PEOPLE POWERED RETROFIT

Home Retrofit Scenarios

Prepared for
Letchworth Garden City Heritage Foundation

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This report was generated using People Powered Retrofit Limited's 'Home Retrofit Planner' software. This software has been developed over the last decade specifically to support high quality retrofit assessments and options appraisals. It is used under licence by a community of practice involved in retrofit. If you would like to know more please visit retrofitplanner.app.

Contents

Introduction

Welcome to your Home Retrofit Plan

This report is the first step on your journey to transform your home into a more comfortable and sustainable place to live. It will help you understand your home's current condition, clarify your project aims, and understand the potential for improvement. It is divided into five sections:

Section 1 Summary presents our current understanding of your aims and brief, describes the logic of improvement scenarios, and highlights any key constraints and decisions.

Section 2 Scenarios outlines the potential impact of the retrofit scenarios created in this report across a range of key indicators related to comfort, carbon and cost, building from 'easy wins' to a deep retrofit.

Section 3 Retrofit suggestions presents a summary of the specific measures involved in each scenario. (Note that Appendix A provides further detail on each of the measures).

Section 4 Context and Constraints provides an overview of what you told us about your aims and basic information on the existing condition and context of your home that should be considered in planning your retrofit.

Section 5 Next Steps provides an outline of what you can do next to develop your project and how we can support you in this.

The appendices provide further detail on the recommendations in this report and useful information such as a glossary of retrofit terms and a description of the assessment methodology.

Disclaimer

This report recommends potential retrofit improvements for your home. It is intended to support the initial decision-making process for your project. We take reasonable skill and care to ensure that the information in this report is of a level of accuracy and completeness sufficient for this purpose. It is prepared for the client named on the associated contract documents. It is not intended for use by third parties without explicit agreement.

Over time the information in this report will become outdated as the condition and context of the building changes. Reports should be considered valid for a maximum of 2 years or until major works are carried out. If the context and condition of the property have changed significantly, an update may be required. In all cases information should be checked and confirmed as still relevant.

This report is not a detailed construction plan or design proposal and should not be used as such. We suggest minimum performance targets (U-values or efficiencies) so that the potential impacts shown in this report are achieved. However these should be confirmed and checked as the detailed design for your project is developed, with due consideration also given to the risks also highlighted in this report or uncovered subsequently. **All information should be checked and verified by a competent person before carrying out detailed design and construction work.**

Cost information is intended to provide high-level guidance only. Figures presented here do not include: VAT, professional or statutory fees, preliminaries, or on costs such as relocation or redecoration. They are based on average historical information gathered over a number of years. Your project might be very different to the average. **Costs can vary significantly from project to project.** This can be due to context (for example location, access and heritage requirements) and the decisions made by you (for example the level of finish required or changes to the amount of work you want). **Costs can also vary due to changes in the market** for the supply of materials and labour that are beyond our control. **These can sometimes happen quickly** and events like Brexit and the pandemic have had a big impact in recent years. **We recommend that any project budget includes a healthy contingency, so that these risks can be managed effectively.**

Our Approach

Designed for you

Home Retrofit Planner is designed to help you understand the best next steps to take - whatever your circumstances - and to plan out your full retrofit journey if you're tackling it in stages. Our advice is informed by what you told us and our assessment of your home. We use scenario-planning in our modelling tool, informed by your aims and the context, to test and suggest options for retrofit. This should enable you to evaluate their different impacts against your aims and project constraints. From simple DIY improvements to a full deep retrofit, we show you the full range of what is required to make your home 'zero carbon ready'.

Whole house (or flat)

We consider any building as a set of interacting systems that all affect its potential for retrofit. This allows us to identify how improvements can work together to create better outcomes. It also helps to reduce the risk of negative unintended consequences. We consider a broad range of factors, not just energy use, including: comfort, ventilation and indoor air quality, building condition and maintenance, aesthetics and heritage. We use a model that includes all energy uses - including appliances - not just those covered by the building regulations.

Build tight, ventilate right

Air leaking through gaps, cracks and holes is a major contributor to heat loss from homes. Draughts make people feel colder, harming comfort. Wet air leaking into cold spaces within the construction can condense and damage the building. To address this, we suggest incremental improvements through draught proofing and airtightness work. You must consider ventilation alongside this work. This is to reduce the risk of moisture and pollutants building up in the internal air which can lead to condensation, damp, mould and poor indoor air quality. Even in less airtight homes, we cannot rely on gaps and cracks or window opening (especially in winter) to provide 'fresh' air. We will always make an assessment of the existing ventilation system and may recommend improvements if appropriate.

Carbon-free heat

The biggest use of energy in most homes in the UK is heat - for space heating and hot water. This is often provided by fossil-fuel-based systems like gas boilers. We help you to plan how to make heating in your home fossil-fuel free, now or in the medium term, using existing proven technology. We do not suggest new biomass or wood based heating systems. This is because burning wood still emits carbon dioxide, with no guarantee that it will be reabsorbed by new tree growth. It also creates damaging air pollution, both inside and outside.

Balancing 'fabric-first' and heating system improvements

We usually prioritise repairs and building fabric improvements ahead of 'add ons' like solar panels. We balance this with the need to rapidly decarbonise heat. Improvements to insulation, draught proofing and ventilation are often necessary to create healthy homes. While we also recognise that the cost and disruption of deeper fabric retrofit can be daunting and may even be inappropriate in some cases.

For many homes a set of basic measures to ensure a well specified, efficient and effective heat pump is possible is a good option. We consider which of your priorities - whether carbon, comfort or running costs - are most important for you. We also consider your budget and timescales and take into account the condition of your home. We recommend a balance of fabric and heating improvements for your home based on this. We also suggest potential further improvements for you to consider in the future. We take this approach because:

1. Making sure homes are in a good state of repair before retrofit reduces the risk of unintended consequences like condensation and damp.
2. 'Fabric first' done well reduces the risk of a 'performance gap' between design expectations and built reality. This is true of energy use but also comfort and health.
3. Reducing heat loss from your home makes it easier for efficient heating systems that use lower flow temperatures to keep your home comfortable.
4. Current plans for decarbonising the national electricity grid assume significantly reduced energy demand. This is especially true at 'peak' times. This needs BOTH efficient heating systems like heat pumps AND improved insulation at a system level. What happens in each individual house will vary depending on context.

Considering 'up front' impacts

'Up front' carbon emissions are created through manufacturing materials and building work. This is sometimes also called 'embodied carbon'. By retrofitting rather than building a new home, you are already avoiding significant 'up front' carbon emissions. To minimise this further, we recommend lower impact options for retrofit measures and materials where we can (though sometimes this is limited by factors like fire safety or other materials performance factors). We also recognise that the 'up front' carbon of deep fabric retrofit, even with carefully selected materials, can take years to recover (hence the balanced approach outlined above).

'Up front' impacts aren't just about carbon and energy; factors such as deforestation, recyclability, pollution, toxicity and health effects on workers are also included. For example - chemical electrical batteries are currently carbon and material intensive to make and can be difficult to dispose of safely. At the same time, depending on exactly how they are used, they often do little to decarbonise energy in use. At present we tend to suggest lower impact energy storage measures like diverters on existing hot water storage instead (helpfully these also tend to be lower cost).

Addressing the performance gap

Too often there is a gap between expectations and reality in building projects - in both energy performance, but also in comfort or air quality and health. We aim to mitigate this in retrofit projects by making sensible assumptions in the modelling work that informs our recommendations. By following through with good design, quality assurance and proper commissioning of heating and ventilation systems in later project stages, you'll ensure your project achieves its aims.

This performance gap might also be present in your home currently, and we consider this in the recommendations we make. For example, you might be frugal with heat in your home now, meaning your energy use is lower, but it is uncomfortable. We adjust our assumptions in the baseline model and in future scenarios to account for this need for greater comfort.

Modelling transparency

Home Retrofit Planner is adapted from the UK's national calculation methodology, SAP (Standard Assessment Procedure). It makes assumptions about external climate and usage patterns that in turn affect the results produced. These assumptions are based on UK standards, published research, our experience, observations made by your assessor, or things you told us. As far as possible we state our key assumptions, so you are aware of the context in which our recommendations are made.

Home Retrofit Planner is the result of a collaborative effort over many years, with input from architects, retrofit specialists, programmers and householders like you. Our methodology is informed by standards like PAS2035 and the work of organisations like the Association of Environmentally Conscious Building (AECB) and Sustainable Traditional Buildings Alliance (STBA).

If you'd like any more information on any of the above, or have any comments, queries or suggestions, please do not hesitate to contact us.

Privacy Notice

You can find a full copy of the People Powered Retrofit's Privacy Notice at retrofit.coop/privacy-policy.

We use the Home Retrofit Planner as part of a a paid service that collects information about your home and how you use energy in it.

Much of the data collected in the course of an assessment about your home does not constitute personal data on its own, but we recognise that when it is combined with other data we may hold about you that it can constitute personal data. This information is collected for the purpose of providing you with a retrofit assessment and options report. We retain a copy of your assessment for a period of 6 years after we finish working with you in order for us to meet our contractual liabilities to you and our insurers.

Data collected through this service may be anonymised and aggregated with other personal data and used for other research or commercial purposes in pursuit of the objectives of the Society.

Section 1

Summary

1.1 Project Brief

PPR have been asked to carry out a survey and retrofit options study of a typical home in Letchworth. The aim of this work is to understand and explore what is possible in retrofitting homes in the world's first Garden City using a real world context.

1.2 Current context and logic of scenarios

The house studied is unoccupied at the moment, awaiting refurbishment works. It is very typical of some of the older homes in Letchworth in style and layout. It is 2 storeys with 3 bedrooms and an external rough render finish. It has a minimal level of existing insulation - with some loft insulation and older double-glazed windows. It has a gas based heating system with a newer boiler and many radiators have been replaced relatively recently. The main electrical installations have been kept up to date - with a relatively modern large capacity consumer unit in place, so adding a heat pump or PVs should be very possible without major electrical upgrade works.

An air pressure test (blower door test) demonstrated that the house has a reasonable level of existing airtightness with an AP50 of 6.
This is well within the current backstop for new-build building regulations. Other homes may vary, but we have found it is common for older homes to be a lot more air-tight than is often assumed - with an AP50 between 8 and 12 being typical.

The home's current space heating demand per square meter is a little above the UK average - so in its current condition it would be relatively expensive to keep warm. However as a smaller home it's total heat loss is low and it would be able to accommodate a medium-sized air source heat pump.

The scenarios in this report have been developed to test a range of options - variously prioritising carbon, comfort or cost. And also demonstrating the difference made by different thicknesses of wall insulation. This means this report covers many more scenarios than we would normally present to an individual client - but we hope the comparisons are useful.

1.3 Scenario 1: Basics

- Estimated net budget cost of this scenario £15400 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £15400 + VAT and on costs

The first scenario covers those elements of work that need to be done to make the home healthy to live in and deal with current problems. We'd assume here that repairs to guttering and rainwater pipes are all carried out as part of this work - and any other repairs that might be needed - though these are not costed.

As a first step we have assumed that basic draught-proofing measures are carried out and a better performing continuous ventilation system is fitted. This is important for the health of the building and any residents, as much as it being about energy use.

The windows are all replaced with good standard double-glazed units to meet current building regulations requirements. These would need to replicate the existing opening patterns to maintain the heritage value of the building. For heritage and environmental performance reasons timber windows may be preferable - though this is something that should be checked and may ultimately be the client's decision based on budget and availability.

Loft insulation is topped up and a new air tight and insulated loft hatch fitted.

The most disruptive element of the work suggested here is the treatment of the skeilings - the sloping ceilings at the eaves at first floor level. Currently these are totally uninsulated. they must be treated to avoid the risk of surface condensation and mould forming here, but it is also important that ventilation to the cold loft space is maintained. It might be possible for this work to be done from above if the house is being re-roofed anyway - though this can be tricky. Otherwise it must be tackled from below. Ideally this will mean removing these areas of ceiling and adding a new build up that includes insulation and full air tightness and wind tightness, while maintaining the ventilation to the loft space. A careful retrofit design including detail drawings and specification will be needed for this element to help manage risks here.

The other area of insulation we have suggested is tackled as part of this scenario is insulation to the underside of the stairs and stair wall to separate this unheated area from the rest of the house and so minimise heat loss here. Alternatively this area could be brought into the heated thermal envelope of the home.

1.4 Scenario 2: Basics + Heat Pump

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £16650 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £32050 + VAT and on costs

Once all of the above basic insulation and refurbishment works are done, the estimated peak heat load of this home has been reduced below 7kW. This means that a medium-to-small sized heat pump will be suitable - that should therefore be able to comply with the requirements for noise in both planning and the Micro generation certification Scheme (MCS) requirements. The garden is relatively generous and there should be space for the external unit. There are also several cupboards inside that home that may be able to accommodate the associated upgraded hot water storage. A heat pump specialist should be able to advise on the best approach for efficiency and ease of install.

Moving to a heat pump at this stage will make a large immediate reduction in carbon emissions from heating. This is important - if reducing carbon emissions is the main aim of retrofit work, moving to a heat pump as quickly as possible is key.

Running a well set up and efficient heat pump should cost about the same as heating a home with a gas boiler. There may even be opportunities for savings if some smart tariffs are used and the gas supply and meter is removed altogether so the standing charge for gas no longer needs to be paid. However this assumes that the home is heated to a similar degree as it was previously. If a home is only heated very sparingly at the moment - for an hour or two a day - heating costs can go up. This is because heat pumps are usually set up to heat 'long and low', providing continuous low level of heat to keep the space comfortable. This is how they work most efficiently. This can be a very good thing for the health of the home and the occupant - creating a more continuous heat and helping to keep the home warmer and drier.
If a heat pump switches on and off a lot, or is used infrequently to try and 'boost' the heat in a space

from being very cold, they will use more energy and so cost more to run.
To tackle running costs where the budget for fuel bills is limited, other steps may be needed.

1.5 Scenario 3: Basics + Heat Pump + Solar

- **This scenario assumes the measures in scenario 2 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £9000 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £41050 + VAT and on costs

In this scenario a solar panel system is added to the rear south-ish facing roof. Adding a solar panel system to the above set up has a significant impact on running costs - especially as the heat pump may be able to make use of the solar electricity generated on site. In some cases this may help offset the cost of running a heat pump for longer.

Adding a battery to this set up may provide some further running costs savings by enabling more of the electricity generated to be used on site - though it would also increase capital costs and up front environmental impacts.

Adding solar to individual homes also has the benefit of supporting the decarbonisation of the electricity grid. It is best thought of at this level, rather than being about turning this home into an 'energy island'.

1.7 Scenario 5: Walls B - Standard IWI

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £23750 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £39150 + VAT and on costs

This scenario is almost exactly the same as the one above, but with a thicker layer of internal wall insulation assumed - at around 80mm depending on the material chosen. This may be trickier to accommodate in some places - like the stairs or around the front door - some in some areas insulation may be reduced. This is accounted for in assumptions about thermal bridging - though in reality may be slightly better or worse than this depending on the decisions made at detailed design stage.

Note that the amount of insulation here does not quite meet the building regulations target of 0.3W/m2.K, but is within the threshold value of 0.7W/m2.K. This is deliberate - increasing the thickness of internal wall insulation makes the existing walls colder, increasing moisture risks and potential damage to the wall and any timbers within it. 0.4W/m2.K is about as far as we would ever recommend going with internal wall insulation - though even then careful detailing and potential further analysis and testing should be considered.

The condition of the external face of the wall is important in all types of internal wall insulation. The render on the outside face in this case needs to be sound and in good condition - and ideally of a type that will allow the wall to dry to the outside, creating a moisture balanced construction.

1.8 Scenario 6: Walls C - Thin EWI

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £19500 + VAT and on costs

- Estimated net budget cost of all works to this point **where scenarios are additive**: £34900 + VAT and on costs

As an alternative approach, where there is a desire to avoid internal disruption and redecoration, external wall insulation is a possibility.

In this scenario we have applied a thin layer of external wall insulation - of around 20-40mm thick, depending on the material used. Most practically this would be in place of the existing external render - so might be a job that is done when this render comes to the end of its functional life. An insulating lime-based render could be applied, to a similar depth as the existing render. This would mean minimal external changes in appearance - but also minimal need to make adjustments to drainage, roofline and window cills etc to accommodate the insulation without causing detailing problems or damage. Using a lime-based material should result in a moisture-balanced structure that is able to dry out and manage moisture - minimising risks. (Note that it would also be possible to add this external insulation if the internal insulation had already been done earlier or was planned for a future phase of works - it would simply result in a slightly better overall performance. Though obviously overall costs would also be higher, if the render needed to be replaced anyway, the extra/over cost would be limited).

We have also assumed some perimeter insulation to the solid ground floor here - as part of the EWI works.

This insulation cuts heat loss through the external walls by just over half - the same as the thin layer of internal wall insulation. It will require scaffold and requires some careful detailing at the eaves to make sure airtightness and insulation is continuous here. It is likely to be slightly more costly than internal wall insulation - though it creates much less need for finishing and changes to fixtures internally, so overall costs may be similar. It would almost always all be done in one go - vs the room by room approach that is possible with internal wall insulation.

1.9 Scenario 7: Walls D - Standard EWI

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £24550 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £39950 + VAT and on costs

This scenario simply increases the thickness of the external wall insulation to the point where it meets the building regulations target for solid walls - a thickness of around 80-100mm, depending on the materials used. It cuts heat loss further - to around 20% of the heat loss of the original wall. This should make a significant difference to comfort and space heating energy demand - but it makes a more marginal difference to overall energy use and peak heat load. It will cost more and will be more complicated to detail well. Adjustments will need to be made to drainage, window cills and reveals and also at the roofline - though at this thickness it might just sneak in below the roof overhang on this home, it will change the appearance.

We have also assumed some perimeter insulation to the solid ground floor here - as part of the EWI works.

In an older solid wall construction like this we would recommend the use of moisture-balancing materials and avoid the use of impermeable plastic foam insulation boards. This is so that the walls can still dry to the outside - though it may also have the benefit of reducing up front environmental impacts by avoiding petrochemical-based insulation.

1.10 Scenario 8: Walls E - Thick EWI

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £26550 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £41950 + VAT and on costs

This scenario considers the impact of a very thick layer of external wall insulation of around 200mm (assuming a moisture-balancing material). This will require major changes to drainage and detailing around openings, and is also likely to require changes to the roofline on the building. In a heritage property this may not be acceptable.

We have also assumed some perimeter insulation to the solid ground floor here - as part of the EWI works.

What is also noticeable is that the gains from this extra thickness of insulation are marginal when compared with a more standard amount of insulation - peak heat load is reduced by 0.2kW as against the previous scenario.

1.11 Scenario 9: Everything - Standard IWI + Heat Pump + Solar

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £49550 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £64950 + VAT and on costs

What is noticeable about all of the scenarios above that add insulation to the walls is that while running costs decrease, and comfort is also likely to increase, the impact on carbon emissions is much less than with a set of very basic fabric measures plus a heat pump (assuming similar heating patterns and standard tariffs).

What will probably therefore make sense for many homes is to combine these measures to achieve the full benefits of carbon emissions reduction, cost reductions, and comfort improvements. This scenario sets out once such approach - adding internal wall insulation to basic improvements and a heat pump and PV. If it made sense given context, budgets and planned maintenance it would be equally possible to combine a change of heating system with external wall insulation or internal wall insulation of varying thicknesses. What route as best for a given house may depend on the project management resources and budget available.

1.12 Scenario 10: Everything!

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £77750 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £93150 + VAT and on costs

This scenario turns everything up to 11.
It keeps the standard amount of internal wall insulation, but swaps out the extract ventilation system for a mechanical ventilation with heat recovery ventilation system, hits a more stretching air tightness target, and goes for triple glazed rather than double-glazed windows. It also replaces the entire ground floor with a new insulated solid ground floor.

This comes close to doubling the cost of the works, whilst producing only marginal improvements in total energy use and heat loss. If you were aiming for a specific standard and wanted to maximise comfort and minimise energy use - and had the budget and time to carry out this work - it may still be worthwhile.

It's also worth noting that with the possible exception of the triple-glazed windows, these works could all be done in accordance with the current Design Principles.

1.6 Scenario 4: Walls A - Thin IWI

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £19750 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £35150 + VAT and on costs

As an alternative approach to changing the energy system in a home, this scenario treats the remaining biggest areas of heat loss after the basic fabric works have been done - the walls.

We have added a minimal amount of internal wall insulation to the inside face of all external walls. This usually involves adding either a lime-based insulating plaster or a woodfibre board and lime plaster within approximately the same thickness as the existing plaster - between 20 and 40mm depending on the material. On a home of this age with solid walls we would not recommend using plastic foam-based insulation, as this is liable to interfere with moisture management within the wall and may introduce risks, especially where moisture may be trapped around joist ends to floors. We would also not recommend the use of insulating plasterboard or 'dot and dab' systems as these tend to be quite poor for airtightness and thermal bypass (air movement behind the insulation that reduces its effectiveness). Wet-plaster based systems or those that include a full airtightness membrane as part of their build up are much more reliable and help to avoid the performance gap often seen in retrofitted buildings.

Adding internal wall insulation would mean quite a lot of disruption, but would be relatively simple to accommodate in the space available. It could be done all at once - as is likely in this house - or room by room as you redecorated/ refurbished. Alongside the internal wall insulation we have assumed that the suspended timber floor in the two downstairs living rooms is also lifted and insulated.

Adding even just this minimal amount of insulation cuts the heat loss from the walls by more than half. It cuts the overall peak heat load to below 4kW, as well as reducing the space heating demand below the UK average. It should also mean that the surface temperature of the walls is raised internally - improving comfort and reducing the risk of surface condensation and mould growth. Improving ventilation to more effectively remove moisture from the home and increasing heating would also reduce this risk.

1.13 Key decisions to be made, risks and constraints, and areas for further investigation and development

In this particular home there are some maintenance issues that should be addressed before any major retrofit works are carried out - and the first set of measures should be about making what are really basic improvements to the health of the building - replacing failed drainage goods and windows and improving the ventilation system throughout. This work really needs to be done anyway.

In going beyond that, it is really a question of priorities and budgets. To make the biggest impact on carbon then the heating system should be swapped out for a heat pump that doesn't run on fossil gas. In doing this affordability also needs to be a consideration, so a combination of some further fabric works and energy generation and potentially also storage may be beneficial. Some of those fabric works could and perhaps should be integrated with general maintenance that will be needed in future - for example when it comes time to renew the external render, or when individual rooms are being redecorated internally.

What's possible will depend on budget and what level of disruption is acceptable. In this home, as it is currently unoccupied, a high level of disruption may be possible. But in other homes, it may be necessary to take a different approach - integrating works with maintenance and other home improvements. .

Section 2

Scenarios

We show the extent to which your home could be improved by comparing the retrofit scenarios developed for your home below. These respond to your brief, the context of your home and the project constraints, and our judgement on what measures would work well together and address your priorities. The scenarios are intended to show you a pathway to achieve significant improvements using technologies and techniques that are available now.

We have modelled the following scenarios for your home:

Scenario 1	Basics
Scenario 2	Basics + Heat Pump
Scenario 3	Basics + Heat Pump + Solar
Scenario 5	Walls B - Standard IWI
Scenario 6	Walls C - Thin EWI
Scenario 7	Walls D - Standard EWI
Scenario 8	Walls E - Thick EWI
Scenario 9	Everything - Standard IWI + Heat Pump + Solar
Scenario 10	Everything!
Scenario 4	Walls A - Thin IWI

We model your home based on the data taken by the assessor on the day of their visit. We then modify this base model to test the effect of the measures proposed in each scenario. We also benchmark results against current UK averages and suggested 'zero carbon ready' targets. Where you have provided fuel bill information we have also compared them with your current energy use.

2.1 Improving Comfort

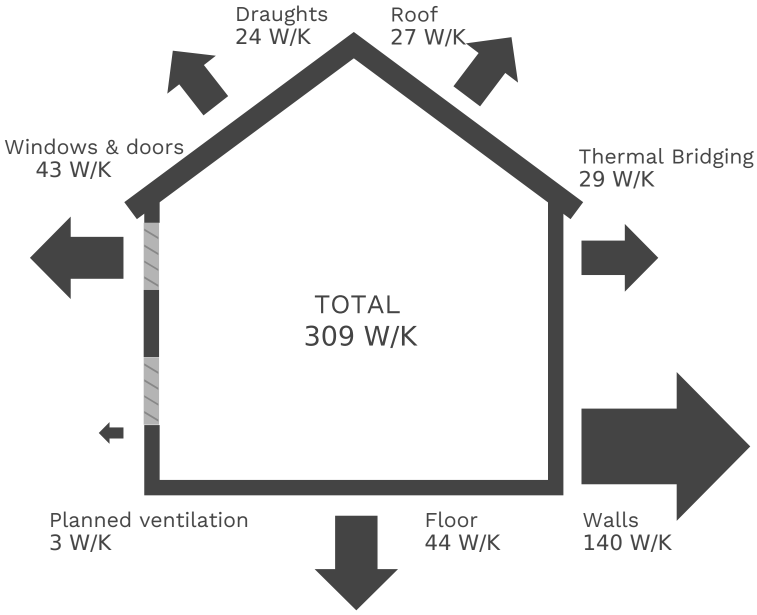
2.1.1 Heat loss

When it is colder outside, your home continuously loses heat through the walls, floor, roof and windows to the external environment. Your home also loses heat through draughts and ventilation. Warm air leaves your home through gaps in the building fabric – or intentionally through windows or fans.

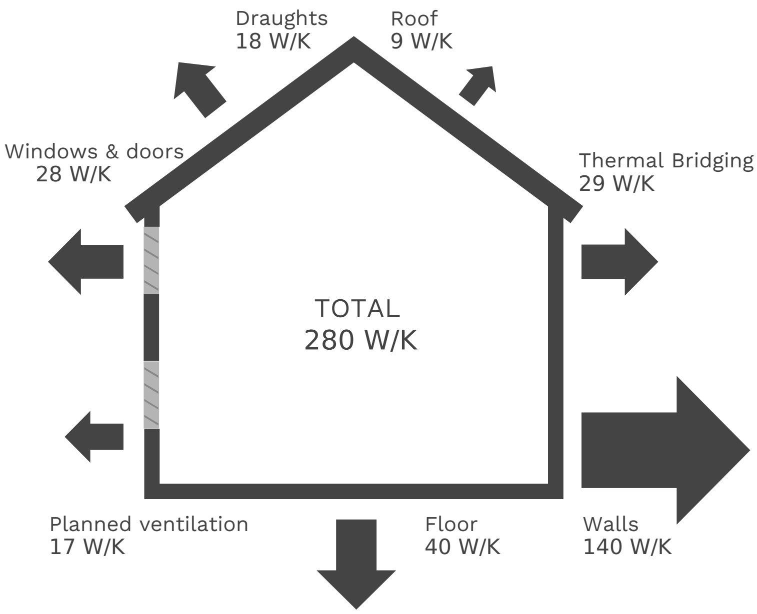
The better insulated and draughtproofed your home, the slower this heat loss happens, so the less energy is needed to keep your home warm and the more comfortable it will be. The figure below compares the relative heat loss of each element across your home now and in the retrofit scenarios we have developed for you. It is measured in watts per degree kelvin (W/K). This is the rate of heat loss for every degree of temperature difference between inside and outside, and is sometimes also known as the 'heat transfer coefficient'.

Figure 1. Heat Loss Summary

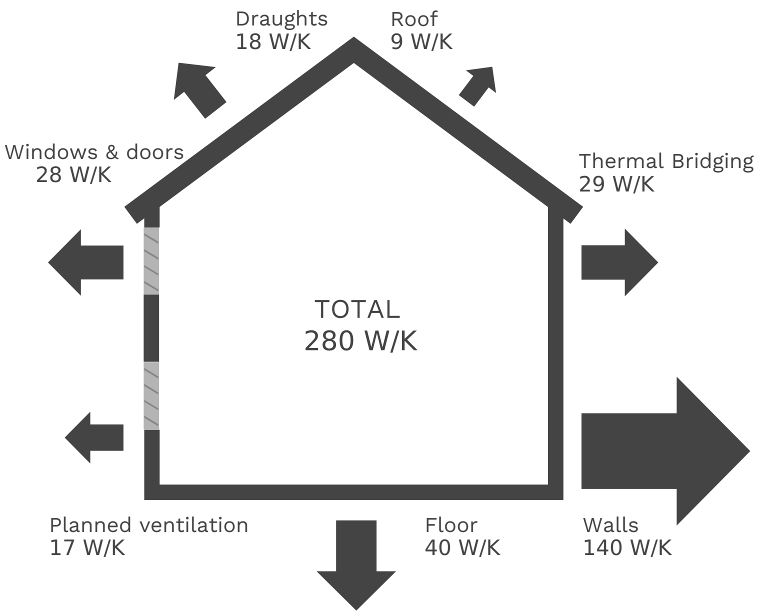
Baseline (Your Home Now)



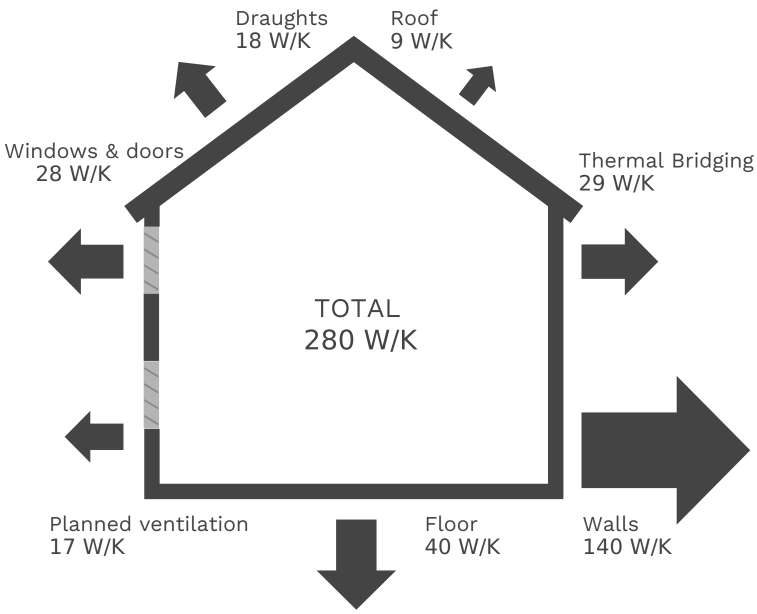
Scenario 1: Basics



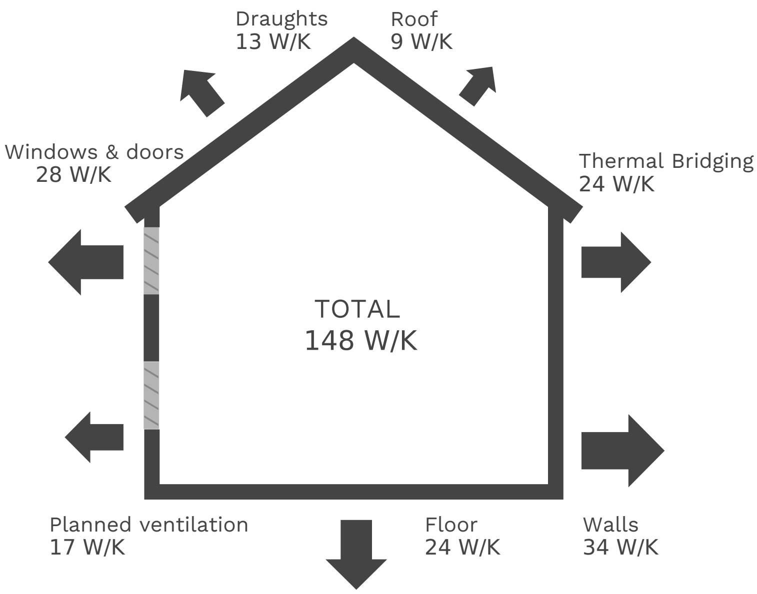
Scenario 2: Basics + Heat Pump



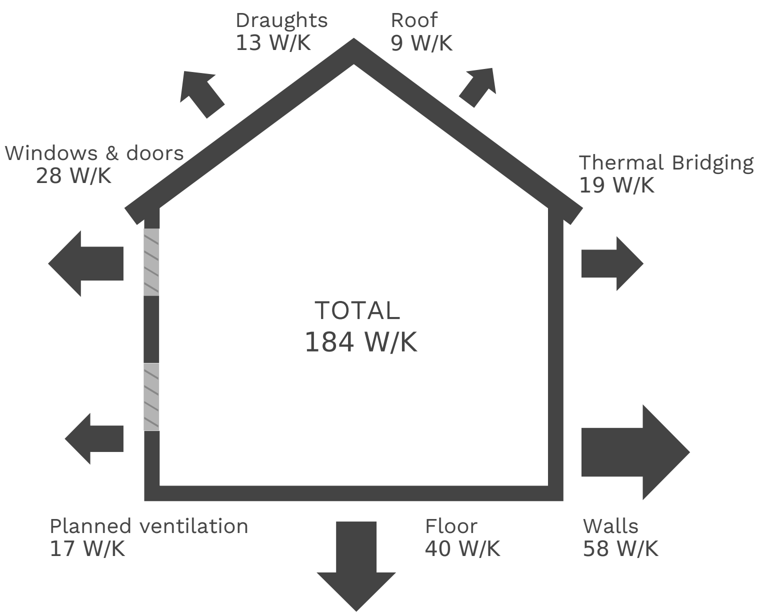
Scenario 3: Basics + Heat Pump + Solar



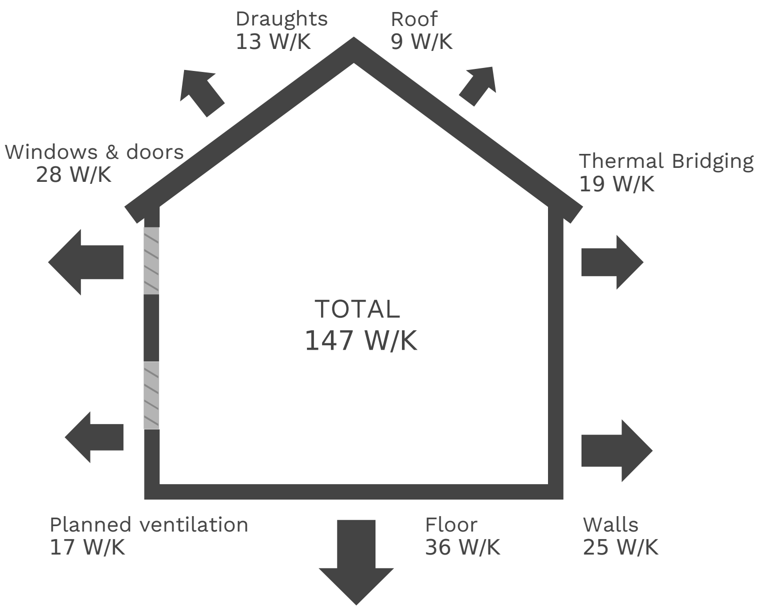
Scenario 5: Walls B - Standard IWI



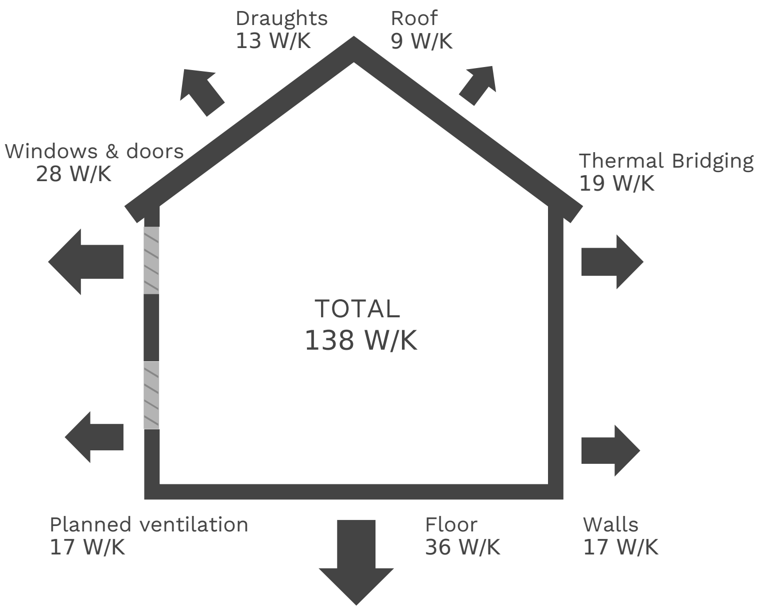
Scenario 6: Walls C - Thin EWI



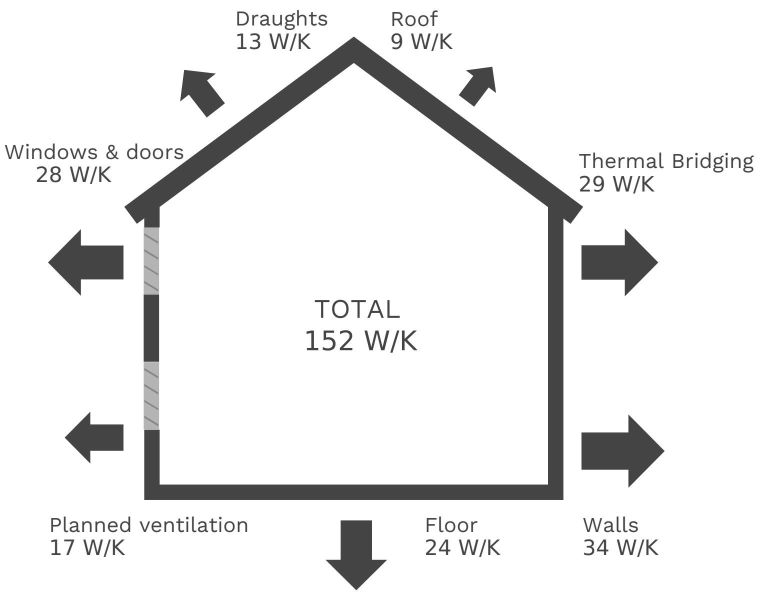
Scenario 7: Walls D - Standard EWI



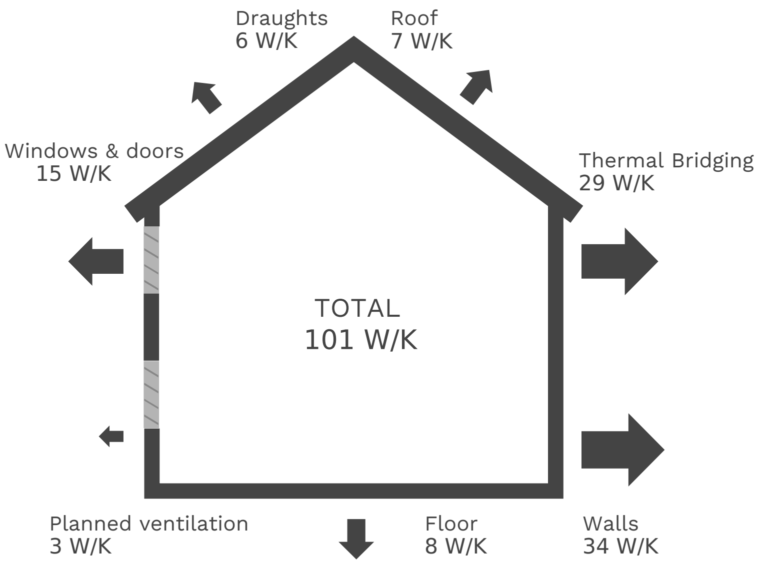
Scenario 8: Walls E - Thick EWI



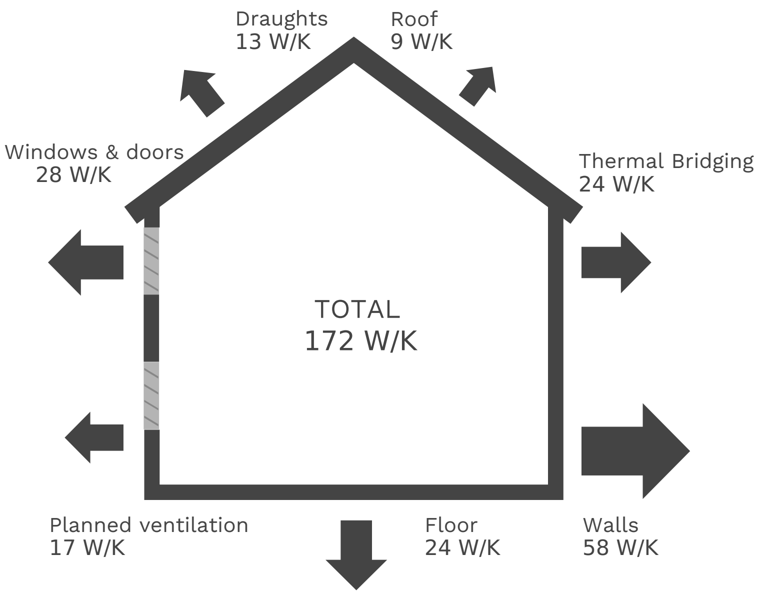
Scenario 9: Everything - Standard IWI + Heat Pump + Solar



Scenario 10: Everything!



Scenario 4: Walls A - Thin IWI



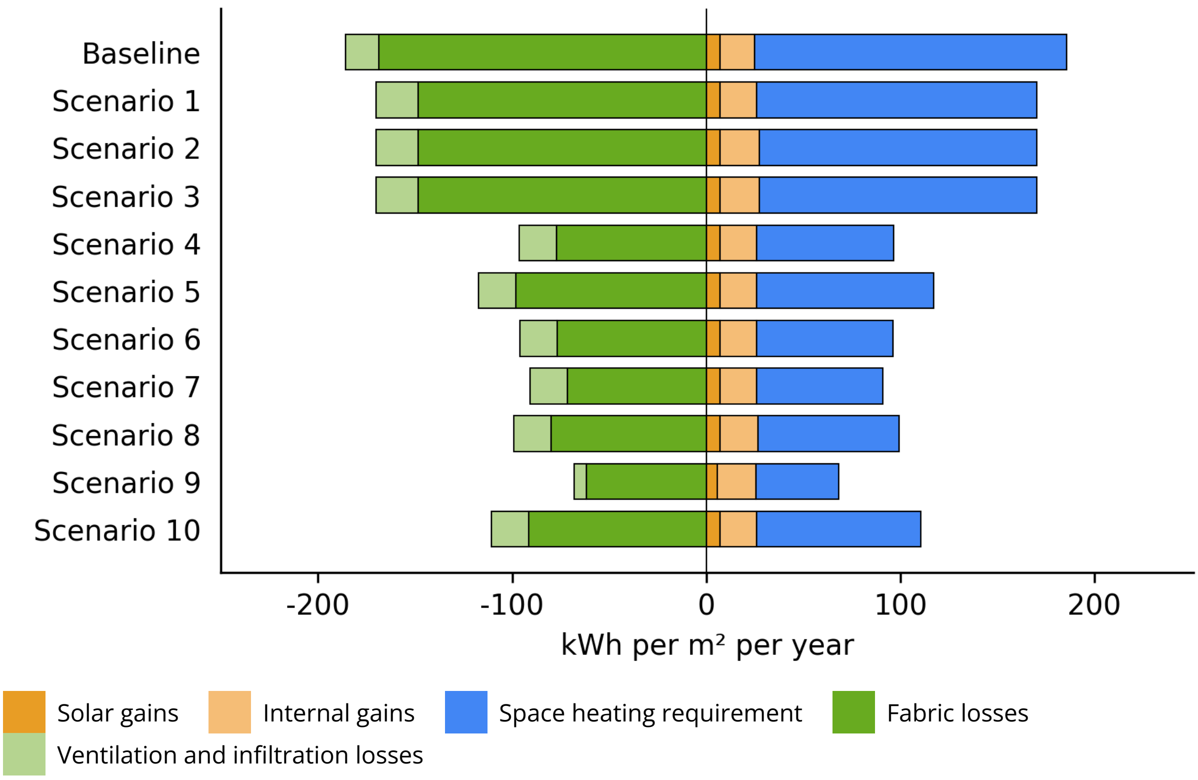
2.1.2 Heat balance

Heat losses are balanced by the heat generated by you and activities in your home, such as cooking or using appliances - known as 'internal gains'. In our assessment, we take a note of the appliances in your home and the actual number of people living there, so we can be more accurate in assessing this and avoid over-estimating the contribution made by these gains.

Heat is also typically topped up by sunlight entering your home – known as 'solar gain'.

The absolute contribution that both solar and internal gains make to heating your home will go down as you make improvements. This is because more efficient appliances, lighting and hot water systems reduce internal gains and better windows reduce the amount of solar gain. However, as you improve the rest of the fabric, the proportion that both of these contribute may go up, reducing the energy needed from your home's heating system to keep warm. It's also important to not rely too much on solar gains because large areas of unshaded south, east or west facing glazing can cause overheating in summer, which is uncomfortable and harmful to the health.

Figure 2. Your home's heat balance (kWh/m²·year)



The bars to the right of the 0 line are gains; the bars to the left of the 0 are losses.

2.1.3 Space Heating Demand

The gap between heat losses and heat gains in your home needs to be bridged by your heating system. The amount of energy needed to do this is known as 'Space Heating Demand'. This is measured in kilowatt-hours per square metre of floor area per year (kWh/m^2·year). This takes into account the heat losses and gains described above but is also affected by your heating controls, how long you heat your home for, and the target temperature (room thermostat setting).

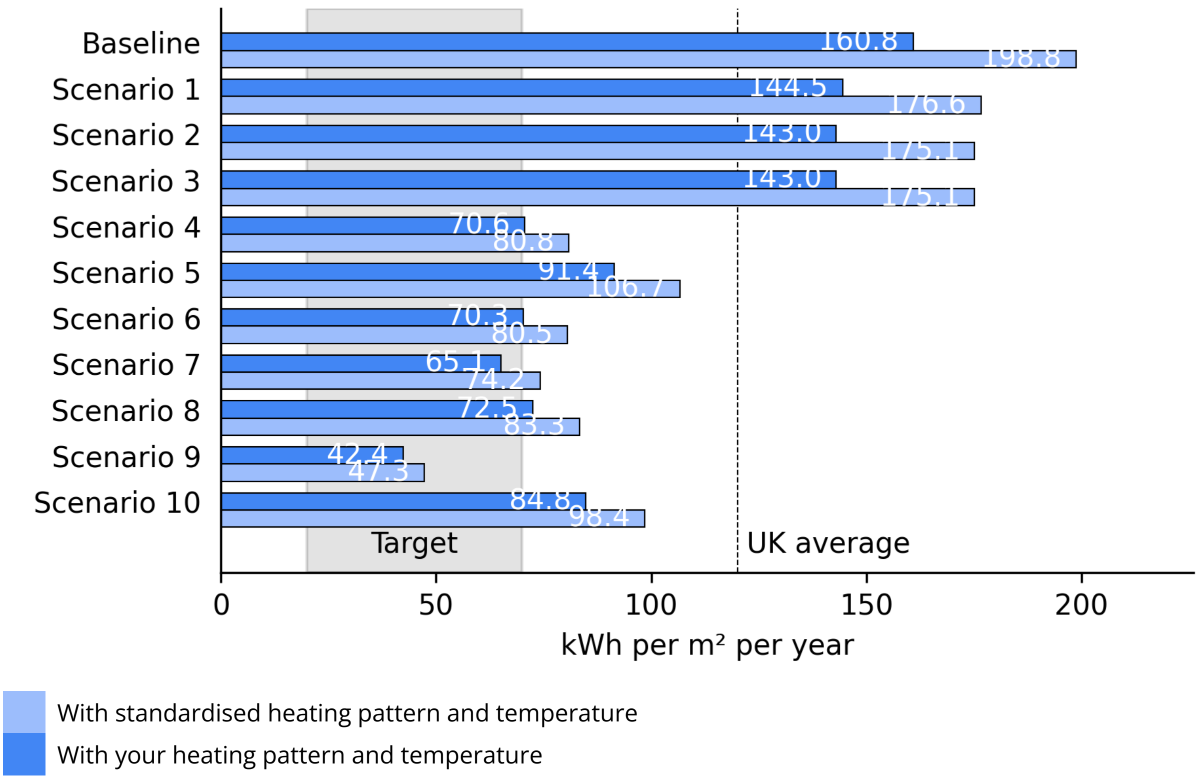
Space Heating Demand is affected by the shape of your home. If your home is complicated or has a large exposed surface area compared to its floor area (known as 'form factor'), it will need more energy to heat it than a simpler building with less exposed area of the same size, even if they are built with similar materials and levels of insulation.

The graph below shows Space Heating Demand in your home compared to the suggested retrofit scenarios. This is benchmarked against the UK average for all homes and a suggested target range that should achieve good comfort and reduced running costs and carbon emissions.

We show two versions of Space Heating Demand in the graph. The first reflects how you told us you heat your home now, using your current target temperature (if applicable) and hours of heating. The second assumes a standardised heating pattern.

You might notice that, especially in earlier scenarios and the baseline, the standardised heating pattern version results in greater Space Heating Demand. This may illustrate a 'comfort gap' - with the standardised pattern demonstrating the energy needed to keep your home at a more comfortable and stable temperature.

Figure 3. Space heating demand (kWh/m²·year)



Key assumptions

- Climate Region: Thames

	Target	Weekday heating total	Weekend heating total
Baseline	20°C	24.0 hours	24.0 hours
Scenario 1	20°C	24.0 hours	24.0 hours
Scenario 2	20°C	24.0 hours	24.0 hours
Scenario 3	20°C	24.0 hours	24.0 hours
Scenario 5	20°C	24.0 hours	24.0 hours
Scenario 6	20°C	24.0 hours	24.0 hours
Scenario 7	20°C	24.0 hours	24.0 hours
Scenario 8	20°C	24.0 hours	24.0 hours
Scenario 9	20°C	24.0 hours	24.0 hours
Scenario 10	20°C	24.0 hours	24.0 hours
Scenario 4	20°C	24.0 hours	24.0 hours

Standardised heating assumes a constant internal temperature of 20°C.

If your current thermostat setting is below 18°C, we usually increase it in the retrofit scenarios to 18°C as a minimum, and to 20°C in deeper retrofit scenarios. We do this because 18°C is generally recommended as a healthy minimum temperature (World Health Organisation).

By taking this approach the scenarios assume that some 'comfort take back' is likely to occur - and so minimise the risk of an energy performance gap. You could of course choose to improve your home's fabric efficiency and keep your thermostat setting low. This might produce greater energy savings, but you should be mindful that there may be consequences for your health and comfort. It may also increase the risk of condensation and mould within your home.

2.2 Decarbonising Heat

2.2.1 Peak Heat Load

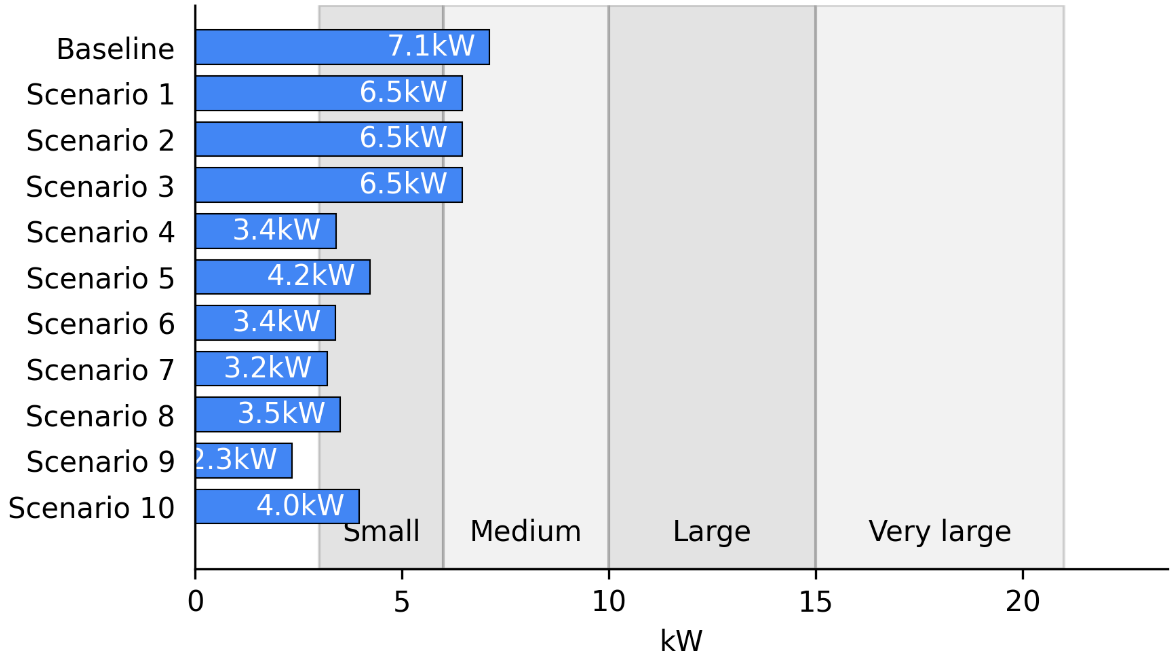
Peak heat load is an indicator of the heating power needed to maintain a comfortable temperature in your home on the coldest days of the year. It is important because it should be used to inform the design of your space heating system. An oversized heating system, capable of providing more heat than you need, will be inefficient. In contrast, an under-sized heating system will struggle to keep your home warm.

A lower peak heating load is a very positive thing. As well as reducing the total amount of energy you need for space heating, it also means that you can achieve a comfortable temperature in your home with a system that runs at a lower temperature (assuming your radiators or other heat emitters are suitably sized). This will improve the efficiency of a condensing boiler system or a heat pump-based system. A lower peak load means that your home will retain heat for longer, so it matters less when you add heat. This makes it more possible to treat your home as a heat battery, enabling you to more easily make use of lower cost or lower carbon electricity at different times of day.

If your heating system is electrically powered, there are also implications for the capacity of the grid connection for your home. If too much heat is needed, it may not be possible to supply this from a normal domestic single phase connection, especially alongside other uses like electric vehicles. This is something that should be checked in the design phase for your project.

The figure provided here is approximate and intended to be used only as a rough guide. If you are planning to install a new heating system your designer should carry out a detailed room-by-room heat loss calculation to more accurately inform the size of the heat source needed and the size of the radiators or other heat emitters.

Figure 4. Peak heat load



'Small', 'medium', etc refer to approximate heat pump size required.

Peak heat load per square metre

Baseline	75.0 W/m²
Scenario 1	68.0 W/m²
Scenario 2	68.0 W/m²
Scenario 3	68.0 W/m²
Scenario 5	36.0 W/m²
Scenario 6	44.0 W/m²
Scenario 7	36.0 W/m²
Scenario 8	33.0 W/m²
Scenario 9	37.0 W/m²
Scenario 10	24.0 W/m²
Scenario 4	42.0 W/m²

Key assumptions

- Lowest external temperature (design temp) assumed to be -3°C
- Internal target design temp assumed to be 20°C

Changing heating temperatures and patterns

Heat pumps and condensing boilers are most efficient when the temperature of water they supply to radiators is low. A design flow temperature of around 40-45°C when it is -3°C outside is often the lowest practical temperature achievable in retrofit. If you can go lower, they will be even more efficient. Temperatures for underfloor heating temperatures can be even lower. Weather compensating controls allow this to reduce when it is warmer outside, so the system can run most efficiently.

Existing fossil fuel systems often run at flow temperatures of 65-75°C. For condensing boilers, which have been the norm since the mid 2000s, this means that they will never reach the 90%+ efficiency for space heating claimed by manufacturer's performance data.

For both fossil fuel and heat pump based systems, there are big advantages to adjusting the flow temperature downwards. The improved efficiency savings should result in lower energy use, carbon emissions and running costs.

However, radiators running at lower temperature emit significantly less heat; for instance, a radiator at 45°C emits about one third of the heat of a radiator at 75°C. This means you may need to upgrade your radiators to more modern or larger versions to provide enough heat for each room in your home to stay warm.

In extreme cases, radiators may need to be impractically large. This may make better insulation even more worthwhile so that smaller radiators can be fitted. It is also worth thinking of this as you plan and phase your works. For example, if you are insulating a suspended timber floor, it might make sense to upgrade radiators and pipework at the same time. This would make use of the access provided by lifting floorboards.

As well as some radiators needing to be bigger, it may also be necessary to run your heating for longer periods. This is because warming up a space can take longer with cooler radiators. Both heat pumps and condensing boilers are more efficient when they are on for longer periods instead of switching on and off frequently (this is called cycling).

This points to a change in heating culture. We are used to having the heating on for a few hours in the morning and a few hours in the evening. Instead, a heating pattern that has been dubbed 'low and slow' can often be more efficient. This also tends to assume that most of the home is heated, with limited zoning. For this to work well, there needs to be a good balance between heat output, fabric efficiency and heating patterns. If your running costs are high, keeping control by only running the heating for short fixed periods, or only heating a few rooms, can also make sense.

Heat Pumps

Heat pumps, just like boilers, come in a variety of sizes. Even if your home has high heat losses, it may still be possible to fit a heat pump; the heat pump will just need to be big enough to match the heat demand. The radiators (or other emitters) associated with it will also need to be big enough to keep your home comfortable. Larger heat pumps in homes with higher heat demand will use more energy and will cost more to run and may cost slightly more to install. This is because the parts may cost marginally more but also because you’re more likely to have to change more radiators and pipework.

A limiting factor on the suitability of a heat pump may be your home’s connection to the electricity grid. This should only be the case in large and very poorly insulated homes or in some isolated locations. There might also be restrictions in the amount of space you have available for the external part of the unit. Noise can also be a limitation if your heat pump is close to living spaces and neighbours.

If designed, installed, and commissioned correctly so it operates efficiently, a heat pump should cost about the same to run as a mains gas boiler. If your priority is to reduce carbon emissions, then just replacing your current fossil fuel system with a heat pump will make a big difference. If your home is already reasonably well insulated and you don’t plan to do much more to the fabric this can be a good solution.

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

Making fabric improvements will reduce the amount of heat you need, and so reduce the size of the heating system. This should mean it costs less to install and to run and your home will be more comfortable.

For all these reasons, we usually recommend that you aim for your home to have a peak heat load of less than 10kW, or preferably around 5kW or less. This should enable you to fit a reasonably sized heat pump and also mean you're making a contribution to a more robust energy system.

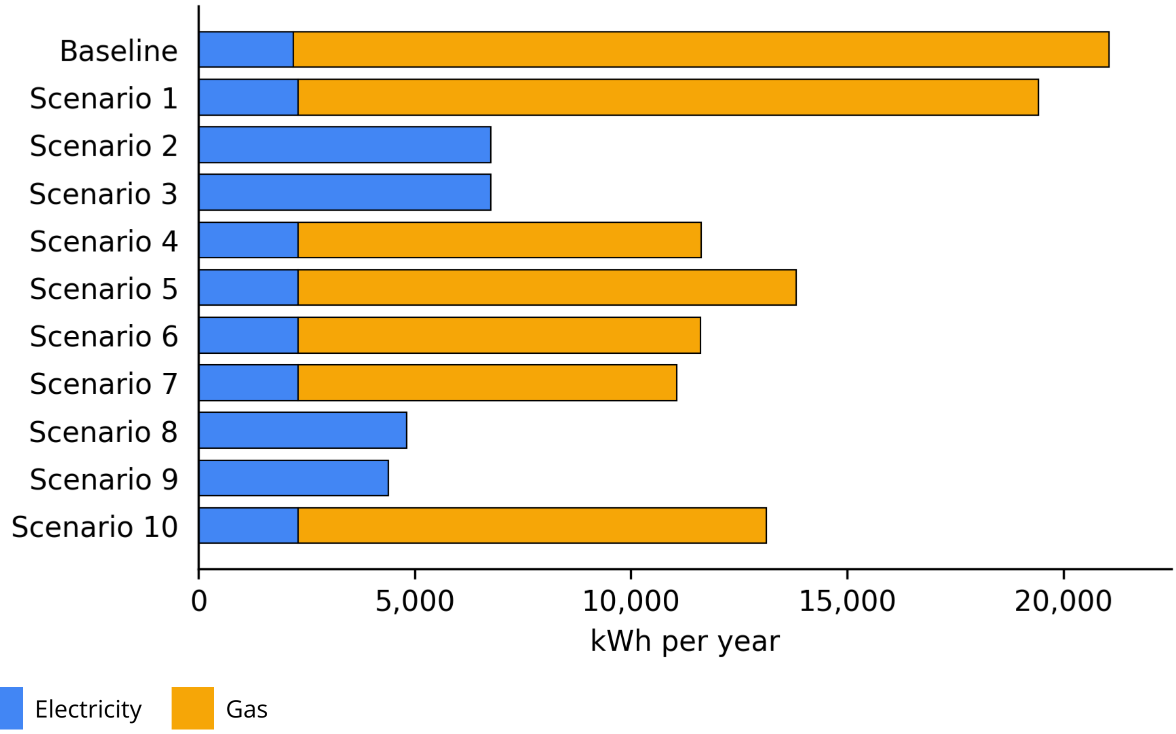
2.2.2 Fuel Mix

The graph below shows the fuel mix for your home in the existing condition and in the retrofit scenarios developed. To make our homes zero carbon we need to stop burning fossil fuels like coal, gas and oil - but also biomass and wood as these also emit carbon dioxide and harmful pollution.

As the national grid decarbonises it becomes possible to consider electricity as a low-carbon fuel. In 2015 electricity was twice as carbon intensive as natural gas. It now produces a similar amount of carbon dioxide per kilowatt hour (kWh). Electricity will continue to improve as more renewable energy capacity is installed. In contrast, fossil fuels like natural gas will remain as carbon intensive as they are now.

Removing fossil or solid fuel heating systems is often easier to do once demand has been reduced. This is because you need less energy overall and so can use a more expensive fuel like electricity but still affordably heat your home, because the total amount you need has been reduced.

Figure 5. Fuel use in your home (kWh/year)



Key assumptions

The current energy use figures here are based on information you provided to us.

2.3 Improving Efficiency

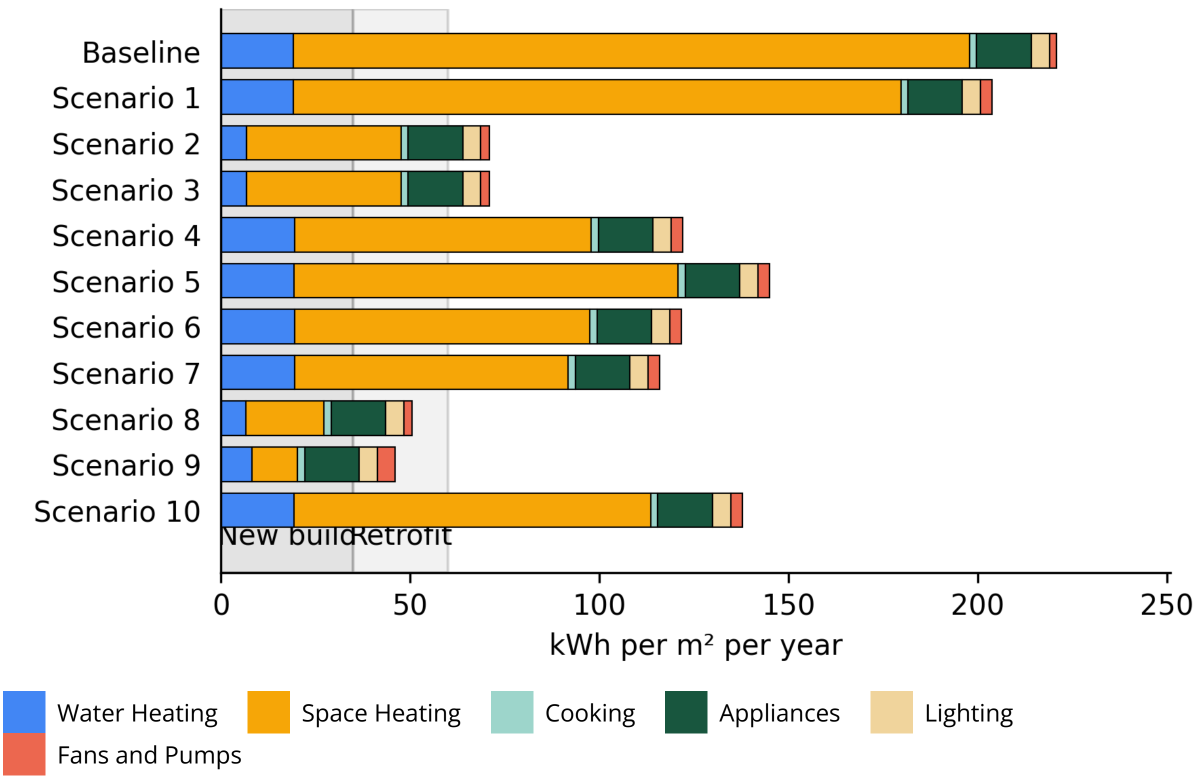
2.3.1 Energy Use Intensity

Energy Use Intensity is a measure of the total energy used in your home in kilowatt hours, divided by the floor area of your home (kWh/m²·year). It includes all uses: space heating, hot water, fans and pumps, lighting, appliances and cooking.

We have shown this for your home as modelled as it exists now and for the suggested future scenarios. We have compared this against current energy use from your bills or monitoring where available. To make your home 'zero carbon ready' this figure should be as low as possible - we've benchmarked your home against the LETI 'zero carbon' target below.

We have also shown the proportion of energy by end use (as assumed in the model) by providing a stacked bar chart. This should help you to understand what the biggest uses are and how this might change in the future scenarios. We are not able to provide accurate information about different end uses from your bill data, so this is shown as a single block.

Figure 6. Energy Use Intensity (kWh/m²·year)



Key assumptions

The two target zones are the LETI retrofit standard and the LETI newbuild standard - from [the LETI Retrofit Guide] and [the Climate Emergency Design Guide].

If you have an electric vehicle that you charge at home, we will seek to omit this from the above figures, so that they only relate to household energy use and not transport.

2.4 Reducing carbon dioxide emissions

It is difficult to be certain of the carbon emissions that result from energy use in our homes. This is because it depends upon the generation energy mix in the national grid. This mix changes hourly, daily and seasonally and is also changing over time, as more renewable generation is added. This is one of the reasons why we concentrate in this report on the energy use that is directly measurable in your home. However, we understand that it may be both useful and interesting to have some idea of the carbon emissions that result from energy use in your home.

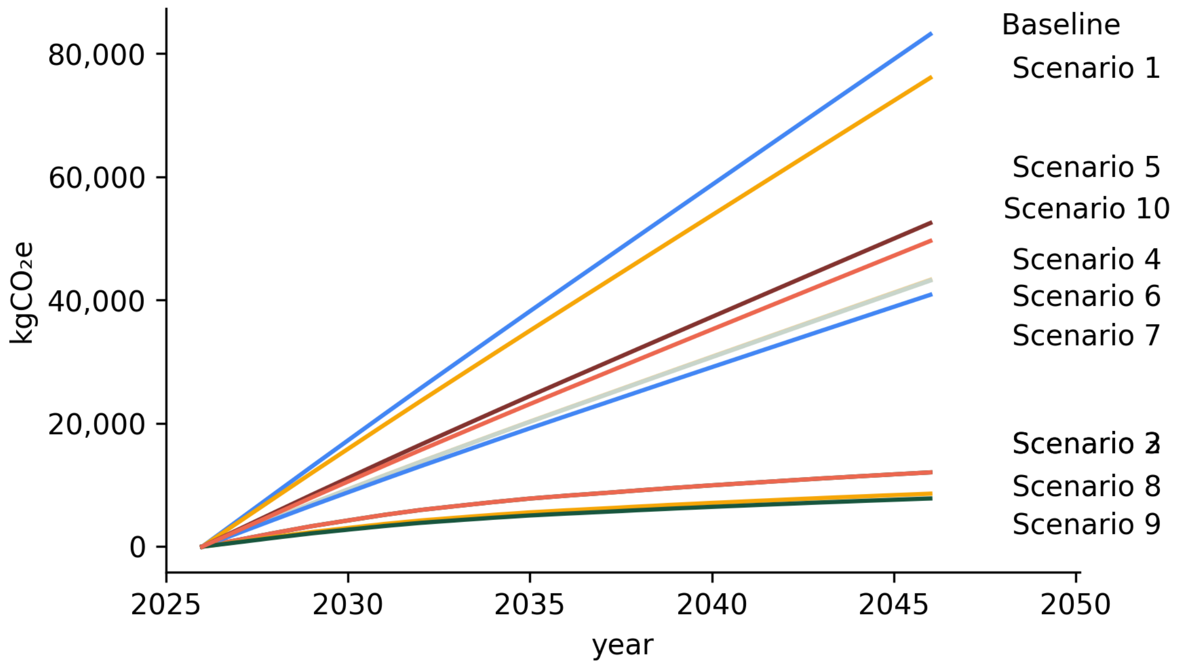
By applying an average 'carbon factor' to each of the fuels used in your home, we estimate that your home-related carbon emissions are:

	Whole home	**Per person**
Baseline	4259 kgCO2e/year	1582 kgCO2e/year
Scenario 1	3910 kgCO2e/year	1453 kgCO2e/year
Scenario 2	919 kgCO2e/year	342 kgCO2e/year
Scenario 3	447 kgCO2e/year	166 kgCO2e/year
Scenario 5	2272 kgCO2e/year	844 kgCO2e/year
Scenario 6	2733 kgCO2e/year	1015 kgCO2e/year
Scenario 7	2266 kgCO2e/year	842 kgCO2e/year
Scenario 8	2151 kgCO2e/year	799 kgCO2e/year
Scenario 9	183 kgCO2e/year	68 kgCO2e/year
Scenario 10	124 kgCO2e/year	46 kgCO2e/year
Scenario 4	2587 kgCO2e/year	961 kgCO2e/year

The figures above assume you have 2.7 people living in your home.

The graph below shows the approximate cumulative carbon dioxide emissions from the fuel used in your home over 20 years so you can see the impact of the improvements in each scenario over time.

Figure 7: Cumulative carbon dioxide emissions



Key assumptions

The carbon intensity of fuels used is measured in kilograms of carbon dioxide equivalent per kilowatt hour of fuel used ($kgCO_2e/kWh$). We base this on a projected future average over the next 15 years that is published by the government. This provides a better understanding of the impact over time, rather than just a snapshot of the situation now.

We have assumed the following carbon intensities:

- Mains Gas: 0.21 $kgCO_2e/kWh$

For electricity use, we use a year-by-year forecast of the carbon intensity of the grid, provided by NESO, the national energy system operator. This accounts for the expected decarbonisation of the electricty system in the coming years.

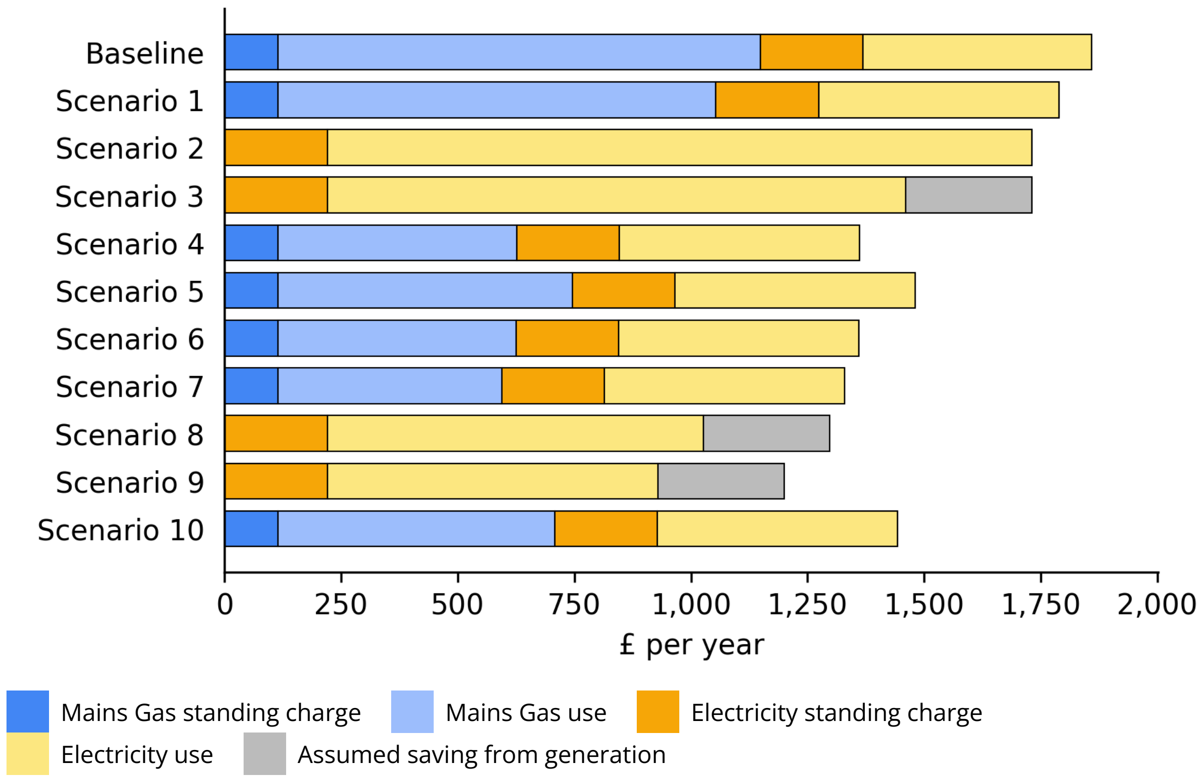
Note that any electricity generated in the home, such as solar panels, is counted with the same intensity as grid electricity. This is because the grid carbon intensity is whole-system and so already includes the effect of home PV panels, so using a different value would be counting its effect twice.

2.5 Reducing Running Costs

Reducing the amount of energy you need to run your home can reduce the amount you spend on fuel. This will be affected by the thermal performance of the building fabric, the efficiency of services, your patterns of use, the type of fuel and your tariff. Improvements to building fabric and services may reduce these costs – or at least improve comfort, whilst not increasing costs. If fuel prices are rising significantly, you may find that retrofit work just helps to reduce the impact of fuel price inflation, so your running costs rise more slowly or to a lesser extent, rather than actually reducing.

The graph below shows the estimated annual cost of fuel for your home now and your retrofitted home as modelled. It also shows your current annual energy costs from bill data, if you provided this. We have used standard fuel unit costs per kWh, based on current national averages. This allows clearer comparison across scenarios and time, rather than being reliant on short-term offers from energy companies or seasonal variations in the unit cost of energy.

Figure 8: Estimated Fuel Costs (£/year)



Key assumptions

Models work on assumptions and there are many reasons why your actual current and future energy use may be different to what is shown above. See the introduction to this report and the methodology section in the appendix for more information.

Fuel costs

- Fuel Type 1: Mains Gas, £0.05/kWh, standing charge £115.0
- Fuel Type 2: Standard Tariff, £0.22/kWh, standing charge £220.0
- Fuel Type 3: generation, £0.22/kWh, no standing charge

If you have on-site energy sources, such as solar panels, we have included the savings from some of their energy being used directly in your home, in accordance with the figures in section 2.3.1 on Energy Use Intensity above. We have not included Feed-in-Tariffs (FITS), the Smart Export Guarantee (SEG), or the Renewable Heat Incentive (RHI) in these figures. The rules around these payments vary over time and between suppliers. We therefore believe this information is more robust if these assumptions are not included.

Section 3

Retrofit Suggestions

We have devised 10 scenarios for your home retrofit. These were compared in the above section. In this section we provide more detail on what is involved in each of the these scenarios:

Scenario 1	Basics
Scenario 2	Basics + Heat Pump
Scenario 3	Basics + Heat Pump + Solar
Scenario 5	Walls B - Standard IWI
Scenario 6	Walls C - Thin EWI
Scenario 7	Walls D - Standard EWI
Scenario 8	Walls E - Thick EWI
Scenario 9	Everything - Standard IWI + Heat Pump + Solar
Scenario 10	Everything!
Scenario 4	Walls A - Thin IWI

3.1 Summary of measures

The following pages show tables of the measures contained within each of the modelled scenarios.

A detailed description of the table headings is contained in section 3.2. This includes things you need to be aware of in planning your works, so please do review this and consider the implications it may have for your project. In summary these are:

- **Performance Target**: This is the standard the measure is assumed to achieve in the model this report is based on. If this is not achieved in reality, there may be a 'performance gap' when compared with the outcomes shown in the graphs above.
- **Benefits**: The headline likely positive effects of each measure.
- **Cost**: This gives a very approximate budget cost for each measure. It is not a quote or formal estimate. Costs will vary across time and contexts. They are also dependent on your decisions on the level of finish and materials and makes of product chosen. The information provided here is a 'ball park' figure only and can be affected by external factors beyond our control.
- **Who by**: The people most likely to carry out each measure - whether independently or working under a main contractor.
- **Disruption**: A rough guide to the level of disruption during installation.

Scenario 1: Basics

- Estimated net budget cost of this scenario £15400 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £15400 + VAT and on costs

Where scenarios are additive, especially for works that might be phased over a number of years, we may suggest items in one scenario that are then replaced in a future scenario. This is likely to apply to ventilation systems in particular - where a simpler and cheaper option is installed to address immediate air quality concerns, but this is then replaced as part of deeper or more extensive works in future. It may also apply to smaller fabric elements that protect the building fabric or your health. In these cases the costs of both are included in the total for all scenarios. This is because where works are phased we don't know how much time might be taken between phases of work, good ventilation and building physics is important throughout the whole process to protect your health and wellbeing. With careful planning you can bring forward the more advanced works, if you know you will be doing more extensive work in future and can plan works to fit. In this case you can omit the cost of the 'temporary' works from your project budget planning.

ID	Name	Label/location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
1.1	Insulation to solid wall to unheated space (constrained)	To rear entrance and stairs - unheated space	0.7 $W/m^2{\cdot}K$	comfort, fuel bills	£550	DIY or general contractor	medium/ high
1.2	Loft insulation (Bregs)	Main loft	0.16 $W/m^2{\cdot}K$	Comfort, fuel bills, carbon emissions	£1900	DIY or General Contractor	minimal
1.3	Pitched Roof Insulation (constrained)	Skeiling	0.35 $W/m^2{\cdot}K$	Comfort, fuel bills, weather proofing, carbon emissions	£1650	Roofing Contractor/ General Contractor/ DIY	high/ medium
1.4	New insulated loft hatch.	First Floor Landing	0.7 $W/m^2{\cdot}K$	comfort, fuel bills, fabric protection	£600	DIY/ General Contractor	minimal

ID	Name	Label/location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
1.5	Insulation to underside of timber stairs over unheated space (BRegs)	Stairs to pantry below	0.3 W/m^2·K	Comfort, Fuel Bills	£350	DIY/General Contractor	Medium
1.6	High Performance Double-Glazed Window	W01 - Front Entrance Cupboard, W02 - Sitting Room, W03 - Living Room, W04 - Kitchen, W05 - Front Bedroom, W06 - Small Bedroom, W07 - Landing, W08- Bathroom, W09 - Rear Bedroom	1.4 W/m2.K	Comfort Carbon Emissions Fuel Bills	£6500	General Contractor/ Window Fitter	HIGH
1.7	Block or remove uncontrolled wall vent	Small Front Bedroom	No infiltration.	Comfort	£150	General contractor	minimal
1.8	Block or remove uncontrolled wall vent	Meter cupboard - upper	No infiltration.	Comfort	£150	General contractor	minimal
1.9	Block or remove uncontrolled wall vent	Meter cupboard - lower - part blocked	No infiltration.	Comfort	£150	General contractor	minimal
1.10	Airtightness improvements	Whole house	Air-permeability - 5m^3/m^2·hr50pa (AP50)	comfort, improved indoor air quality, fuel bills, carbon emissions	£2500	DIY/ Joiner	Medium

ID	Name	Label/location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
1.11	Decentralised Mechanical Extract Ventilation (dMEV)	Whole house	Minimum Building Regulations - Part F	Improved indoor air quality and reduced risk of condensation and mould.	£900	Electrician	Minimal

Scenario 2: Basics + Heat Pump

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £16650 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £32050 + VAT and on costs

Where scenarios are additive, especially for works that might be phased over a number of years, we may suggest items in one scenario that are then replaced in a future scenario. This is likely to apply to ventilation systems in particular - where a simpler and cheaper option is installed to address immediate air quality concerns, but this is then replaced as part of deeper or more extensive works in future. It may also apply to smaller fabric elements that protect the building fabric or your health. In these cases the costs of both are included in the total for all scenarios. This is because where works are phased we don't know how much time might be taken between phases of work, good ventilation and building physics is important throughout the whole process to protect your health and wellbeing. With careful planning you can bring forward the more advanced works, if you know you will be doing more extensive work in future and can plan works to fit. In this case you can omit the cost of the 'temporary' works from your project budget planning.

ID	Name	Label/ location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
2.1	New medium hot water cylinder (170-250 litre)	Whole house	<0.08 kWh loss per day	Fuel bills, demand response and flexibility	£1800	Plumber or heating engineer	medium
2.2	Basic primary pipework insulation.	Whole house	basic	Improved system efficiency. Reduced bills, improved comfort (reduced overheating risk)	£100	heating engineer/ general contractor / DIY	minimal
2.3	Hot water controls	Whole house	basic	Improved system control and efficiency. Reduced bills, improved comfort (reduced overheating risk)	£250	Heating engineer	minimal
2.4	High Quality Air Source Heat Pump (ASHP)	Whole house	SPF of 3.5 or more	Carbon emissions reduction	£14500	Heating engineer, MCS accredited installer	medium

Scenario 3: Basics + Heat Pump + Solar

- **This scenario assumes the measures in scenario 2 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £9000 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £41050 + VAT and on costs

Where scenarios are additive, especially for works that might be phased over a number of years, we may suggest items in one scenario that are then replaced in a future scenario. This is likely to apply to ventilation systems in particular - where a simpler and cheaper option is installed to address immediate air quality concerns, but this is then replaced as part of deeper or more extensive works in future. It may also apply to smaller fabric elements that protect the building fabric or your health. In these cases the costs of both are included in the total for all scenarios. This is because where works are phased we don't know how much time might be taken between phases of work, good ventilation and building physics is important throughout the whole process to protect your health and wellbeing. With careful planning you can bring forward the more advanced works, if you know you will be doing more extensive work in future and can plan works to fit. In this case you can omit the cost of the 'temporary' works from your project budget planning.

ID	Name	Label/ location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
3.1	Solar Photovoltaic Panels - Large System	Whole house	4 kWp	Reduced energy bills, reduced whole grid carbon emissions	£9000	Qualified electrician, Microgeneration Certification Scheme (MCS) accredited.	MEDIUM

Scenario 5: Walls B - Standard IWI

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £23750 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £39150 + VAT and on costs

Where scenarios are additive, especially for works that might be phased over a number of years, we may suggest items in one scenario that are then replaced in a future scenario. This is likely to apply to ventilation systems in particular - where a simpler and cheaper option is installed to address immediate air quality concerns, but this is then replaced as part of deeper or more extensive works in future. It may also apply to smaller fabric elements that protect the building fabric or your health. In these cases the costs of both are included in the total for all scenarios. This is because where works are phased we don't know how much time might be taken between phases of work, good ventilation and building physics is important throughout the whole process to protect your health and wellbeing. With careful planning you can bring forward the more advanced works, if you know you will be doing more extensive work in future and can plan works to fit. In this case you can omit the cost of the 'temporary' works from your project budget planning.

ID	Name	Label/location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
5.1	Insulation to suspended timber floor (B Regs)	Living Room and Sitting Room	$0.25\ W/m^2{\cdot}K$	Comfort, Fuel Bills	£4250	DIY/General Contractor	Medium or high (depending on access)
5.2	IWI to solid masonry wall (standard)	Front Elelvation, Rear Elevation, Side Elevation, Main Entrance Porch Walls	$0.4\ W/m^2{\cdot}K$	comfort, fuel bills	£16000	approved installer	high
5.3	Deep airtightness improvements (constrained)	Whole house	comfort, improved indoor air quality, fuel bills, carbon emission	comfort, improved indoor air quality, fuel bills, carbon emissions	£3500	DIY/ Joiner/ Airtightness specialist	High

Scenario 6: Walls C - Thin EWI

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £19500 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £34900 + VAT and on costs

Where scenarios are additive, especially for works that might be phased over a number of years, we may suggest items in one scenario that are then replaced in a future scenario. This is likely to apply to ventilation systems in particular - where a simpler and cheaper option is installed to address immediate air quality concerns, but this is then replaced as part of deeper or more extensive works in future. It may also apply to smaller fabric elements that protect the building fabric or your health. In these cases the costs of both are included in the total for all scenarios. This is because where works are phased we don't know how much time might be taken between phases of work, good ventilation and building physics is important throughout the whole process to protect your health and wellbeing. With careful planning you can bring forward the more advanced works, if you know you will be doing more extensive work in future and can plan works to fit. In this case you can omit the cost of the 'temporary' works from your project budget planning.

ID	Name	Label/location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
6.1	EWI to solid masonry wall (constrained)	Front Elevation, Rear Elevation, Side Elevation, Main Entrance Porch Walls	0.7 $W/m^2{\cdot}K$	comfort, fuel bills	£16000	approved installer	high
6.2	Deep airtightness improvements (constrained)	Whole house	comfort, improved indoor air quality, fuel bills, carbon emission	comfort, improved indoor air quality, fuel bills, carbon emissions	£3500	DIY/ Joiner/ Airtightness specialist	High

Scenario 7: Walls D - Standard EWI

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £24550 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £39950 + VAT and on costs

Where scenarios are additive, especially for works that might be phased over a number of years, we may suggest items in one scenario that are then replaced in a future scenario. This is likely to apply to ventilation systems in particular - where a simpler and cheaper option is installed to address immediate air quality concerns, but this is then replaced as part of deeper or more extensive works in future. It may also apply to smaller fabric elements that protect the building fabric or your health. In these cases the costs of both are included in the total for all scenarios. This is because where works are phased we don't know how much time might be taken between phases of work, good ventilation and building physics is important throughout the whole process to protect your health and wellbeing. With careful planning you can bring forward the more advanced works, if you know you will be doing more extensive work in future and can plan works to fit. In this case you can omit the cost of the 'temporary' works from your project budget planning.

ID	Name	Label/location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
7.1	External perimeter insulation to solid floor	Entrance and Kitchen	0 $W/m^2 \cdot K$	Comfort , Fuel Bills	£2550	External wall insulation specialist	Medium
7.2	EWI to solid masonry wall (building regs)	Front Elelvation, Rear Elevation, Side Elevation, Main Entrance Porch Walls	0.3 $W/m^2 \cdot K$	comfort, fuel bills	£18500	approved installer	high
7.3	Deep airtightness improvements (constrained)	Whole house	comfort, improved indoor air quality, fuel bills, carbon emission	comfort, improved indoor air quality, fuel bills, carbon emissions	£3500	DIY/ Joiner/ Airtightness specialist	High

Scenario 8: Walls E - Thick EWI

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £26550 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £41950 + VAT and on costs

Where scenarios are additive, especially for works that might be phased over a number of years, we may suggest items in one scenario that are then replaced in a future scenario. This is likely to apply to ventilation systems in particular - where a simpler and cheaper option is installed to address immediate air quality concerns, but this is then replaced as part of deeper or more extensive works in future. It may also apply to smaller fabric elements that protect the building fabric or your health. In these cases the costs of both are included in the total for all scenarios. This is because where works are phased we don't know how much time might be taken between phases of work, good ventilation and building physics is important throughout the whole process to protect your health and wellbeing. With careful planning you can bring forward the more advanced works, if you know you will be doing more extensive work in future and can plan works to fit. In this case you can omit the cost of the 'temporary' works from your project budget planning.

ID	Name	Label/location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
8.1	External perimeter insulation to solid floor	Entrance and Kitchen	0 W/m²·K	Comfort , Fuel Bills	£2550	External wall insulation specialist	Medium
8.2	EWI to solid masonry wall (high performance)	Front Elelvation, Rear Elevation, Side Elevation, Main Entrance Porch Walls	0.2 W/m²·K	comfort, fuel bills	£20500	approved installer	high
8.3	Deep airtightness improvements (constrained)	Whole house	comfort, improved indoor air quality, fuel bills, carbon emission	comfort, improved indoor air quality, fuel bills, carbon emissions	£3500	DIY/ Joiner/ Airtightness specialist	High

Scenario 9: Everything - Standard IWI + Heat Pump + Solar

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £49550 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £64950 + VAT and on costs

Where scenarios are additive, especially for works that might be phased over a number of years, we may suggest items in one scenario that are then replaced in a future scenario. This is likely to apply to ventilation systems in particular - where a simpler and cheaper option is installed to address immediate air quality concerns, but this is then replaced as part of deeper or more extensive works in future. It may also apply to smaller fabric elements that protect the building fabric or your health. In these cases the costs of both are included in the total for all scenarios. This is because where works are phased we don't know how much time might be taken between phases of work, good ventilation and building physics is important throughout the whole process to protect your health and wellbeing. With careful planning you can bring forward the more advanced works, if you know you will be doing more extensive work in future and can plan works to fit. In this case you can omit the cost of the 'temporary' works from your project budget planning.

ID	Name	Label/location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
9.1	Insulation to suspended timber floor (B Regs)	Living Room and Sitting Room	0.25 W/m²·K	Comfort, Fuel Bills	£4250	DIY/General Contractor	Medium or high (depending on access)
9.2	IWI to solid masonry wall (standard)	Front Elelvation, Rear Elevation, Side Elevation, Main Entrance Porch Walls	0.4 W/m²·K	comfort, fuel bills	£16000	approved installer	high
9.3	Deep airtightness improvements (constrained)	Whole house	comfort, improved indoor air quality, fuel bills, carbon emission	comfort, improved indoor air quality, fuel bills, carbon emissions	£3500	DIY/ Joiner/ Airtightness specialist	High

ID	Name	Label/location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
9.4	New medium hot water cylinder (170-250 litre)	Whole house	<0.08 kWh loss per day	Fuel bills, demand response and flexibility	£1800	Plumber or heating engineer	medium
9.5	Advanced primary pipework insulation.	Whole house	advanced	Improved system efficiency. Reduced bills, improved comfort (reduced overheating risk)	£250	heating engineer/ general contractor / DIY	medium
9.6	Hot water controls	Whole house	basic	Improved system control and efficiency. Reduced bills, improved comfort (reduced overheating risk)	£250	Heating engineer	minimal
9.7	High Quality Air Source Heat Pump (ASHP)	Whole house	SPF of 3.5 or more	Carbon emissions reduction	£14500	Heating engineer, MCS accredited installer	medium
9.8	Solar Photovoltaic Panels - Large System	Whole house	4 kWp	Reduced energy bills, reduced whole grid carbon emissions	£9000	Qualified electrician, Microgeneration Certification Scheme (MCS) accredited.	MEDIUM

Scenario 10: Everything!

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £77750 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £93150 + VAT and on costs

Where scenarios are additive, especially for works that might be phased over a number of years, we may suggest items in one scenario that are then replaced in a future scenario. This is likely to apply to ventilation systems in particular - where a simpler and cheaper option is installed to address immediate air quality concerns, but this is then replaced as part of deeper or more extensive works in future. It may also apply to smaller fabric elements that protect the building fabric or your health. In these cases the costs of both are included in the total for all scenarios. This is because where works are phased we don't know how much time might be taken between phases of work, good ventilation and building physics is important throughout the whole process to protect your health and wellbeing. With careful planning you can bring forward the more advanced works, if you know you will be doing more extensive work in future and can plan works to fit. In this case you can omit the cost of the 'temporary' works from your project budget planning.

ID	Name	Label/location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
10.1	Loft insulation (High performance)	Main loft	0.11 W/m²·K	Comfort, fuel bills, carbon emissions	£2100	DIY or General Contractor	minimal
10.2	New insulated solid floor (B Regs)	Entrance and Kitchen	0.18 W/m²·K	Comfort , Fuel Bills, Flood Resilience	£2800	General Contractor	Very High
10.3	New insulated solid floor (B Regs)	Living Room and Sitting Room	0.18 W/m²·K	Comfort , Fuel Bills, Flood Resilience	£5500	General Contractor	Very High
10.4	New insulated part-glazed external door (high performance))	D01 - Front Door	1 W/m²·K	comfort, fuel bills	£1450	General Contractor/ Joiner (FENSA)	medium

ID	Name	Label/location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
10.5	New insulated part-glazed external door (high performance))	Back Door	1 $W/m^2 \cdot K$	comfort, fuel bills	£1400	General Contractor/ Joiner (FENSA)	medium
10.6	IWI to solid masonry wall (standard)	Front Elelvation, Rear Elevation, Side Elevation, Main Entrance Porch Walls	0.4 $W/m^2 \cdot K$	comfort, fuel bills	£16000	approved installer	high
10.7	High Performance Triple Glazed Window	W01 - Front Entrance Cupboard, W02 - Sitting Room, W03 - Living Room, W04 - Kitchen, W05 - Front Bedroom, W06 - Small Bedroom, W07 - Landing, W08- Bathroom, W09 - Rear Bedroom	0.85 $W/m^2 \cdot K$	comfort, fuel bills, ventilation	£11000	Joiner/ Window Fitter/ Glazing Specialist (FENSA)	medium
10.8	Cap and fill chimney	Front room - ground floor (sealed over)	10m3/h assumed infiltration rate.	Comfort, fuel bills	£500	General contractor	medium
10.9	Cap and fill chimney	Main Front Bedroom	10m3/h assumed infiltration rate.	Comfort, fuel bills	£500	General contractor	medium
10.10	Cap and fill chimney	Back Bedroom	10m3/h assumed infiltration rate.	Comfort, fuel bills	£500	General contractor	medium

ID	Name	Label/location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
10.11	Deep airtightness improvements	Whole house	Air-permeability - 2 $m^3/m^2 \cdot hr50pa$ (AP50)	comfort, improved indoor air quality, fuel bills, carbon emissions	£3500	DIY/ Joiner/ Airtightness specialist	High
10.12	Mechanical Ventilation with Heat Recovery (MVHR)	Whole house	Minimum Building Regulations - Part F or Passive House Certified.	Improved indoor air quality and reduced risk of condensation and mould. Reduced heat losses from ventilation. Insulation from external noise.	£9000	Approved installer	High
10.13	High Quality Air Source Heat Pump (ASHP)	Whole house	SPF of 3.5 or more	Carbon emissions reduction	£14500	Heating engineer, MCS accredited installer	medium
10.14	Solar Photovoltaic Panels - Large System	Whole house	4 kWp	Reduced energy bills, reduced whole grid carbon emissions	£9000	Qualified electrician, Microgeneration Certification Scheme (MCS) accredited.	MEDIUM

Scenario 4: Walls A - Thin IWI

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £19750 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £35150 + VAT and on costs

Where scenarios are additive, especially for works that might be phased over a number of years, we may suggest items in one scenario that are then replaced in a future scenario. This is likely to apply to ventilation systems in particular - where a simpler and cheaper option is installed to address immediate air quality concerns, but this is then replaced as part of deeper or more extensive works in future. It may also apply to smaller fabric elements that protect the building fabric or your health. In these cases the costs of both are included in the total for all scenarios. This is because where works are phased we don't know how much time might be taken between phases of work, good ventilation and building physics is important throughout the whole process to protect your health and wellbeing. With careful planning you can bring forward the more advanced works, if you know you will be doing more extensive work in future and can plan works to fit. In this case you can omit the cost of the 'temporary' works from your project budget planning.

ID	Name	Label/location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
4.1	Insulation to suspended timber floor (B Regs)	Living Room and Sitting Room	0.25 $W/m^2{\cdot}K$	Comfort, Fuel Bills	£4250	DIY/General Contractor	Medium or high (depending on access)
4.2	IWI to solid wall (constrained)	Front Elelvation, Rear Elevation, Side Elevation, Main Entrance Porch Walls	0.7 $W/m^2{\cdot}K$	comfort, fuel bills	£12000	general contractor/ approved installer	very high
4.3	Deep airtightness improvements (constrained)	Whole house	comfort, improved indoor air quality, fuel bills, carbon emission	comfort, improved indoor air quality, fuel bills, carbon emissions	£3500	DIY/ Joiner/ Airtightness specialist	High

3.2 Explanation of table headings

In addition to listing and describing proposed measures, we use the following table headings to guide you through our recommendations.

Performance target

This is the standard that needs to be achieved to match the assumptions in the model. For a wall, floor, window or roof this is usually a measure of its thermal performance and insulation value. This is known as a U-value and is measured in watts per square metre of building envelope area per degree of temperature difference between inside and outside (in degrees Kelvin) - or $W/m_2 \cdot K$. For a heating system it will be its efficiency. It is important to reference this when looking at detailed specifications. If this report recommends 200mm of high quality insulation this is what is required to achieve the scenario outcomes shown above. The same effect won't be achieved with 100mm of lower quality insulation.

Benefits

We understand that you may wish to carry out retrofit works for reasons other than carbon emissions reductions and cost savings – such as comfort improvements, improved indoor air quality or reducing energy demand. It's important in planning the work to understand and communicate your priorities to any professionals or builders you're working with. The relative impact of each measure will vary depending on the order you do them in. For example, if you change your boiler before installing insulation, the absolute savings from the insulation work will be less than if you had installed the insulation first.

How much?

We have provided some rough cost information for each of the measures suggested. It is an approximation so that you can begin to plan a budget for your project. It is not a fixed cost or quote. It is based on generic cost information, informed by our experience.

Cost rates in your project may vary significantly from those suggested here. This is dependent on a number of factors including: the construction market at the time you carry out the works; inflation in labour and material prices; the scale of the work; the specifications, standards and level of finish you request; the contractor you choose and their overheads, experience, capacity and attitude to risk.

Estimated budget costs **do not include**:

- **Contingency**: Any refurbishment project is likely to encounter unforeseen issues that may mean you will have to spend more money than planned. Careful planning and investigation before carrying out the work will help reduce the risks - but it is impossible to eliminate this risk altogether. It is therefore sensible to include a contingency sum in your project planning. You can then hold back this money and use it to pay for unplanned parts of the work. Around 10% of the construction cost is a standard amount to allow - but in complex projects 20-25% might be more appropriate. Complex projects are likely to include works to buildings with significant heritage value, including listed buildings. It will also cover deeper retrofit works that involve significant strip back or structural alterations. This may be higher or lower depending on your confidence in the likely works and your own attitude towards risk. If you are more risk averse, a bigger contingency is advisable. If you are able to carry more risk, you may choose to hold a smaller contingency.

- **Preliminaries**: These are the costs for management and supplementary works associated with building work. They include things like scaffolding or the services of a site manager. These costs will vary depending on the scale and complexity of the work and the contractors and procurement route chosen. Bigger contractors and bigger or more complex works tend to carry higher preliminaries. Small and simple works carried out by micro-businesses or DIY may have very limited preliminary costs. We would suggest 10% is a sensible budget cost, but this should be adjusted according to your project requirements.

- **Professional fees**: You may need to engage designers and advisors on your project, for example a retrofit designer, a retrofit assessor or coordinator, or quantity surveyor or contract administrator. This is in addition to paying contractors to carry out the work. The costs for this will vary according to the amount of work involved in your project. It will also be influenced by the skills and experience of your advisor and the way the fee is calculated (whether a fixed fee, a time charge, or a percentage of the construction costs). In the initial planning stage a budget cost of 15-20% would be sensible to assume for professional fees in most cases - but you should try to work this out in detail.

- **Statutory fees**: These include fees for planning permission, listed building consent or building control approval or fees associated with party wall matters. You may not need planning permission for the works you propose. However most building works will require building control approval, and this should be allowed for. You can find out the normal rates for planning and building control fees from your local authority.

- **VAT**: We have not included VAT (Value Added Tax). This is because the rate may vary depending on government policy and the way that you procure the works. Discount VAT rates are available for some works - consult HMRC for more information. If you make assumptions about VAT in your project planning, you should make this clear to your contractor as they may be required to take action themselves or inform their accountant and HMRC.

- **Inflation**: Budget costs are based on current information. Costs will increase over time. This is true both for construction work and for professional and statutory fees. We cannot be certain of when you will carry out any of the works suggested, so cannot allow for this. Construction price inflation is also difficult to predict. It is highly sensitive to things like currency fluctuations and changes in the workforce.

- **New Build Elements**: Where you're planning an extension alongside your retrofit works we haven't included any estimated costs for the wholly new elements involved in constructing this. This is because we often only have very limited information about your plans, as they are often at an early stage of development, and because our libraries and databases only include information on refurbishment and retrofit elements. You will need to create a separate line in your budget for your extension. At the early stages of your project planning this might just be a simple cost per square metre of floor area rate. Once you have more detailed designs for this element, it might be possible to create a more accurate budget.

- **Redecoration costs**: We have not included costs for the redecoration work. This is because this could vary significantly between households. It depends on whether you choose to do the work yourself, or pay someone else to do it. It also depends on the level of finish and the materials you choose.

- **Relocation costs**: We have not included any costs associated with you moving out of your home while construction work takes place. You should think carefully about whether this will be necessary for you. You might choose to move out for a short while during the most disruptive parts of the work, or for a longer period if works are extensive. You should build this into your cost plan. Think carefully about what will happen if work takes longer than planned and consider whether you need a contingency for this.

- **Grants and other funding**: We have not included any assumptions about grants or funding in the costs given above. The rules for these schemes vary over time and by location and according to household income and circumstances. You can more easily investigate this once you know what you plan to do and when.

Major works:
If you are planning major work we recommend that you or your advisors prepare a detailed cost plan. This should include costs for the construction work and all of the items outlined above. It should be up to date, and use quotes from suppliers where possible. When it comes to choosing a contractor, it will enable you to compare the quotes against this estimate.

Smaller works:
For smaller and more self-contained works it may not be necessary to prepare a full detailed cost plan. As a minimum we recommend that you obtain itemised quotes from several suppliers. This is so you can compare costs and the level of service when deciding who to work with.

Who by?

We've provided a guide to who might carry out each measure. This is subjective and dependent on context. For example you may choose to do more or less work yourself depending on your skills and experience. Do make sure you are aware of any accreditations you need for funding.

Disruption

We've given a guide as to the level of disruption. Again, this is subjective and dependent on context. Your own experience and tolerance may vary from what we suggest here.

3.3 Quick Wins

The suggestions we've made above may seem daunting. We know many people want to get moving as soon as they can on making improvements to their home. Here we've provided a list of some simple things you can do that will make an immediate difference, though often a relatively small one.

Building Maintenance

Check and clean gutters and rainwater downpipes to avoid making your walls wet and cold through leaks. Unblock air-bricks that provide ventilation below suspended timber floors and check ventilation paths in your attic or cold loft space. If you live in an older building, the SPAB provide useful guidance on carrying out better building maintenance, and even have an annual 'Festival of Maintenance': spab.org.uk/news/maintenance-win-more-sustainable-homes

Lighting

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

Appliances

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

Cooking

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

Heating System and Controls

Spend some time properly checking how you use the controls for your existing heating system, so that you are using it effectively and efficiently. The Centre for Sustainable Energy publish useful video guides on this: cse.org.uk/advice/advice-and-support/central-heating-controls and cse.org.uk/advice/advice-and-support/night-storage-heaters plus other links in the same place for different systems.

If you have a central heating system with a condensing boiler, you may also be able to adjust some of the settings on this to make it work more efficiently. You can find out more about this in this useful guide published by the Heating Hub: www.theheatinghub.co.uk/articles/turn-down-the-boiler-flow-temperature

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

Ventilation

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

Laundry

Clothes should dry in a place that is well ventilated and has some heating. This is so that they dry quickly and the moisture doesn't stay in your home. Drying clothes outside is best if you have space - though given the climate of the UK that is not always possible. Avoid drying clothes on radiators as this makes your radiators less efficient. If you have a hot water store or cylinder, or plan to add one, the space this sits in is a good place for drying clothes, as it makes use of waste heat. If this is near a ventilation extract to a bathroom or utility space, that's even better. The University of Glasgow have published a useful guide on clothes drying available here: https://www.dewasdrogen.nl/wp-content/uploads/2021/05/MEARU-Laundry-Design-Guide.pdf

Using Renewable Energy

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

Monitoring

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

Section 4

Context and Constraints

It is important that in planning the work to your home that you understand and are able to communicate your priorities to any professionals or builders you're working with. In this section we record what you told us about your aims and your approach to the retrofit project.

4.1 Your Plans

You told us that you have not yet moved in.

You told us that you plan to stay in your home in the .
Comment: House not currently occupied.

You told us that you **do not** envisage any significant changes to your lifestyle.
Comment: House not currently occupied.

You told us that you **are not** planning other building works in your home.
Comment: House not currently occupied.

You hope to start retrofit work on your home in the next **3–6 months**.
Comment: House not currently occupied. Housing association plan to carry out work to bring it up to standard before letting it out again.

4.2 Your priorities

You told us what was most important to you in considering energy efficiency retrofit options for your home. We have considered these preferences in developing the scenarios set out in this report.

Your priorities were:

You told us that the key qualitative criteria in planning works to your home are:

The scenarios in this report have been constructed to serve a range of possible desired outcomes.

You told us that you **wouldn't mind changing** the appearance of your home inside.
You told us that you **would prefer not to change** the appearance of your home outside.

Comment: There are some restrictions on what is possible externally, because of the heritage status of the property. Internally some refurbishment is needed in any case, so changes are more likely to be acceptable.

4.3 Logistics

You told us that you plan to do the work **all in one go**.
You told us that you **were not** willing to do some of the work yourself.
Comment: It's likely that the housing association will want to complete all the necessary work before someone moves back in to the home - though there could also be future phases of work that are less disruptive internally.

When thinking about the disruption involved you told us that you would be willing to live with **live elsewhere during the works**.
Comment: We have assumed that major disruption is possible while the house is empty, and that work will be carried out by professionals. Though in another home similar work could be phased and done at least partially DIY.

You told us you **would work out your budget after understanding what was possible**.

4.4 Context

To make effective improvements to your home you need to understand where you're starting from. Taking a balanced fabric-first and whole-house approach isn't just about improving insulation or airtightness.

Before carrying out improvement works, you should fix damaged structures and make sure general maintenance is in good order. If this is ignored it can mean energy efficiency work exacerbates existing problems or creates new ones. This can damage your home or mean that insulation and other measures don't perform as well as they could.

Identifying the existing condition can also be helpful to identify problem areas like cold or draughty rooms. These can then be addressed in the scenarios suggested in this report.

Understanding the context of your home also helps in general project planning. It helps to identify climate change adaptation needs, such as addressing flooding or overheating risks.

4.4.1 General Property Information

Property type: semi-detached
Number of bedrooms: 3
Gross internal floor area: 95.3m^2

This is not a full building inspection and condition survey, and it should not be used as such.

We strongly recommend you seek further advice from a surveyor or structural engineer for major works. This is particularly important where structural alterations are planned, or potential structural problems have been identified. We will however notify you if we see something in your home that concerns us as to its safety or condition.

We do not carry out invasive surveys as part of this report. We also do not access areas where to do so would cause undue risk to the assessor. We therefore have to make some assumptions about the construction of your home in preparing this report. These may need to be verified by further investigation and detailed condition surveys to inform detailed planning and design work.

4.4.2 General construction

Based on the information provided by you and our assessment, the general construction of the property is as follows:

Floors:

Ground floor is solid to the outside gable wall - below the hallway and kitchen. Suspended timber to the living rooms to front and rear along the party wall line.

Walls:

Assumed solid brick with thick render coating and wet plaster finish internally.

Roof:

Tiled with some signs of again and wear and tear.

Windows and doors:

Mostly older uPVC windows, some of which have warped or seals are damaged and don't close fully.

Rainwater and drainage goods:

Mix of cast iron and plastic with some damage. In particulat the downpipe next to the front door is cracked and leaking, leading to the ground here being saturated.

Evidence of moisture ingress or leaks (including internal):

leaking external down pipe. Some staining on first floor ceilings at skeiling - might be leaks or might be comdensation.

4.4.3 Works already undertaken

You told us you had already made the following improvements to your home:
The house hasn't had much done to the fabric for a long time.
The heating system is relatively new - with a modern condensing gas boiler and controller.

4.4.4 Past, Current and Potential Structural Issues

You told us: n/a
We noted that: Nothing significant was observed - though we'd suggest if major works are planned a full structural survey is carried out.

4.4.5 Damp, condensation or mould

You told us: n/a
We noted that: There is evidence of condensation and mould on skielings and some window cills. There is a significant amount of mould and damp in the meter cupboard next to the front door - where the broken downpipe has saturated the ground.

4.4.6 Heating and water services

Your space heating is currently provided by: Gas boiler
Which you control by: Room programmer and thermostat
Your hot water is currently provided by: Gas boiler.

4.4.7 Utilities

Your home has a mains electricity connection.
Your home has a mains gas connection.
Your home has a mains water connection.
Your home has a mains sewer connection.

4.5 Ventilation and Indoor Air Quality

Your well-being and the internal environmental conditions in your home are affected by indoor air quality. Damp, dry, or polluted air can create or exacerbate a range of health conditions. It can also affect the health of the building structure, creating surface or hidden condensation, mould and risking rot.

The best way to avoid these issues is to have a well-designed and well-functioning ventilation system, in accordance with Part F of the building regulations as a minimum. This should ensure that stale air is removed and fresh air is provided to keep your home healthy. In the scenarios outlined in this report we suggest upgrades to ventilation systems where appropriate.

We recommend making your building as airtight as possible and then using continuous planned ventilation. This extracts unwanted, stale, moist air from 'wet rooms' - bathrooms, kitchen, utility rooms etc. It also delivers the appropriate amount of fresh air to 'habitable' rooms - living rooms, bedrooms, and studies etc.

We usually recommend one of three ventilation system options:

- dMEV - decentralised mechanical extract ventilation. This is individual continuous trickle extract fans in all 'wet rooms', with a 'boost' function. Each 'habitable' room then has a background ventilator in the form of trickle vents in windows or wall mounted vents.
- MEV - centralised mechanical extract ventilation. This is very similar to dMEV. In place of a unit in each room, ducts take stale air to a central extract fan unit from each 'wet room'. The larger single fan can improve reliability, reduce noise and provide better volume control. They are also often easier to clean and otherwise maintain. As above, each 'habitable' room needs planned intake air points, whether via trickle vents in windows or wall mounted vents.
- MVHR - whole house mechanical ventilation with heat recovery: Here a single central unit has two continuous fans. One extracts stale, warm air from 'wet rooms'. The other supplies filtered fresh air to 'habitable' rooms. This is pre-warmed by passing it over a heat exchanger next to the outgoing stale air. This has great advantages in improved comfort, air quality and heat retention and also noise separation from outside. Due to the need for ducting to every room it is more expensive and can be particularly challenging in retrofit.

Other ventilation system types are available, such as different forms of single room MVHR. There is a risk of air short circuiting from the exhaust to the intake, so we don't normally recommend those outside of particular special circumstances. An alternative MVHR further system has single room units in each room that work in tandem, alternating their direction of flow. A ceramic core absorbs heat in the extract mode, and this then warms incoming air when they are supplying. These systems are new and we don't yet have enough data on their effectiveness to recommend them.

We do not recommend the use of intermittent fans which only come on for a limited time. This is because we feel in even moderately airtight dwellings they can not provide adequate ventilation. When the extract fan is not on, good ventilation relies on the background ventilators. These are often undersized and very reliant on the weather for effectiveness. Intermittent extract fans are generally small and cheap. They suffer from reliability issues and can be noisy, often leading to them being deliberately disabled or failing without occupants being aware. This means they are no longer working to remove moisture and indoor pollutants.

A simple assessment of your existing ventilation system is set out below.

4.5.1 Existing Ventilation System

The ventilation system in your home at present is: Intermittent Extract.

We noted: The existing ventilation system is intermittent extract. But supply and background vents are limited and the extract fans do not seem to be functioning properly.

There is not evidence of an adequate supply of fresh air through planned intake vents such as trickle vents in walls and/or windows or a mechanical supply system.

Ventilation systems need routes for both supply and extract air. Supply air could be supplied by a ducted mechanical system, or via adequately sized trickle vents in windows and walls. Lack of a route for supply air may mean there is an under-supply of fresh air into your home.

There is provision for purge ventilation in each habitable room (for example by opening windows or by a ‘boost’ on a mechanical ventilation system).

There is not a clear undercut/overcut of 10mm above or below internal doors to allow air to move through the dwelling.

In addition if condensation and mould growth is noted in section 4.4.5 above, this suggests that the existing ventilation system is inadequate.

Given the above information we would suggest that your current ventilation system is **Inadequate and should be upgraded as soon as possible**.

4.5.2 Solid Fuel Appliances

If you have an appliance in your home that creates heat by burning oil, gas, coal or wood it needs proper ventilation to ensure that it burns cleanly. This can take the form of a dedicated supply air vent or duct, or a fixed vent in the wall or floor. We would recommend that all fuel burning appliances should be serviced on a regular basis by qualified professionals (HETAS or Gas Safe) to ensure they are safe and properly ventilated. If you are improving the airtightness through draught-proofing and insulation work this will become even more important to avoid the risk of carbon monoxide poisoning.

When we visited your home we noticed that you did not have a fuel burning appliance. There are a couple of open fires at first floor level in each of the larger bedrooms but look to have not been used for some time. The fireplace in the front living room has been sealed over with card.

In all cases where there is a fuel burning appliance in your home you should fit a carbon monoxide alarm near this appliance. You should also ensure that any ventilation provided to the appliance is kept clear of obstructions.

We do not normally recommend wood-burners or other solid or liquid fuel burning appliances as part of a low carbon retrofit. This is for several reasons:

- Fuel burning appliances often need separate fixed ventilation. This conflicts with the need for improved airtightness. It can have a detrimental effect on energy efficiency and also adds complexity to the work.
- Burning fuel causes both internal and external air pollution. In urban areas where external air quality is already poor, this can be especially harmful. It also creates pollution in your home, which is not good for your health. This is especially the case if you suffer from asthma or other respiratory conditions. (The same is also true of burning fuel such as gas for cooking).
- Burning wood and most other fuels creates carbon dioxide at the point of combustion. The idea that wood and biomass fuels are ‘low carbon’ is based on the assumption that new growth will take up the carbon emitted from burning. In most cases you can’t know when you burn the fuel whether this will actually happen. Trees also take time to grow - something that we have precious little of in a climate emergency.

However, we also understand that you may have access to a ready supply of local wood fuel. You might also be subject to occasional power cuts - especially if you live in a more rural location. In such cases we'd suggest that a woodburner is not your main source of heat. Instead it is best kept for 'top up' and emergencies, with due care given to providing it with a direct air supply so that it burns efficiently. Ideally you'd also source the fuel for it locally, from well-managed and fast-growing timber.

4.5.3 Laundry

You told us you dry your laundry by: **Unknown - though there is a large garden with space for a washing line.**

Drying clothes indoors releases a lot of water vapour into the air, which can have a severe negative impact on indoor air quality. Using an electric dryer is very energy intensive, so should be avoided wherever possible. Drying outside is the most energy efficient way, but in the UK's climate this is not always possible.

As part of your retrofit project you could improve the way you dry your clothes, for example by providing a new dedicated drying space integrated with your heating and ventilation systems.

4.5.4 Radon

Radon is a naturally occurring gas that is a known carcinogen - that is it increases the risk of cancer. The risk of high levels of radon build-up within homes varies across the country, dependent on the local geology.

Your home is in an area where there is a less than 1% chance of high levels of radon in homes. This figure is taken from information provided by Public Health England - see www.ukradon.org for more information.

We would recommend that if you are planning works you obtain the individual report for your home, which is available for a small fee from here: https://www.ukradon.org/services/address_search. If your home is in a higher risk area, or just to provide further reassurance, you can also order a simple testing kit to test existing levels of radon in your home here: https://www.ukradon.org/services/orderdomestic

Where the risk of radon build up is higher adequate ventilation becomes even more important. It may also be necessary for you or your advisors to incorporate anti-radon measures into the designs for your home improvements, especially in the construction build-ups for floors. In some cases this may conflict with the need for airtightness and may require careful consideration and detailing.

4.6 Your experience

Living in a home that is too cold, hot, damp, dry or draughty can affect your physical and mental wellbeing. It may trigger or worsen respiratory and cardiovascular problems, skin conditions, trips and falls, anxiety and depression. Understanding your perceptions of comfort allows us to tailor the reports recommendations with your comfort and health in mind. What you told us about your comfort is set out below:

4.6.1 Thermal comfort

Temperature in winter	Don't know
Temperature in summer	Don't know
Air in winter	Don't know

Air in summer	Don't know
Draughts in winter	Don't know
Draughts in summer	Don't know

You told us there were problem locations for thermal comfort.

The secondary glazing on the double glazing in the front large bedroom is suggestive of problems - though this could also have been added because of noise.

4.6.2 Daylight

Amount of daylight	OK

You told us there were not problem locations for daylight.

4.6.3 Noise

You told us there were problem locations for internal or external noise.

Assessor comments: The secondary glazing to the double glazing in the front bedroom is suggestive of issues.

4.6.4 General

Your favourite room?
n/a

Any rooms in your home you don't love?
n/a

4.7 Historic significance

Many of the UK's homes are old and may be considered to have some historic significance. We consider this as part of the assessment because it may influence what is possible. In properties which are of particular historic significance the measures possible may be limited. Where buildings are listed or in a conservation area you may need to apply for permission to your local planning authority to make changes.

Property built: 1900–1929

The property is in a conservation area.

4.8 Climate change adaptation

4.8.1 Flood Risk

When planning the retrofit and refurbishment works for your home you should consider whether it is at increased risk of flooding. In areas of high risk you might choose to incorporate flood resilience or flood resistance measures as part of your retrofit. It may also affect which measures you choose to implement and how. For example, in an area with a high risk of flooding you might replace uninsulated timber ground floors with a solid insulated floor.

You told us that your home did not have a history of flooding.
Your home is in a very low risk area for flooding from rivers and the sea.
Your home is in a medium risk area for flooding from surface water.

Assessor comments:
Unknown.

What do the risk levels mean?

High risk	… means that each year this area has a chance of flooding of …	greater than 3.3%
Medium risk		between 1% and 3.3%
Low risk		between 0.1% and 1%
Very low risk		less than 0.1%

This is based on flood map data available at *https://flood-warning-information.service.gov.uk/long-term-flood-risk/map* .

4.8.2 Overheating Risk

The UK's climate is changing, with summers becoming hotter. This means more of our homes are at risk of overheating. Improving insulation, airtightness and ventilation in your home can reduce this risk, as it helps keep out heat during the day. However, if you have large areas of glazing and not much shade, especially if glazing faces East or West, your living spaces may become too hot from excess solar gains.

The rear of the house faces south-ish and is not shaded - but windows are of a reasonable size. The risk of overheating seems manageable.

4.9 Context and Other Points of Note

Parking is on street with no driveway, so access for construction needs a little planning. The house is entered at the side. There is also a back door a little further down the same side. there is an unheated lobby at the back door and store to under the stairs. A decision needs to be made about whether this is inside or outside the 'thermal 'envelope' if planning works.

Section 5

Next Steps

5.1 The Process

Making decisions about your project

There is no one-size-fits-all solution for retrofit. Some people employ professionals to oversee all their improvements; others carry out the work in whole or in part on a DIY basis. Some achieve everything at once in a 'big project'; others work in stages.

All building projects face three main constraints: time, cost and quality. As a general rule, in a given situation, only two of these can be the focus. Quality is important in retrofit to avoid the performance gap and achieve your desired outcomes. This means that your project can either be delivered quickly at some expense, or more cost-effectively given more time (not accounting for any external effects due to inflation). You should try to be clear about where your priorities lie.

Logistics can be another major constraint that can influence your decision making. This is often about the order that you can do things in, and how you plan to tie retrofit into any other works you are planning such as extensions or repair and maintenance work. This requires some careful thought and will often differ from house to house and project to project depending on what your aims are, the availability of materials and labour and other works you have planned.

Getting your home ‘retrofit ready’

Before you carry out retrofit improvements to your home you should make sure it is in good condition and well-maintained. We have included some basic relevant information about your property above. If you are considering major works you should carry out more detailed survey work. In particular you should check things like the condition of any existing cavity wall insulation, roof coverings and rainwater drainage. A structural survey may be needed, especially where there are any suspected problems or if you’re planning major alterations. You should resolve any problems with water ingress, condensation or damp before the retrofit work or as part of it.

Developing designs

This report can’t just be handed to a builder. It is not a detailed design proposal and it is not suitable for use as construction information. You may need to involve an advisor, designer or specialist contractor to help you develop your plans so they can be delivered. They can also help you with approvals like planning and building regulations – to make sure you have permission to build what you want and the designs are safe. Once you have detailed proposals you will be ready to start work.

Getting the work done

It is important to choose contractors who understand the work you want to do. They should be happy to take a 'whole house' approach that pays attention to risks in retrofit and work with you to achieve a good outcome. The type of contractor you need will vary depending on the scope, scale and the nature of the work. You might work with a small local building company for some parts, and a specialist retrofit firm for others - or do it all with one construction firm managing everything, including the design work. Finding the right contractor for the job may take time but in the long run it’s worth getting right. Whatever route you take it’s worth getting written confirmation of what you've agreed your contractor will do. Ideally this should be a standard contract form that is well understood.

Completion and Handover

Once the work is complete you should obtain all the information from your installers and suppliers so you can look after your retrofitted home and maintain it. This is likely to include things like instruction manuals and guarantees and warranties for elements of the work. If you’re not sure about heating or ventilation controls or similar, ask your contractor to demonstrate them to you. Air pressure tests, thermal imaging and commissioning checks of heating and ventilation systems can help make sure everything is as it should be.

Monitoring and Evaluation

It’s important to understand the impact your retrofit project has had on your home. This means looking back at your original aims once the work is completed to find out if they were achieved. For example, you can check whether your energy bills have changed or if you are more comfortable. Going further you can track internal temperature and other environmental data. This can highlight any tweaks that might improve things further, or spot issues before they become bigger problems.

Appendices

Appendix B

Glossary

Retrofit and building efficiency have a language all of their own. In this report there may be words and concepts that are unfamiliar to you. If there is anything you don't understand, please ask us.

We believe in using the correct terminology wherever possible, so that when you speak to professionals and tradespeople involved in retrofit you are familiar with the terms. To help your understanding we have provided the short glossary of common words and phrases below.

ACH: Air changes per hour

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

AECB: Association of Environmentally Conscious Building

A membership organisation for building professionals interested in sustainable building and energy efficiency. http://aecb.net/

Air permeability

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

Air tightness

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

Air Pressure Test (or "blower door test")

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

A2AHP: Air to Air Heat Pump

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

ASHP: Air Source Heat Pump

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

BUS: Boiler Upgrade Scheme

This is a government funded grant scheme that supports the installation of low carbon heating systems in homes in England and Wales. It replaces the Renewable Heat Incentive (RHI). Instead of the ongoing payments under the RHI, it provides a lump-sum up-front grant. You must use a Microgeneration Certification Scheme registered installer and meet the requirements of the scheme to get the grant. You can find out more about it on the gov.uk website: https://www.gov.uk/apply-boiler-upgrade-scheme/what-you-can-get

Comfort Take-Back (rebound effect)

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

ECO: Energy Company Obligation

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

Fabric First

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

FIT: Feed-in Tariff

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

GSHP: Ground Source Heat Pump

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

K (degrees Kelvin)

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

kWh: Kilowatt-hour

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

LETI: Low Energy Transformation Initiative

A network of built environment professionals working together to research and advocate actions to address the climate and ecological emergencies. www.leti.uk

MCS: Microgeneration Certification Scheme

This is a national standard for the certification of renewable and low-carbon products and installations. This includes things like solar photovoltaic panels and heat pumps. This provides some degree of assurance of the quality of an installation. It is a requirement for any installation for which you plan to claim the Renewable Heating Incentive (RHI) or other public funding.

MVHR: Mechanical Ventilation with Heat Recovery

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

MEV: Mechanical Extract Ventilation (Centralised)

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

MEV/dMEV: Mechanical Extract Ventilation (Decentralised)

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

PAS2035

PAS stands for Publicly Available Specification. These can be developed by any organisation, association or group who wish to document standardised best practice on a specific subject, both for the benefit of their industry and to help promote their expertise. However, it must be overseen by the BSI (British Standards Institute).

PAS2035:2019 covers the specification for the energy retrofit of domestic buildings, and is used in conjunction with PAS2030 for installers of insulation and the Microgeneration Certification Scheme MCS for heat pumps and solar panels. This is a requirement of some public funding for energy efficiency work, like ECO and Green Home Grant.

Performance gap

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

- sensible assumptions in design and modelling that properly consider the project brief
- care and attention to buildability in detailed design
- good quality control during construction
- an allowance for proper commissioning of systems on completion
- appropriate maintenance throughout the life of the building

Radon

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

Regulated emissions

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

RH: Relative Humidity

Relative humidity is a measure of how saturated with moisture the air is: how close it is to reaching its maximum holding capacity. It is expressed as a percentage. When RH is at 100%, the air is saturated. It has reached 'dew point' - so any more water added to the air will condense into liquid form.

An accepted healthy range for RH is 40 - 70%, though it's not always possible to stay below 70% RH in the mild but damp conditions that are often experienced in the UK in spring and autumn. On cold winter days, which are also drier, it should be possible to achieve this as long as your home is heated to a reasonable temperature - you may sometimes even find it gets a little dry.

Risks of condensation and mould increase when the internal temperature, and in particular surface temperatures, drop below 15°C for extended periods and relative humidity is high (this is one of the reasons why paying attention to thermal bridges is important). The duration of any peaks in RH is also important - a very short peak above 70% isn't likely to be problematic, but once this happens for several consecutive hours then the risk of mould increases.

RHI: Renewable Heat Incentive

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

Retrofit

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

Retrofit Academy

A training and development organisation for retrofit professionals.

SAP: Standard Assessment Procedure

SAP is the system used to assess energy use in UK homes. The UK government devised SAP as a way to compare homes and test them against Building Regulations. SAP forms the basis of the energy model used in this report.

SAP makes assumptions about the number of people living in a home and how it is heated and used, based on averages for the UK. You may not be 'average' and may use your home in different ways. So, SAP is not an exact predictive tool. In Home Retrofit Planner we have taken SAP as our base calculation methodology and adapted it so that we can adjust some of the key assumptions.

SAP model

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

SAP rating

Domestic buildings are given a SAP rating in the Building Regulations approval process for new-build homes. Energy Performance Certificates (EPCs) for sales and lettings of existing homes also include a SAP rating. The higher the SAP rating, the better the building is in terms of energy efficiency, carbon dioxide emissions and fuel costs.

The SAP rating is influenced by predicted energy use, carbon emissions and fuel costs. This means that the SAP rating is influenced by levels of insulation, how efficient your heating system and other services are, the type of fuel you use to heat and light your home, and whether you have any renewables. However, the SAP rating only covers regulated emissions. It does not cover appliances or cooking.

SEG: Smart Export Guarantee

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

SPAB: Society for the Protection of Ancient Buildings

A charity, founded by William Morris, that promotes the care of old buildings. They have collaborated with the STBA on research on responsible retrofit and building performance. They offer accredited building conservation training for professionals.

STBA: Sustainable Traditional Buildings Alliance

An organisation for building professionals interested in promoting sustainable approaches to the retrofit of older buildings.

Thermal ('Cold') bridge

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

Thermal imaging

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

Unregulated emissions

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

U-value

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

Vapour Open - Vapour Permeable and Hygroscopic (‘Breathability”)

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

It is an important consideration in retrofit, because older building materials are generally more vapour open than modern materials. This needs to be considered when suggesting changes to older buildings. Otherwise this risks the build up of damp, mould and condensation.

VAT

VAT - Value Added Tax - is a sales tax that applies to both goods and services in the United Kingdom. In some cases there are exemptions or discounts for energy efficiency work - though you must be careful to ensure that you meet all the required criteria if you are going to claim these. Seek specialist advice if you are uncertain from a suitably qualified accountant. You can find out more about it here: gov.uk/guidance/vat-on-energy-saving-materials-and-heating-equipment-notice-7086

Watt

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

Whole House Retrofit

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

W/K - Watts per degree Kelvin (heat loss)

This is the rate at which heat is lost through a building element. It is measured in Watts per degree of temperature difference between inside and outside, in degrees Kelvin.

Zero Carbon / Net Zero Carbon

If a building or service is ‘zero carbon’ it results in no carbon dioxide emissions. Most often this is qualified by ‘in use’ meaning that whilst it might have taken energy and resources to create - which result in carbon emissions - during its use phase there are no associated emissions. So in the case of a house, the energy used by a house during its occupation does not result in carbon emissions.

‘Net Zero Carbon’ means that there are still some carbon emissions associated with the building or service - but these are offset in some way. This might be over time - so for example a house generates as much electricity as it uses in a year from solar panels, but still needs to use electricity from the national grid that has associated carbon emissions at times when the solar panels are not generating. Alternatively the home may use a fuel, such as a form of biomass, which in theory is ‘zero carbon’ because new biomass growth will absorb the resulting carbon emissions. However this is a carbon accounting minefield, and can lead to perverse incentives.This is why we prefer the term ‘Zero Carbon Ready’. By reducing the energy use and stopping burning fuels in our homes, we can make them ready for a time when the energy supplied to our homes is truly zero carbon and help speed this along by reducing the amount of infrastructure investment required to achieve this decarbonised energy supply.

Appendix C

Modelling Methodology

Home Retrofit Planner is a bespoke modelling tool, based on the full version of the 'Standard Assessment Procedure' (SAP). This is the UK's national methodology for calculating the energy performance of domestic buildings. This model is a useful representation that allows different approaches to be compared. It does not produce guaranteed absolute predictions and should not be treated as doing so. We strive to be accurate, but understand that any model is an approximation. It can be helpful in comparing options, but cannot fully reflect reality. It's often not possible for us to identify all variables and match your existing energy use perfectly, especially if your patterns of use have changed over time or your bill data is incomplete or estimated. For this reason we also report on things that aren't affected by this - including heat loss and peak heat load.

Home Retrofit Planner and SAP are based on a 'steady state' heat loss model. This calculates the average annual heat loss from your home, and consequently the amount of energy needed to heat it from your heating system. Alongside this there are separate but related calculations for energy use from lighting, appliances, cooking and other building services.

Home Retrofit Planner is based on a number of key assumptions, in common with SAP. We have also adapted or amended some of these - as described below:

- **Climate:** When producing EPCs SAP uses a 'national average' climate dataset. Instead We use climate data for the region of the UK that your home is in. This should be more accurate for your particular home - but these assumptions may not prove true in any given year. So if there is a colder or milder winter than average your home may use more or less energy than predicted here.
- **Occupancy:** We use the actual number of people who live in your home in our calculations. This is in place of assumption based on floor area that SAP generates. This should help make the model more accurate.
- **Heating Target Temperature:** When calculating heating demand, SAP assumes a temperature of 21°C in your living area. We deliberately deviate from this. In the baseline model we use your current target temperature for your heating system, if this is known. This is the temperature your thermostat is normally set at. If this is not known we assume an average target temperature in the existing condition of 20°C - though we may adjust this if we have reason to believe it is actually much higher or lower. In the future scenarios we will generally use a target temperature of 20°C, even if at the moment you generally keep your home cooler. This allows for some 'comfort take back' to occur. Even if you prefer your home to be cooler than this. Generally we would never assume an internal temperature of less than 18°C in modelled future scenarios - this is to ensure the model is set at a level which is generally agreed to be healthy.
- **Heating Period:** SAP would normally assume a standard number of hours for the heating system to be on in your home. In Home Retrofit Planner we adjust this to more closely reflect how you live in your home, based on information provided by you. We still also provide a comparison of this in the space heating demand graph above.

- **Existing Construction Information:** When carrying out a standard SAP assessment for regulatory compliance the assessor must assume the worst for any element of the construction unless they have official documentation. So for example, unless they have certificates from installers and good photographic evidence they cannot assume that an existing inaccessible floor is insulated. This is so that buildings cannot 'pass' the regulations without proper checks. A Home Retrofit Planner assessment is carried out for a different purpose - that is to help you make decisions about future improvements to your home. For that reason we are less prescriptive about the evidence we require for some elements. This means that if you know that an inaccessible part of the structure was insulated - like a roof or floor - and can provide us with some details, we can include these in our modelling assumptions. This should enable a greater degree of accuracy and avoids the risk of exaggerating potential savings by assuming that your home performs at the moment than in reality.
- **Chimneys and Flues:** The current standard assumptions in SAP for heat loss from vents and flues has been shown by recent research to be conservative. We have therefore used the figures from this research in their place.
- **Appliances and Cooking:** We use a bespoke calculation for energy use from appliances and cooking that takes into account the actual appliances you own, rather than making standard assumptions based on floor area. We include the result from this in the overall results so that it includes the total energy use of your home, not just those parts covered by the building regulations. We don't make recommendations about improvements to appliances in the model - so any savings you are able to make by improving the efficiency of appliances as you replace them will be in addition to those outlined in this report (unless you have a stove that contributes to heating).
- **Carbon Factors:** Different fuels have different average annual rates of carbon emissions associated with them. This is changing quite rapidly as the national electricity grid decarbonises. We aim to use the latest recognised carbon factors in our modelling, rather than waiting until those used for building regulations purposes are updated - and these are stated in the report above.
- **Cost of Fuel:** We use standard assumptions for the costs of different fuels in our modelling. This is because it is more appropriate in this report to concentrate on the performance of the building and its services than any current deal you have with your energy provider (which in any case is likely to change over time). This enables simpler comparison over time and between properties. We aim to update these on a regular basis.
- **Suggested Measures:** Whilst changing the physical properties of your home, as suggested in this report, should make a positive contribution towards energy saving, the actual amount of energy saved will vary. It will depend on how you use your home, the order in which the works are done, and how closely they match the assumptions made in this report. Measures related to building services are more difficult to predict. For example, the use of electrical appliances, hot water and cooking varies significantly between households and over time. Similarly the savings available from improved heating and ventilation systems will depend on the quality of their installation, commissioning, control systems and maintenance.
- **Scenario Planning:** We present the findings from the modelling in three scenarios. This allows us to adapt our suggestions to what you told us and map out potential routes for action so you can see the possibilities available to you. We don't necessarily expect you to pick one of these scenarios and rigidly stick to it. Most often what you eventually choose to do may be a mix of things from several scenarios. It's important however to make sure that your planned improvements work well together and do not create any unintended consequences. You may need to seek further advice on this.

Appendix D

Data sources

The calculations that went into this report use data from various sources.

Elevation data

We use publically available data sources to work out the elevation (height above sea level) of your building.

Your report may have been produced using elevation data from the Copernicus project. This elevation data was provided with funding from the European Union. This does not mean that this report is endorsed by the European Union.

Subsidence data

Soil heave risk