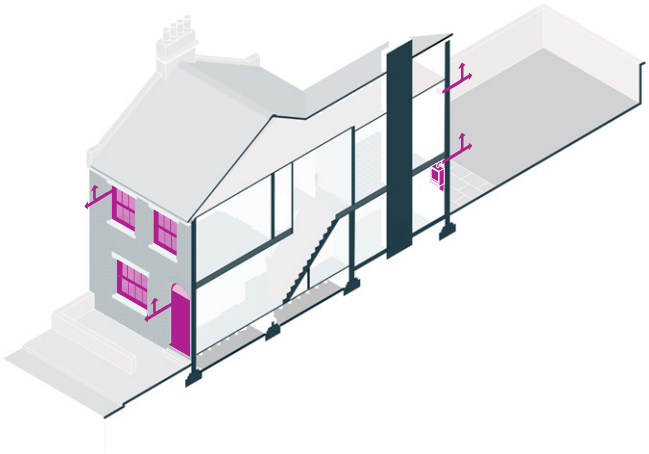
Part-glazed softwood back door



1 **Replace existing door and frame with insulated door and frame**

2 **Replace existing door and frame with insulated door and frame with double or vacuum glazing**

Ventilation & infiltration



Background

As described above, the Victorian house was naturally ventilated. In the summer this was by simply opening sash windows – a form of window that offers great variation in extent of openness. In the winter, trickle ventilation was driven by the draught required by the open fires.

The main sources of humidity in the home are from cooking, bathing and showering, but the breath and sweat of occupants alone can contribute to unhealthily stuffy and humid conditions.

The switch to convection heating and higher temperatures – related to increased expectations of appropriate domestic comfort – led to a reduced tolerance of draughts and the sealing up of trickle ventilation through floors, and around windows etc.

This has led to reduced health of these homes, with increased humidity and temperatures encouraging development of moulds, mite and bug infestations.

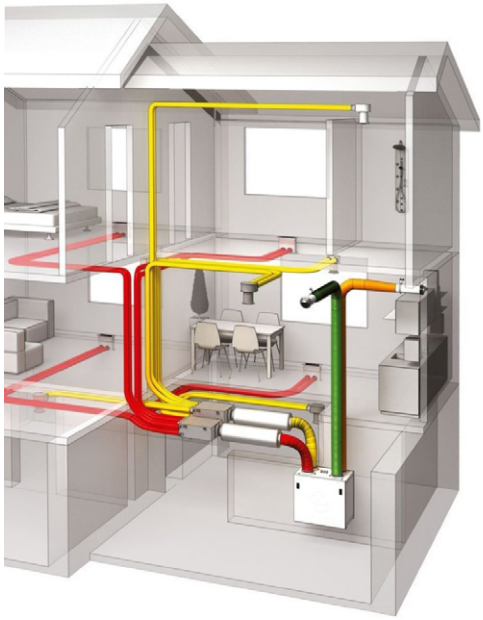
To recover the health of the terraced home, all works should incorporate an increase in ventilation to align with best practice air change rates. Principally this should be natural but there are mechanical ventilation systems that are suitable for installation in terraced houses, delivering fresh air that is pre-warmed with heat recovered from extracted air.

MVHR units

Mechanical ventilation with heat recovery (MVHR) systems extract stale air from buildings and supplies fresh, filtered air back into rooms, whilst retaining much of the heat from the extracted air.

It can be installed on a room-by-room basis, or through following a whole-house approach:

Example of a proprietary **single-room heat recovery unit**.



Example of a proprietary **whole-house heat recovery system**.

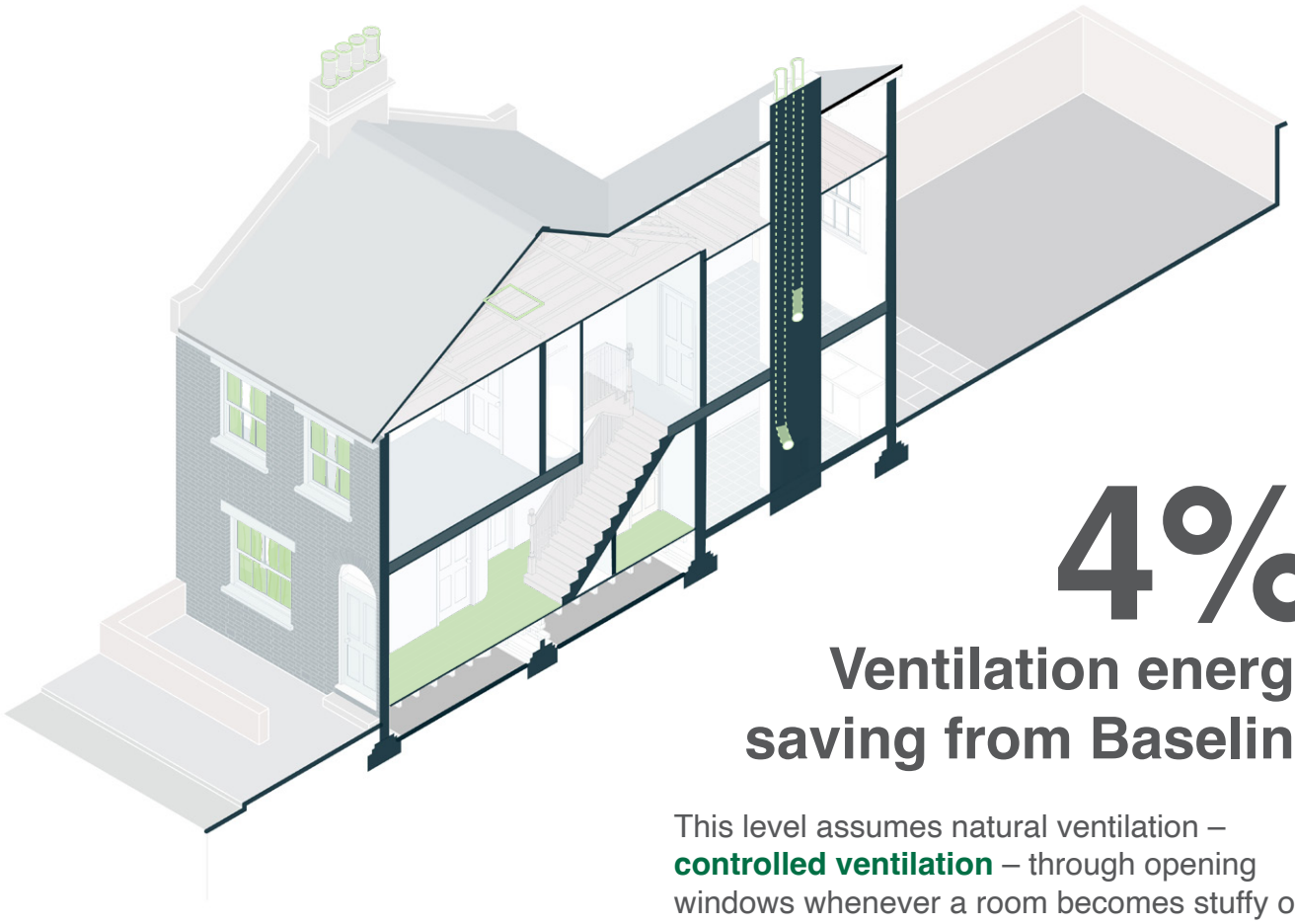
Above: Images sourced from Blauberg - https://www.blauberg.co.uk/en/blauberg-midi-air-decentralised-heat-recovery-ventilator-smart-wifi-home-automation-controlled-single-room-unit.

Note

MVHR units filter the supply and extract air and it is important to their efficiency that these filters are inspected and cleaned or replaced regularly – at between 6-12 month intervals – so, with whole-house systems, it is good to make sure that the unit is easily accessible. The control apps that commonly come with these systems will give advice and warning about the need to do this.

Ventilation

LEVEL 1



4%

Ventilation energy saving from Baseline

This level assumes natural ventilation – **controlled ventilation** – through opening windows whenever a room becomes stuffy or uncomfortable. This is the source of the 6% of heat loss in the Baseline house.

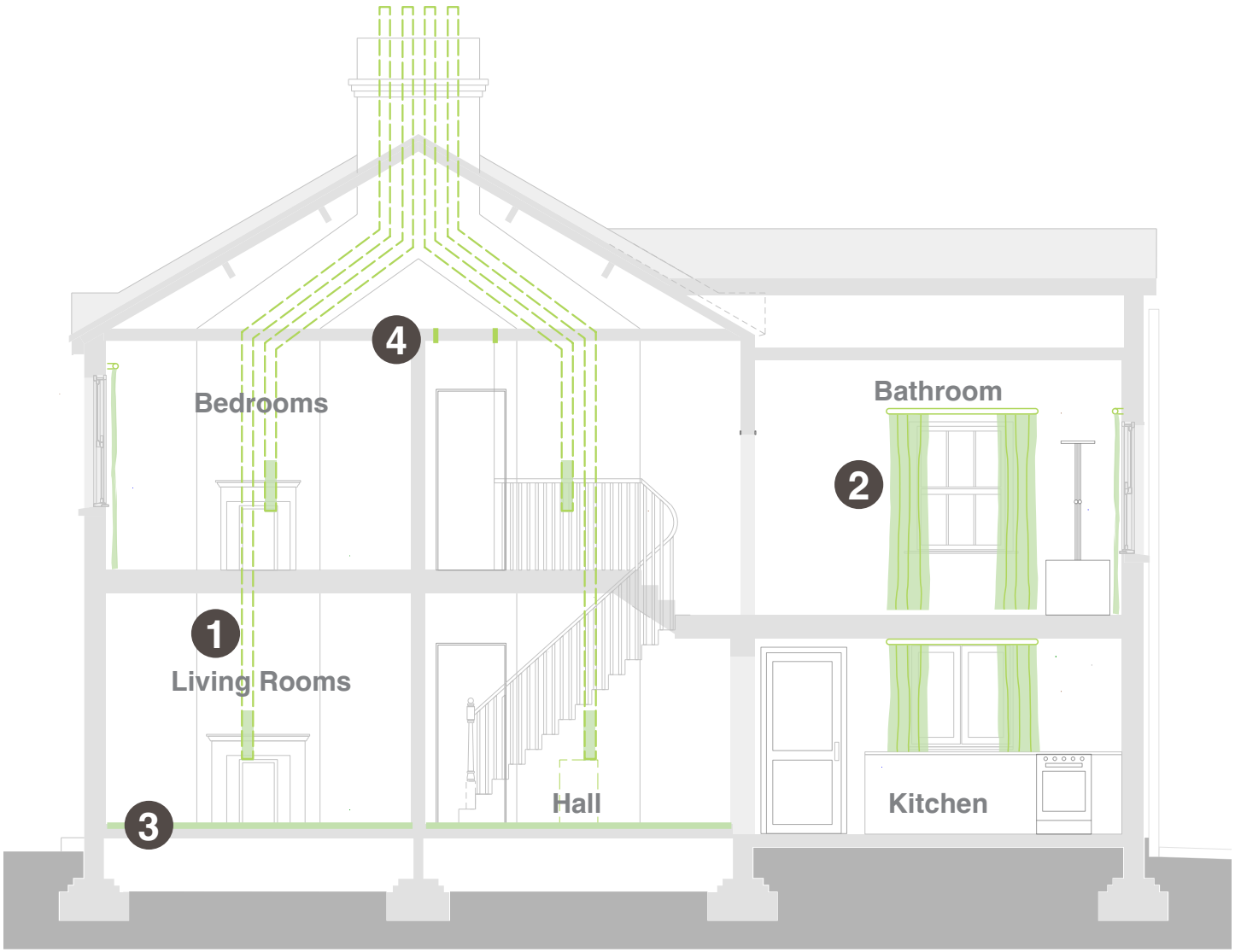
Draughts – **uncontrolled ventilation** — are the source of 11% of the heat loss in the Baseline house and can be minimised by installing proper draught seals – or heavy curtains – to existing windows and doors, and by sealing open fireplace flues with a vapour-permeable draught stop (Chimney Sheep).

Note

This natural ventilation should be augmented by mechanical extract ventilation from bathrooms and kitchens.

These fans usually run on a timer linked to the room light switch. However these can, more efficiently and usefully, be controlled by a built-in humidity sensor, coming on automatically when the room humidity reaches a certain, unhealthy, level.

A refinement of this approach would be to install trickle vents where possible to all windows. These can also be fitted with humidity control so that they only open when the humidity in that room reaches a set level.



1 **Install a proprietary chimney draught excluder**

2 **Install heavy curtains**

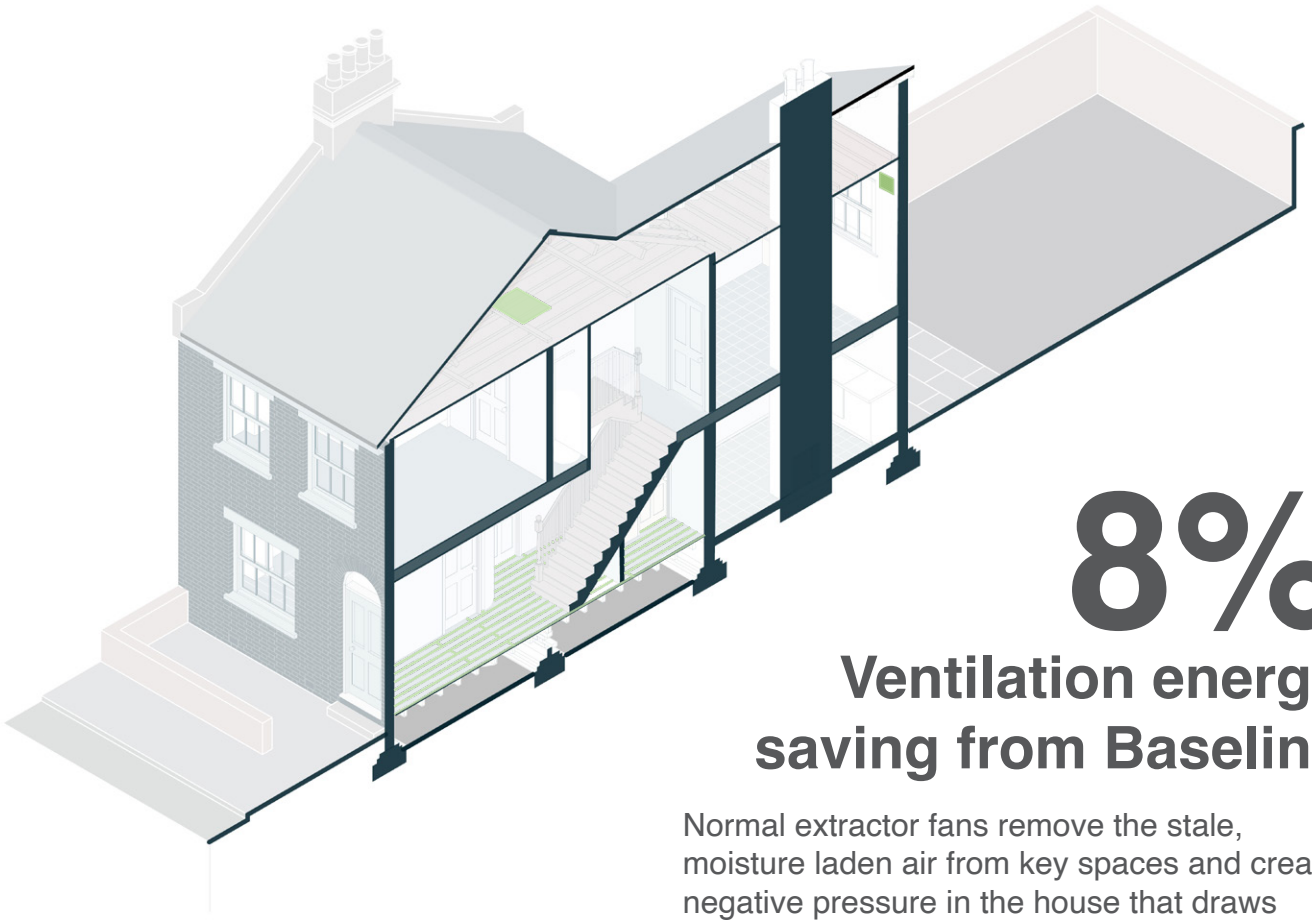
3 **Install fitted carpet and underlay**

4 **Add draught strips to existing loft access hatch**

Above: chimney draught excluder. Sourced from Chimney Sheep - https://chimneysheep.co.uk/products/chimney-sheep-chimney-draught-excluder-oblong-8-x-20-20cm-x-51cm

Ventilation

LEVEL 2



8%

Ventilation energy saving from Baseline

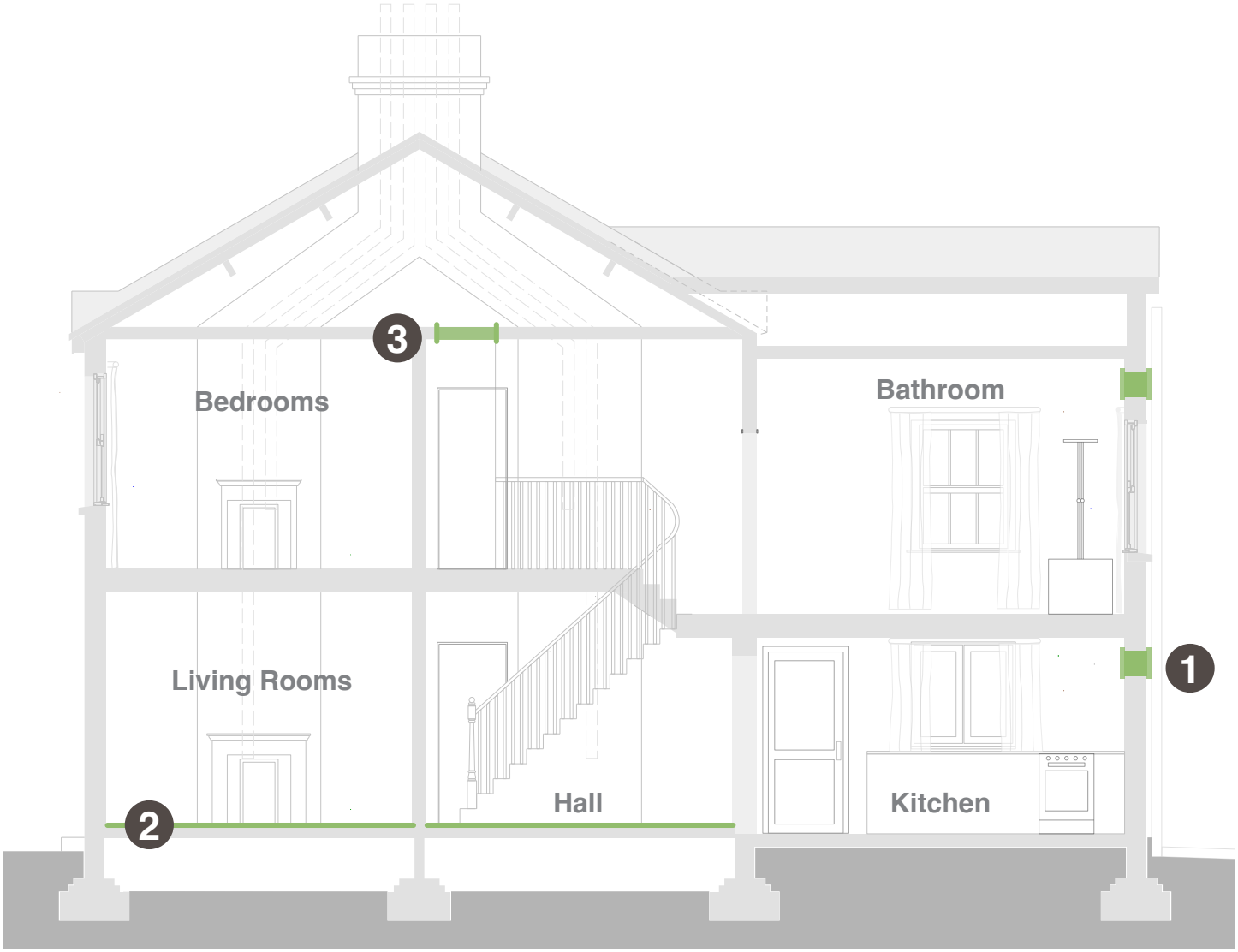
Normal extractor fans remove the stale, moisture laden air from key spaces and create negative pressure in the house that draws fresh air into other rooms, but they also throw away expensively-heated air.

Room-by-room MVHR units can act as a replacement for the extractor vents in bathrooms and kitchens. By providing pre-heated fresh air to other rooms (bed and living rooms) they can reduce ventilation heat loss and, during the heating season, act as an alternative to natural ventilation.

Note

Room-by-room MVHR units work by recovering the heat from extract air and transferring this into fresh air delivered to the room. They can be 80% efficient – which broadly means that the air that they deliver might be at 80% of the temperature of the air that they extract – and so probably not perceived as a cold draught. MVHR units are silent enough to use in bedrooms.

Installing MVHR units does not mean that the house is 'sealed' or that windows cannot be opened normally. During the heating season they will simply provide tempered fresh air at an appropriate background level to allow normal occupation without the need to open windows – and thus reduce heat loss and energy costs.



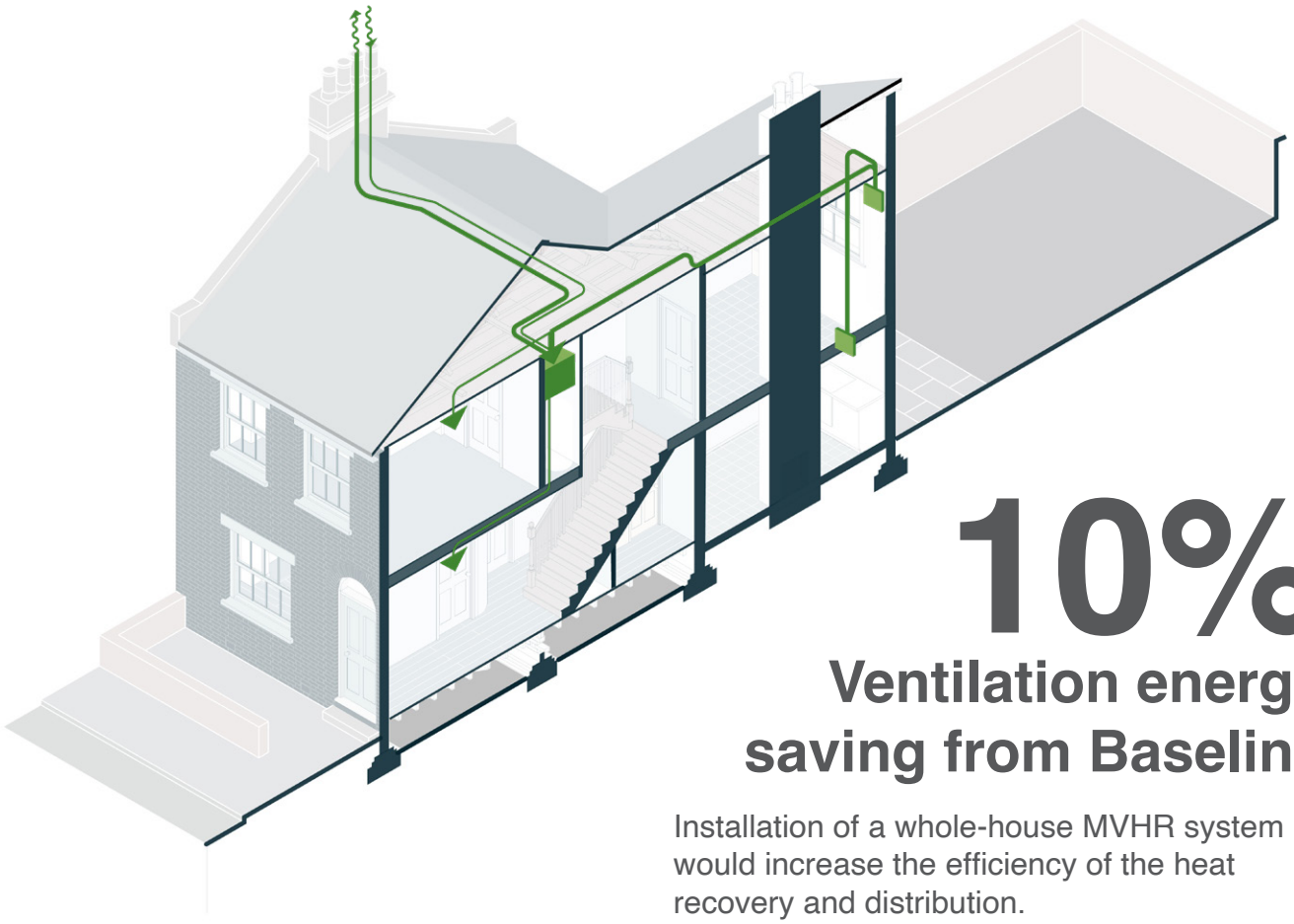
1 Install room-by-room MVHR units to kitchens and bathrooms

2 Re-lay floorboards to close gaps

3 Install insulated and airtight loft access hatch

Ventilation

LEVEL 3



10%

Ventilation energy saving from Baseline

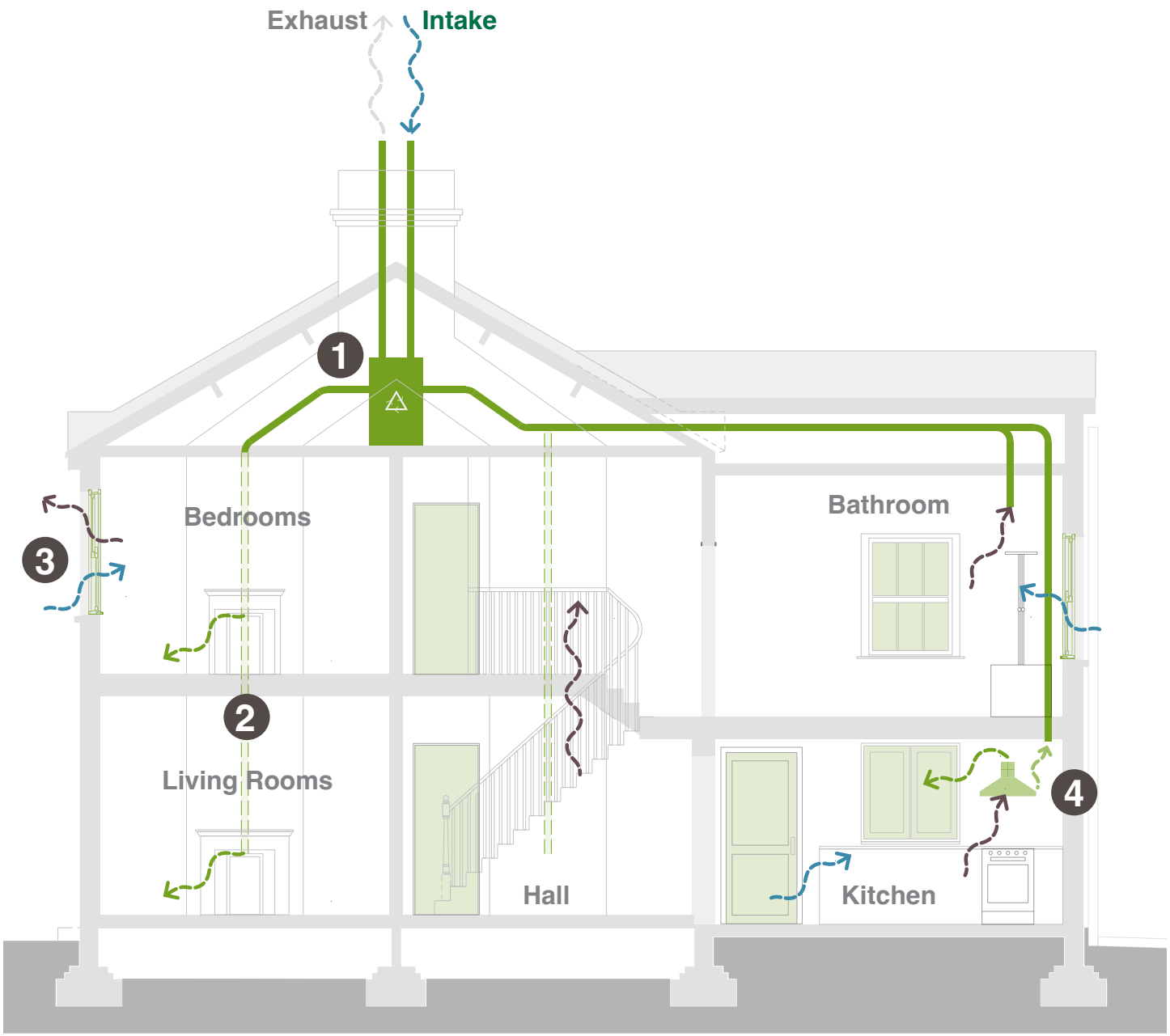
Installation of a whole-house MVHR system would increase the efficiency of the heat recovery and distribution.

The principle is to supply warmed fresh air to the living rooms and bedrooms and to extract air from the main sources of heat and humidity – bathrooms, kitchens, shower rooms etc.

Note

A central vent unit (typically the size of a counter-top fridge) could be mounted in a loft space or cupboard. Twin pipes for intake and exhaust air need to pass to external walls or roof terminals and then smaller-bore (75mm) pipework ducts distributing to the living spaces and collecting air from the kitchens, bathrooms etc.

Unless the fireplaces in a terraced house are still used for real fires or log-burning stoves, then the chimney flues can form pre-made routes for the supply and extract ductwork and, via the chimney stack, the external air connections.



1 **Install MVHR system using chimney flues as atmosphere connections and for supply of air to rooms** – in an accessible space e.g. a cupboard or the loft

2 **Stair and hall forms return air plenum with extract through landing ceiling**

3 **Ensure windows and doors are openable** – for manual-controlled ventilation

4 **Install a re-circulating cooker hood with an activated charcoal filter** – *it is not recommended to connect to the MVHR system as grease can get deposited in the extract ductwork*

Services & renewable energy measures

Services

Background

The services within a terraced house normally include the following:

- Heating and hot water
- Cooking appliances
- Lighting
- Ventilation systems
- Other power uses – white goods, standby, etc
- Mains and stored water

While heating, hot water and cooking may rely on gas, most others are run on electricity.

Water

The energy, and carbon emissions involved in supplying drinking water and operating drainage systems are significant and form part of the metered charges on which water is supplied.

To reduce costs and the carbon implications of water usage, it is important to explore the potential to reduce costs and carbon emissions by safely reducing water usage in baths, showers, basins, and sinks as well as in watering gardens and cleaning cars.

General guidance

Fossil fuels for heating and cooking

Oil-fired and gas-fired boilers, gas fires, and gas cookers are all still common in homes. These clearly form major sources of the home's carbon emissions but, while the cost per kWh of gas is so much cheaper than that of electricity, it is hard to make a case for switching off fossil fuels for any other than carbon reduction reasons.

It is probably the case that the controls, timing and operating temperature of almost all oil-fired and gas-fired boilers can be refined and tweaked to improve their energy efficiency. This improvement can achieve as much as a 20% reduction in energy use and carbon emissions.

A good first step in any home would be to have a qualified engineer inspect your heating installation, understand your home and your heating and hot water requirements and adjust the system to provide this in an optimal way.

Electric cookers, especially induction cookers and hobs have proved to be more efficient and safer than gas and new technologies – microwave and air-frying – use exclusively electrical power.

Open fires and log-burning stoves

The NO_2 and particulate emissions from open (log, coke, or coal) fires or enclosed log (and other fuel) burning stoves has been shown to cause significant pollution within the home, and neighbourhood, and the acceptability of these forms of heating will inevitably diminish as the air-quality of our homes and the well-being of our families rises up the political and health agendas.

Any proposal to increase the energy efficiency and health of our homes will include the need to cease use of open fires and log-burning stoves.

Air source heat pumps

The c.3x increased efficiency of ASHPs (Air source heat pumps) – compared with a gas-fired boiler – can, depending on your electricity tariff (see p19) be balanced out by the c.3x cost per kWh of electricity.

The largest domestic ASHPs have a typical range between 12-14kW. Smaller units (e.g. 5kW) are available but, to ensure that a smaller unit can provide sufficient heating and hot water, it will probably be necessary to reduce the heat loss by undertaking extensive fabric works to improve the thermal performance of the house.

There are government grants to replace gas-fired boilers with ASHPs: https://www.gov.uk/apply-boiler-upgrade-scheme – but there is only real logic (and cost saving to realise) to making this switch if the heating demand for the house has been reduced by some of the retrofit measures outlined above.

Lighting

A first and easy step to increasing the energy efficiency of lighting is to change all tungsten, halogen, or fluorescent bulbs for the LED equivalent bulbs that are now commonly available.

To reduce the time for which lights are left on and consuming energy ensure that you switch off the lights as you leave any room. 'Push' timer or presence-detector controlled switches are available to control the time for which lights are left on in halls and landings but careful thought is required to ensure that stairs remain safely lit at all times.

Service measures

The levels of things that can be done to improve the energy efficiency of the services that heat, light, power, and maintain your home and lifestyle, also vary with the amount of time, cost, and disruption that you can afford. The list is cumulative – Level 3 includes all of the measures in Levels 1, 2 and 3.

LEVEL 1

- LED lamps in every light fitting
- Increase boiler efficiency – get it serviced and optimised
- Reduce running temperature of boiler for hot water and central heating – down to as low as 60° (it is important to not go below this to protect against Legionella)

LEVEL 2

- 'A'-rated white-goods and other appliances
- Install thermostatic radiator valves to all radiators
- Room-by-room MVHR to kitchen and bathrooms
- Install humidity-controlled trickle vents to windows

LEVEL 3

- Install whole-house MVHR – reducing heat loss through controlled ventilation and thus heat demand required from boiler or heat pump
- Replace oil-fired or gas-fired boiler with an air source heat pump

Renewable energy

Background

In the constrained urban street settings in which most Victorian terraced houses are found, the opportunities for generating renewable heat or electricity are extremely limited and so the focus of effort should be on reducing energy demand and increasing the efficiency with which this demand is met.

Roof-mounted photovoltaic panel (PV) arrays can generate renewable electricity to supply part of the demand, and if installed with battery storage, can balance the times of maximum generation (when demand is likely to be lowest) with those of maximum demand (when generation is likely to be least).

For maximum efficiency, roof-mounted PVs should have an orientation between south-east and south-west – ideally due south, and not be overshadowed by neighbouring buildings or trees.

It is important to check whether there are any planning or conservation area constraints that would affect the installation of PVs on the street-facing or rear roof slopes.

Renewable energy measures

There are few low-impact ways of adding renewable generation of heat or electricity to your home and those below:

LEVEL 1

- None (as Baseline)

LEVEL 2

- Install PV array on roof slopes with an orientation between south-east and south-west. The most cost-effective way to use this electricity is during the period when it is being generated (rather than exporting this to the electrical grid and then buying it back later).

LEVEL 3

- As the daily and seasonal cycle of electricity generation from PV does not closely match normal domestic electricity usage, install a battery (to save electricity generated by PV) for use by the house when the PVs are not generating.
- Invest in an electric vehicle (EV) that is capable of Vehicle-to-Home or Vehicle-to-Grid discharging. This allows you to use the car as a battery to your house and, if scheduled appropriately, the discharge of power to the grid at peak times can reduce the power load on the National Grid and the need for more power stations.

The potential benefits

The following pages illustrate how your house could perform with the addition of an ASHP and / or PVs, including:

- Cost of annual energy bills
- Annual carbon emissions (CO_2)

The graphs are arranged by the different levels of retrofit (and assumes the respective fabric measures have been completed).

Why is the Baseline excluded from service measure options?

The heat demand of the house at Baseline is likely beyond the level that could be met by an ASHP operating on a typical domestic (single-phase) electrical supply.

Most homes don't have a three-phase electrical supply.

At present, domestic heat pumps suitable for typical homes have a capacity of between 12-14 kW. This is unlikely to meet the heating needs of a home with the lack of insulation and draught proofing represented by the Baseline Level, so the option of adding ASHP to a house at Baseline Level has been discounted.

This demonstrates that although there may be government grants available to replace boilers with ASHPs – this is unlikely to make sense in terms of comfort, energy, or bills unless retrofit measures to at least Level 1 and, even at this level, the current price differential[1] between gas and electricity is likely to make this cost-neutral in terms of running costs.

[1] The Secretary of State for Energy Security and Net Zero has announced that the government will unveil its plans to decouple gas and electricity prices. https://www.energylivenews.com/2023/03/27/uk-energy-secretary-hints-at-splitting-electricity-and-gas-prices/.

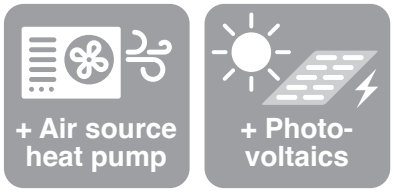
Potential benefits of renewable energy measures with the relative levels of retrofit

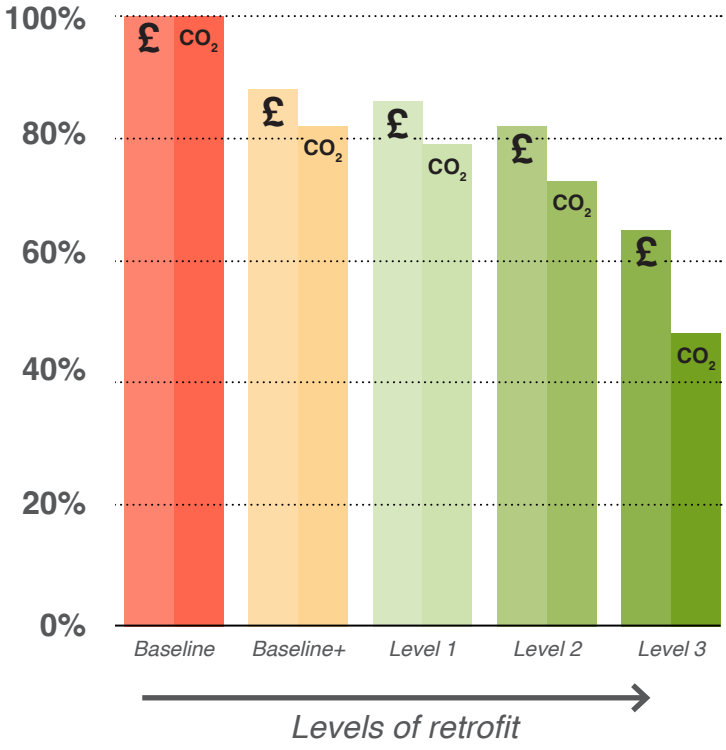
£ Approximate percentage of annual Baseline energy bills
+
CO_2 Approximate percentage of annual Baseline carbon emissions

Note: The diagrams below exclude the potential reduction of annual bills that might be gained from adopting a 'Fabric Fifth' approach with a smart electrical tariff, battery, and ASHP, with or without Photovoltaic panels.

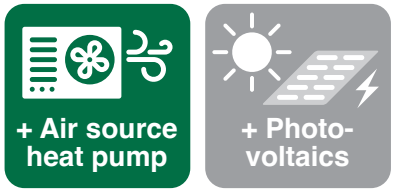
As these reductions are dependent on the availability of smart tariffs and the affordability of the renewable energy installations, they are difficult to model.

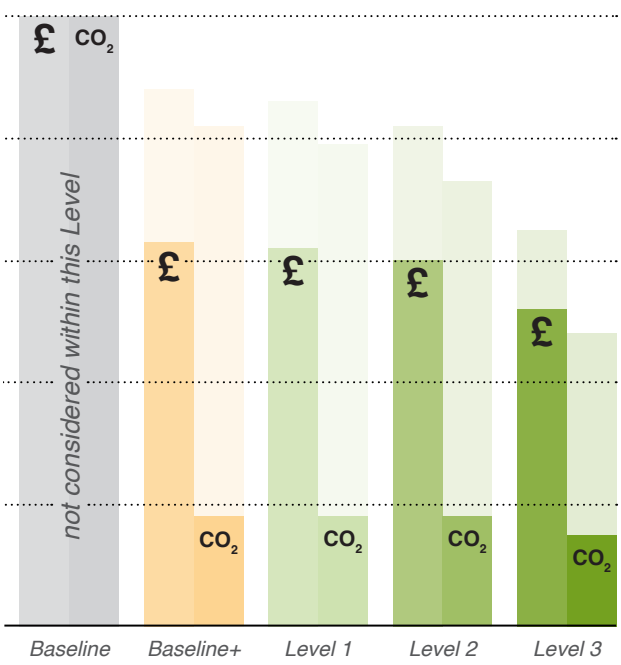
Potential benefits of the relative levels of retrofit without additional services or renewable energy measures



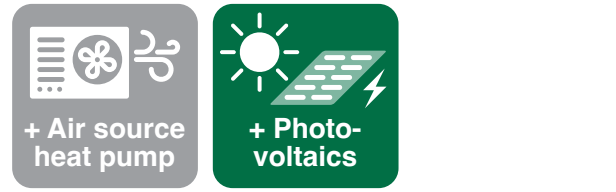


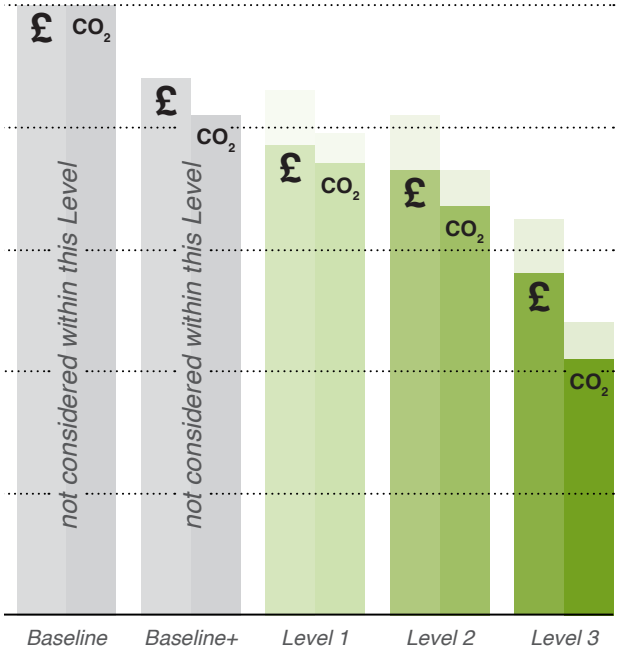
Potential benefits of the relative levels of retrofit with an ASHP



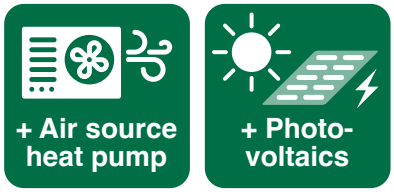


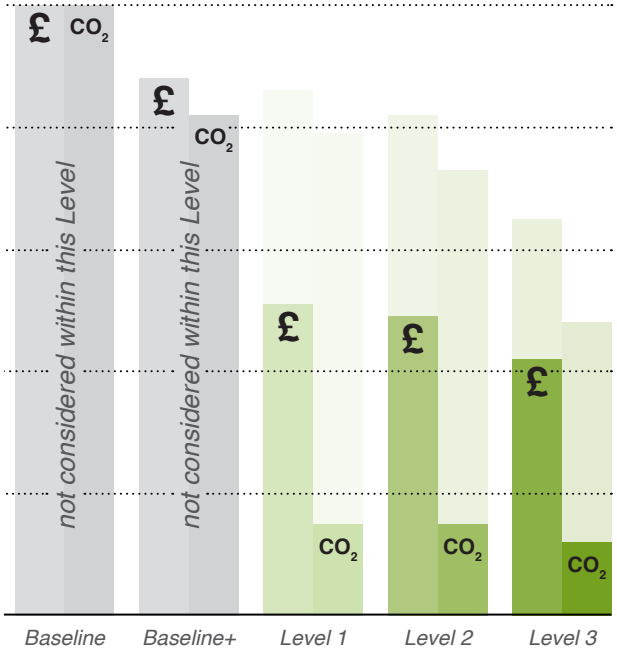
Potential benefits of the relative levels of retrofit with photovoltaic panels





Potential benefits of the relative levels of retrofit with ASHP + photovoltaic panels





Consents & guidance

Planning, conservation areas, listed buildings, Party Wall Act, and Building Control

Historic buildings, such as Victorian terraced houses, can be protected by planning, conservation areas and listed building legislation, which can limit the scope and nature of retrofit measures that can be delivered.

It is wise to check the level of protection (if any) that relate to your house before commencing work.

It is important to note that these differing levels of protection do not mean that all changes are prohibited, indeed many measures to improve the thermal performance of a house fall into the category of permitted development.

The different levels of designated protection simply mean that it is necessary to go through different processes of application and approval before some works can be undertaken.

Planning

Planning permission is required if proposals involve significant change to the appearance, height, or floor area of the building.

The planning portal has a interactive guide to the need to apply (or not) for planning or other permissions for works to a typical house. This link is to the terraced-house page: https://interactive.planningportal.co.uk/terraced-house/outside-terraced-house

In addition, most local authorities publish their own guidance to help residents understand the consent processes required to install low-carbon technologies in homes.

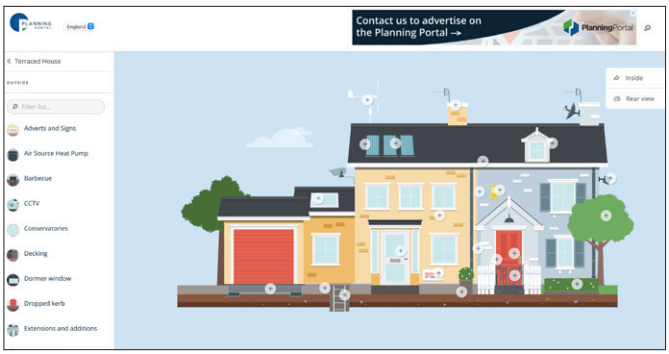
Conservation areas

About 25% of the Victorian terraced houses in the UK are now sited within, and sometimes form the defining characteristic, of conservation areas.

This designation has been shown by Historic England (and the LSE) to have a positive effect on property values. However, this can limit the extent to which the street frontage of properties can be altered by, for example, external insulation, changing the form and construction of windows, or roof. In many cases, even though the street frontage is protected, it is possible to undertake more extensive works to the rear of the building, the elevation, extensions, and roof form (with dormer windows etc).

How to find out if your house is in a conservation area?

To work out whether your home lies within a conservation area, consult the duty planning officer in your local authority (by phone or in person) – or follow links to the 'Planning and Conservation' section on their website.



The Planning Portal Interactive Terraced House. Source: https://interactive.planningportal.co.uk/terraced-house.

Listed buildings

Other, exceptional, terraced housing may be listed, with further degrees of protection, and the retrofit of these should be undertaken with the help of professional and conservation advisers.

It is possible to check whether your property is protected:

- The extent and description of (what's important about) conservation areas are published on all local authority planning websites – often alongside guidance for householders.
- Historic England have a map or property address search which will identify all listed buildings:

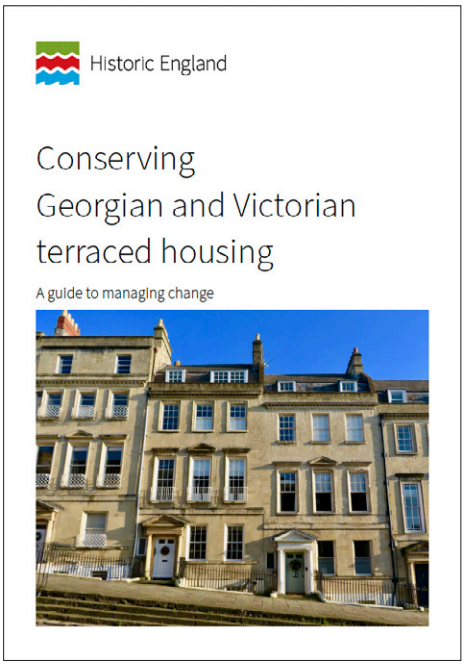
https://historicengland.org.uk/listing/the-list/map-search

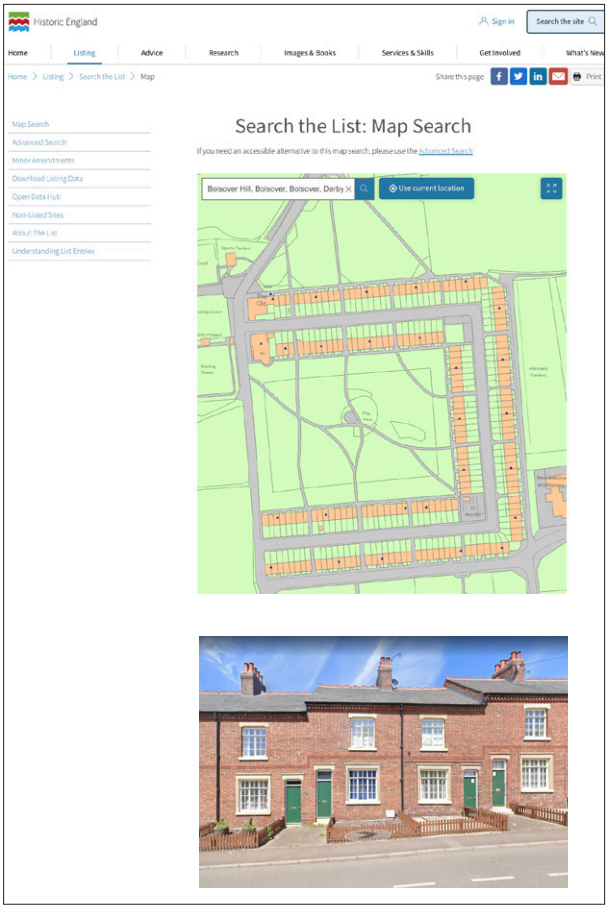
Historic England also publish a guide to conserving Victorian terraced houses: https://historicengland.org.uk/images-books/publications/conserving-georgian-victorian-terraced-housing/heag277-conserving-georgian-and-victorian-terraced-housing/

Link to Insulation and house prices: https://www.gov.uk/government/news/energy-saving-measures-boost-house-prices

and specifically for solid-wall insulation: https://www.gov.uk/government/publications/the-impact-of-solid-wall-insulation-on-property-value

Note on breakdown of UK housing stock: https://www.gov.uk/government/statistics/council-tax-stock-of-properties-2021/council-tax-stock-of-properties-statistical-summary





Top: Historic England guidance. Source: https://historicengland.org.uk/images-books/publications/conserving-georgian-victorian-terraced-housing/heag277-conserving-georgian-and-victorian-terraced-housing/

Right: A map search for Bolsover identifying the number of listed terraced Victorian homes in New Bolsover. Source: https://historicengland.org.uk/listing/the-list/.

In addition, there are other processes and legislation that can affect the way that building work is undertaken. As with the above, these are not intended to prevent work from being carried out, but to ensure that they are carried out in a way that minimises harm to you, your home, or neighbours.

Party Wall Act

If the works involve, for example, insulating the outside of a wall that sits on, or faces, a boundary to your neighbours, a party wall agreement for these works may be required under the Party Wall etc. Act 1996.

Party Wall Surveyors can be found in all areas.

Building Control

A lot of the smaller works involved in the suggested retrofit measures do not require Building Control approval. However, if these are undertaken at the same time as major structural works inside or loft or rear extension works to the house, the Building Control officer may wish to discuss these retrofit measures with you. In some of these circumstances Building Control may require these retrofit improvements are carried out as 'consequential improvements' as part of the major works.

Other

Skip and scaffolding permits may be required for work directly onto the street.

Protected species

There are many protected species and habitats in the UK and what you can, and cannot do by law varies from species to species. At your house you should consider: bats, breeding birds, reptiles, great crested newts in particular. If you plan to carry out works that may disturb a protected species or habitat, you should seek advice from a qualified ecologist.

Bats

All species of bats in the UK are protected and although frequent visitors to both old and new houses, they are small, harmless mammals that do not cause any damage.

Bats do not make much noise or smell and their droppings soon crumble away to dust. They do not use bedding or return with any insect prey to the house. Indeed, householders are usually unaware of them.

Whatever the age of your house, it is possible that bats will find somewhere to roost within, either in the roof space, under a roof tile or lead flashing, between gaps in mortar, or behind fascias and soffits.

A roost is not likely to be used all year round, but bats will return at appropriate times each year to a traditional site. All bats and their roost sites are fully protected by law, even if bats are not present all the time. If you have bats in your roof, their access must not be impeded.

If any problems are encountered with bats, or if any repair work to the roof is necessary, advice must be sought from the relevant statutory nature conservation agency or a specialist trust like the Bat Conservation Trust.

https://www.bats.org.uk/index.php

Further retrofit guidance

Valuable further advice on retrofit and home energy is available from the following non-profit organisations.

Which?

The UK's Consumer champion.
https://www.which.co.uk/reviews/insulation/article/how-to-insulate-your-home-aGWRW8t8YX1j

National Retrofit Hub:

An organisation that brings together all those involved in retrofit to collectively drive and accelerate the local delivery of retrofit.
https://nationalretrofithub.org.uk

Most local authorities publish their own guidance to help residents understand the consent processes required to install low-carbon technologies in homes.

Eg:
Camden
https://www.camden.gov.uk/documents/20142/4855432/Retrofitting_Planning_Guidance_October_2013.pdf/a7c3580b-af1f-6b03-260f-da25ad1a7707

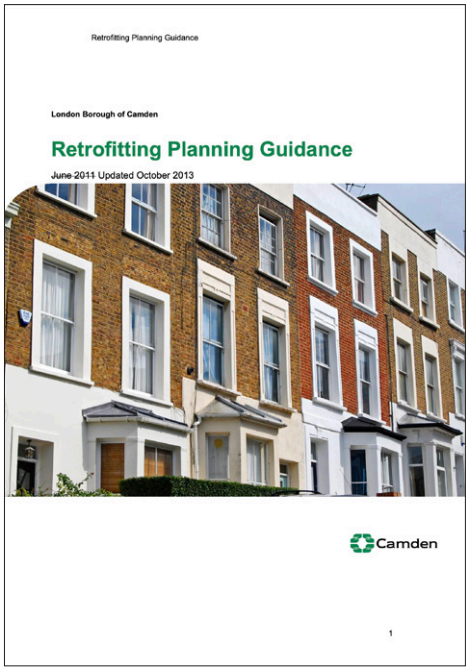
Cambridge
https://www.cambridge.gov.uk/media/11677/retrofitting-your-home-report-non-accessible-version.pdf

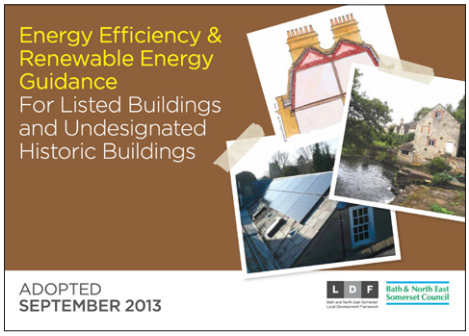
Bath and North East Somerset
https://beta.bathnes.gov.uk/sites/default/files/2020-01/listed_building_guidance_-_energy_0.pdf

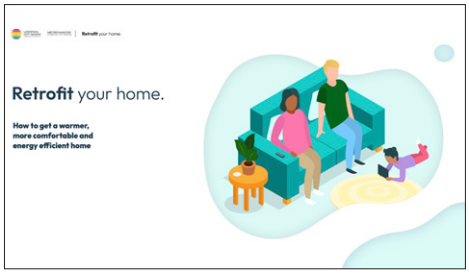
Liverpool
https://www.liverpoolcityregion-ca.gov.uk/wp-content/uploads/Retrofitting-guide.pdf

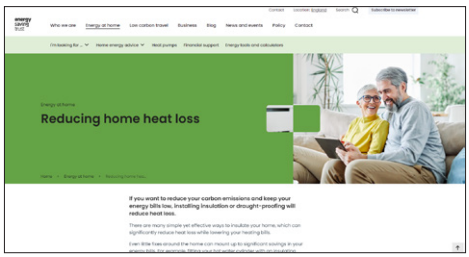
Energy Saving trust
https://energysavingtrust.org.uk/hub/quick-tips-to-save-energy/

Sources for images on this page correspond to the order of links listed above.









5

Quick recap

This Retrofit Pattern Book illustrates the value, including reducing carbon emission and enhancing comfort, of investing in upgrading the building fabric, improving energy efficiency and decarbonising the energy used in our homes.

There are resources available to support the delivery of improvements to homes through contributing to their cost.

Summary recap

The Retrofit Pattern Book is a guide for homeowners. It provides general information on energy use and illustrates how best to increase energy efficiency, whilst maintaining comfort and reducing the risk of unintended consequences.

The Victorian 'two-up-two-down' terraced house with a garden has come to represent, in the UK, the typical family home. This type of house has, over time, informed different space standards and sizes used in the design of new homes.

Built over 100 years ago, the character of these houses means they remain a popular house type, with Victorian terrace homes representing some 8.5% of England's housing stock. However, they were not constructed to the same energy standards as today's homes so are likely to need substantial retrofit to support the UK's goals of becoming net zero by 2050.

Retrofitting these homes offers the opportunity to greatly increase their comfort, health and energy efficiency, bringing multiple benefits to residents and the long-term stability of the building.

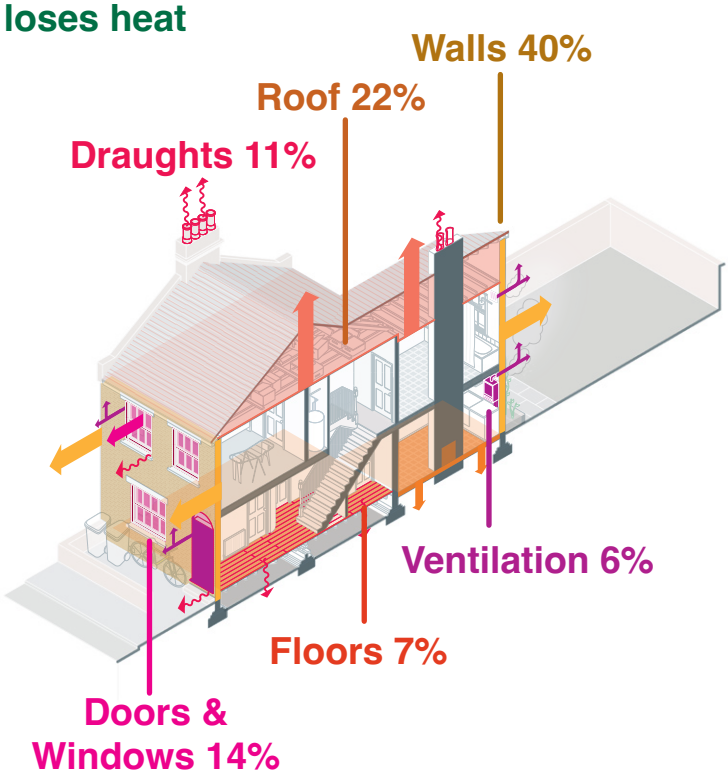
If you only make a few upgrades to your house, you should consider the benefits of:

1. Completing any **maintenance tasks** that are undermining the thermal performance of your house – leaks, blocked vents, etc.
2. **Insulating** your loft
3. Addressing heat losses from **draughts** (uncontrolled ventilation / infiltration)

By this point your annual energy use could well have been reduced by c.20%

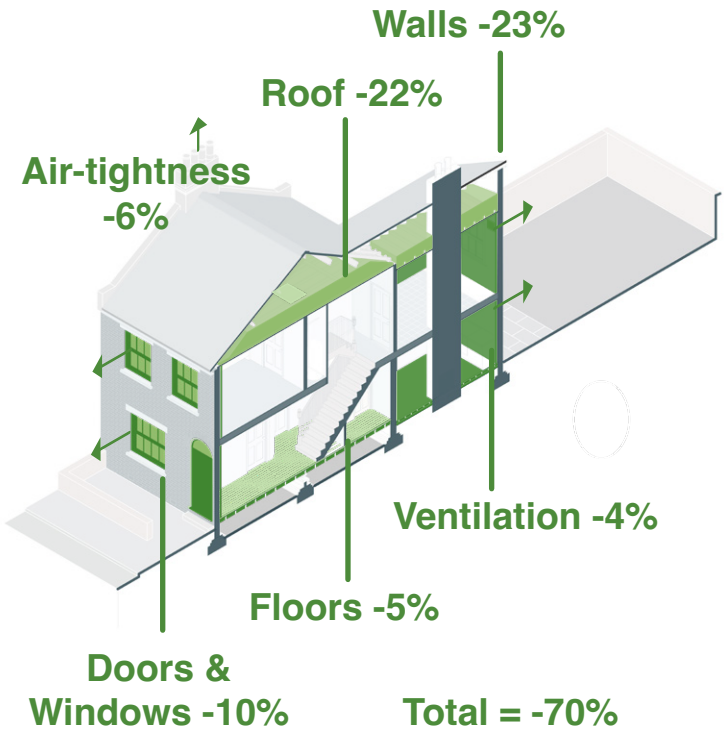
4. Install an **air source heat pump** (and possibly a battery) using smart tariffs to reduce the costs and carbon emissions of your energy.

Where the typical terraced house loses heat



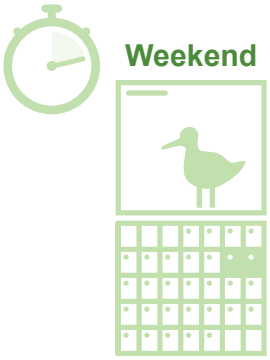
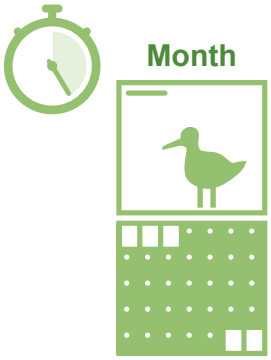
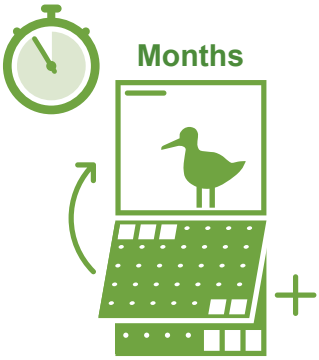
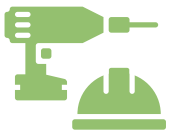
The unmodified typical Victorian terraced house loses heat in multiple ways, the above is the likely % losses from the main areas of the house

Potential to reduce heat loss



Level 3 fabric measures and potential % of peak heat loss reduction from the baseline of an unmodified Victorian terraced house

Reducing heat loss through fabric improvements:

	Level 1	Level 2	Level 3
Timescale			
Delivery	DIY	 Small builder	 Small builder + professional advice
Disruption	Minimal	 Room by room	 Phased room by room, or one-hit whole house
Cost	£	££	£££
Potential peak heat loss reduction[1]	28%	38%	70%
Potential annual energy bills[2]	86%	82%	65%
Potential annual CO_2 emissions[2]	79%	73%	48%

Increasing efficiency of heat sources, and decarbonising the energy used:

If Level 3 improvements are combined with the installation of an air source heat pump and photovoltaic panels, this could lead to:

25% annual energy bills[2] & 11% of annual CO_2 emissions[2]

1. Potential total reduction in peak heat loss from the Baseline Level - Unmodified Victorian terraced house
2. Potential reduced level compared to Baseline Level - Unmodified Victorian terraced house

Issue:

Date	Revision
27/04/23	1. Draft
25/05/23	2. Final Draft
12/10/23	3. Final Draft
09/05/24	4. Revisions to calculations following review and validation by Etude & minor text and layout revisions
16/01/26	5. Refreshed content to update retrofit context

5th studio

Architecture & Urbanism

www.5thstudio.co.uk

Unit 14
21 Wren Street
London WC1X OHF
+44 (0)20 7837 7221

Darkroom
Gwydir Street
Cambridge CB1 2LJ
+44 (0)1223 516009

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Company No. 3373123
VAT No. 711 206 489