Home Retrofit Scenarios

Prepared for
A N Other

Address
Taigh Beag

Local Authority Area
Tir Na Nog

Survey visit
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Report by
A N Surveyor

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PEOPLE POWERED RETROFIT

This report was generated by People Powered Retrofit Limited's 'Home Retrofit Planner' software. It 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.

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 survey 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 surveyor, 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

PLEASE NOTE THIS IS A DUMMY REPORT - It is based on real situations we have come across but is not wholly representative of a real existing house or project.

The house is a late 19th century mid-terrace with a square plan and a ground floor bay window, but no outrigger or roof extensions.

You are in the process of buying this house and plan to move in later this year. You'd like to do as much as possible before you move in that involves disruption, to avoid having to live in a building site. Making the house comfortable and decarbonising the heating system are your main priorities. Saving money on bills isn't as significant - but you'd like to reduce the impact of future bill rises by making your home as energy efficient as possible.

1.2 Current context and logic of scenarios

We've arranged the scenarios so that the works that will be messy and disruptive are all kept together in the first set of works so that you can do all this before you move in. This includes improving ventilation and decarbonising the existing heating system by installing a small air source heat pump, as well as floor and wall insulation works and new windows and doors.

We've included the changes you said you wanted to make, removing the back door in the kitchen and installing new french/patio doors from the dining room. (The space left in the kitchen would be a good place to build a cupboard for your new hot water storage - right next to the space on the external wall that would be a good spot for the external unit on your new heat pump).

We then suggest some further steps that could be taken to improve comfort and energy efficiency while you're living in the house. These are focused on the front elevation - adding internal wall insulation and new windows. This may still require some disruption, but it is contained and there is the potential to do the messiest internal wall insulation works one room at a time.

We have included an alternative that gets you to roughly the same point, but using wholly internal insulation measures to the rear - taking account of the fact you're in a row of flat-backed terraced houses, and so stepping the insulation out here might be difficult.

Finally we add mechanical ventilation with heat recovery to show the impact this might have, if you can fit it in your budget and you're able to accommodate the additional disruption and building work for ducting etc. associated with this. Though we've shown it in a later scenario, we'd strongly suggest this work is done as part of the disruptive works before you move in if at all possible.

1.3 Scenario 1: Ground floor and disruptive works

In this scenario we've included the key things it's probably best to get done before you move in - like the insulation to the floor and the heating and ventilation systems that will cause some disruption in the kitchen and bathroom. As you've said you plan to replace the kitchen and bathroom, and also make some changes to the layout downstairs, it makes sense to do all of this at once.

We've also included external wall insulation to the rear - as you're also planning to reroof and the area of wall here is small, this is a relatively small additional cost and should make a difference to comfort. Since you're also rearranging windows and doors on this rear wall at the same time, we've also assumed these are replaced. This should mean you get the maximum benefit from this work.

1.4 Scenario 2: Front elevation works.

In this scenario we have simply added new windows and internal wall insulation to the front of the house. This is assuming that this work would more easily be done at a later date as these are rooms you've said you probably wouldn't use much.

1.5 Scenario 3: Alternative - Internal wall insulation and suspended timber floor retained

In this scenario we've tested an alternative solution that looks to install only internal wall insulation and rather than insulating the ground floor by replacing it with a new solid floor, we've suggested simply insulating the existing suspended timber floor. It achieves a similar outcome to the two scenarios outlined above.

It would however make infilling of the old back door position and changing window sizes on the back wall as planned a bit trickier - with a need for visible mending on the outside face. It would also mean that the external face of the rear wall may need some remedial work.

1.6 Scenario 4: Sceanrio 2 plus MVHR and PV

In this scenario we have simply added mechanical ventilation with heat recovery and solar PV to the measures outlined in scenario 2, so you can see the impact of these technologies.

Installing PV may be best done at the same time as reroofing - however we know that your budget might not stretch to this and whilst it would help with bills, it would do little for your primary aim of improving comfort.

Installing MVHR is best done with other disruptive work internally - though as heat loss from your home is already low, the benefit of this would be relatively marginal in energy terms in your case. Its main benefits would be in terms of improved indoor air quality and better sound insulation from outside.

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

With internal wall insulation a likely part of the works, especially to the front, you'll need to make a careful examination of the existing condition of the external face of these walls to make sure they are in good condition and suitable, with minimal risk of moisture ingress. At the least the gutters on the front elevation need some attention - though you have suggested you are replacing these as part of the planned re-roofing works.

A key decision will be whether to insulate the rear of the house with external or internal wall insulation. This may come down to practicalities and timescales. The junction to the neighbouring houses may be simpler in internal wall insulation, with the added potential to phase these works if required. External wall insulation may be the better solution for moisture risk and because space in the bathroom and kitchen is limited. The external brickwork on the rear of the house especially is not in perfect condition, and may need some attention and remedial work either way. You should also double check which way the floor joists run here. (This was not possible during our visit as you do not yet own the house and it would have required floor coverings to be lifted and potentially damaged).

Similarly, you need to decide whether to insulate the ground floor by creating a new solid floor or by insulating the existing floor. A solid floor is likely to be more expensive but quicker to do and achieves a good airtight finish. It will be more likely to be flood resilient if detailed properly - though your property is not in a flood risk zone, it is adjacent to an area where surface water flooding is a risk. A suspended floor will be cheaper in materials but may take longer and be more labour intensive to create a good airtight finish. It will also be more susceptible to moisture damage in future.

In all of the reported scenarios we've assumed you'd install a centralised mechanical extract ventilation system, with a reasonable level of airtightness, to extract from kitchen and bathroom. This could easily sit within the first floor airing cupboard, in place of the existing gas boiler. However, if you chose to - and had the budget and the ability to cope with some further disruption - you could look to install a heat recovery ventilation system and push airtightness works further. We've shown this in scenario 4.

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	Ground floor and disruptive works
Scenario 2	Front elevation works.
Scenario 3	Alternative - Internal wall insulation and suspended timber floor retained
Scenario 4	Sceanrio 2 plus MVHR and PV

We model your home based on the data taken by the surveyor 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

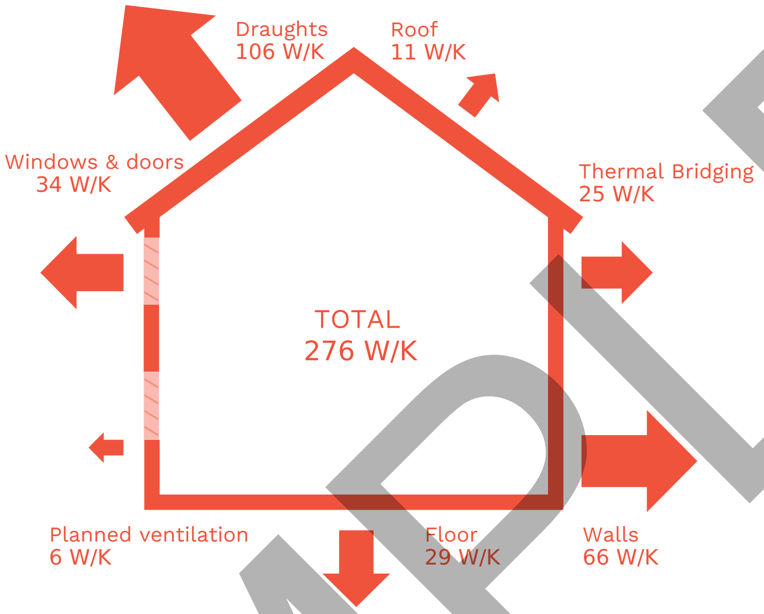
2.1.1 Heat loss

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.

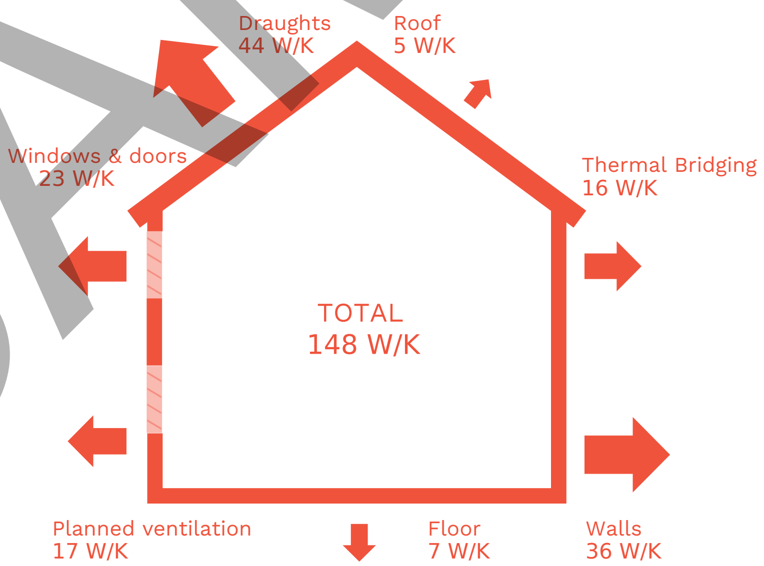
The better insulated and draughtproofed your home, the slower this heat loss happens, so the less energy is needed to keep your home warm and the more comfortable it will be. The figure below compares the relative heat loss of each element across your home now and in the retrofit scenarios we have developed 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

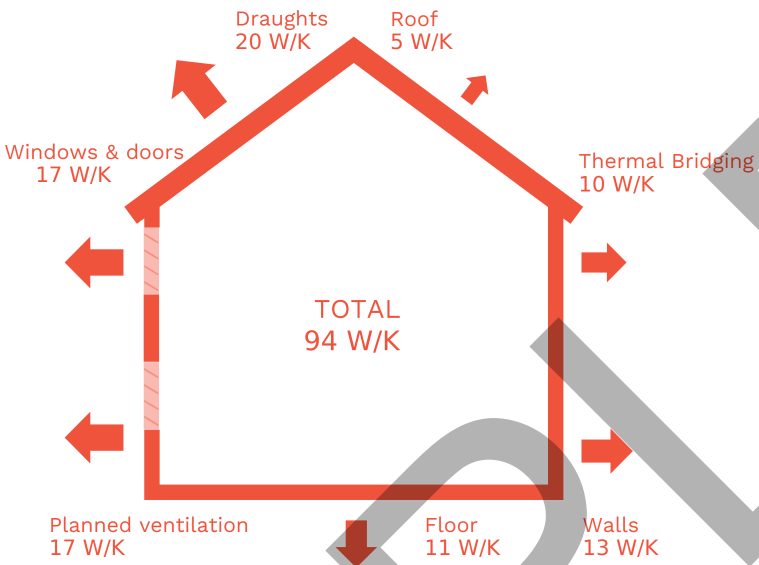
Baseline (Your Home Now)



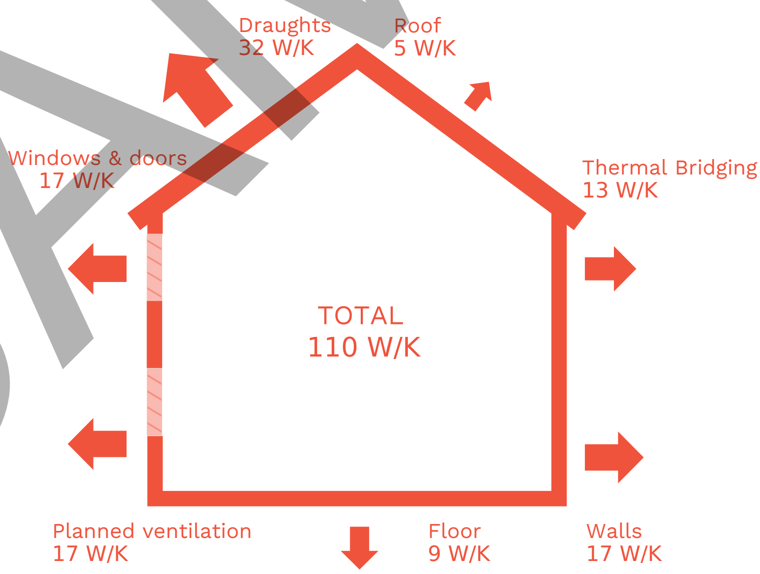
Scenario 1: Ground floor and disruptive works



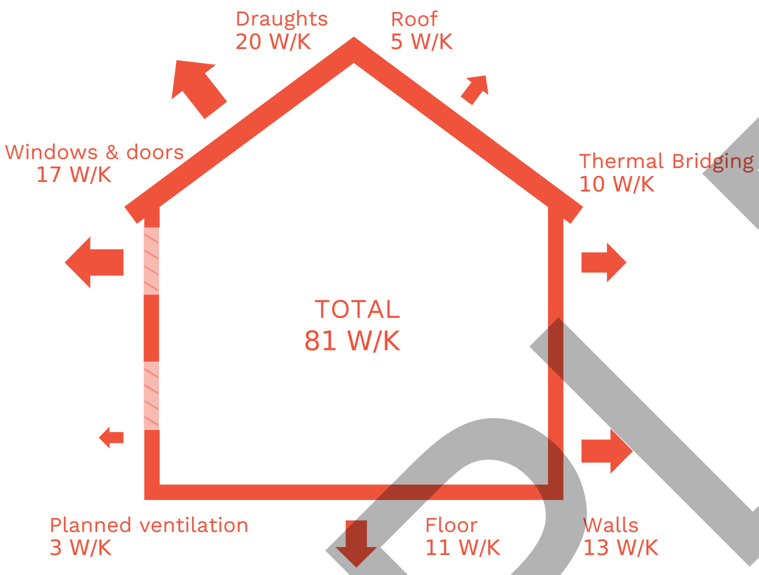
Scenario 2: Front elevation works.



Scenario 3: Alternative - Internal wall insulation and suspended timber floor retained



Scenario 4: Sceanrio 2 plus MVHR and PV



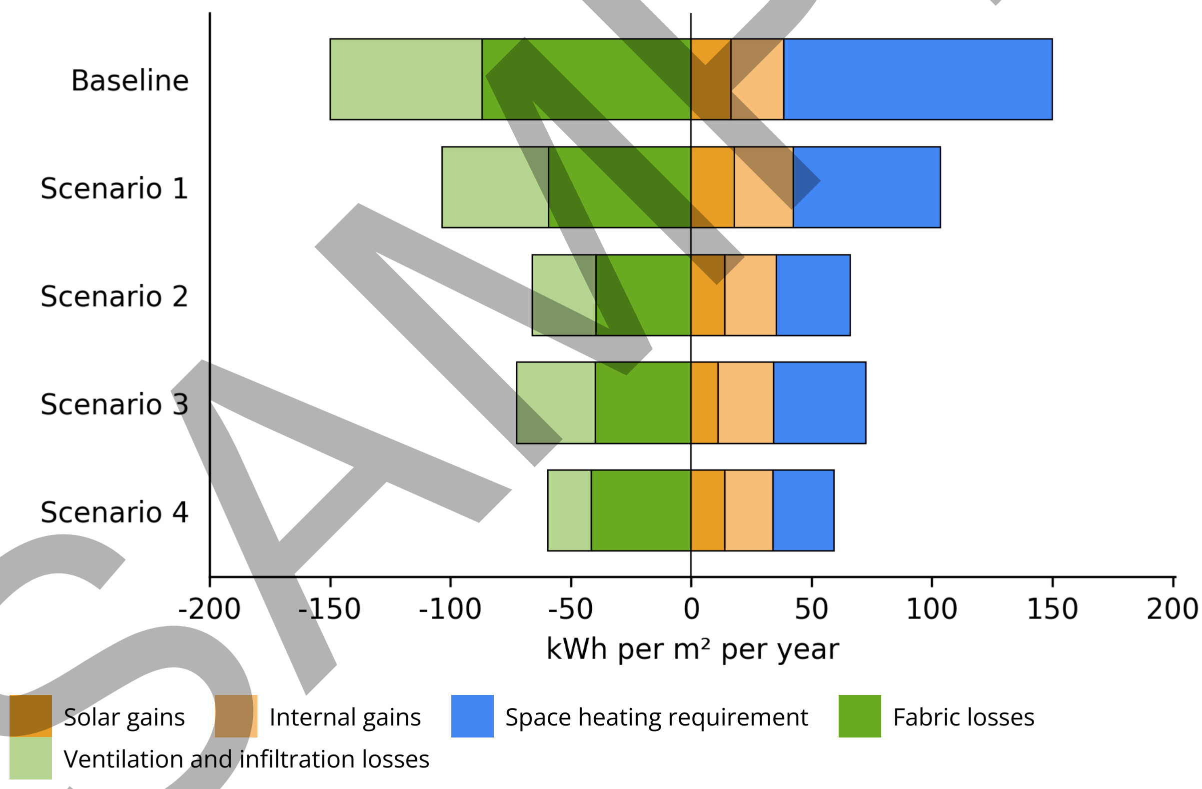
2.1.2 Heat balance

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 survey, 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/m²·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).

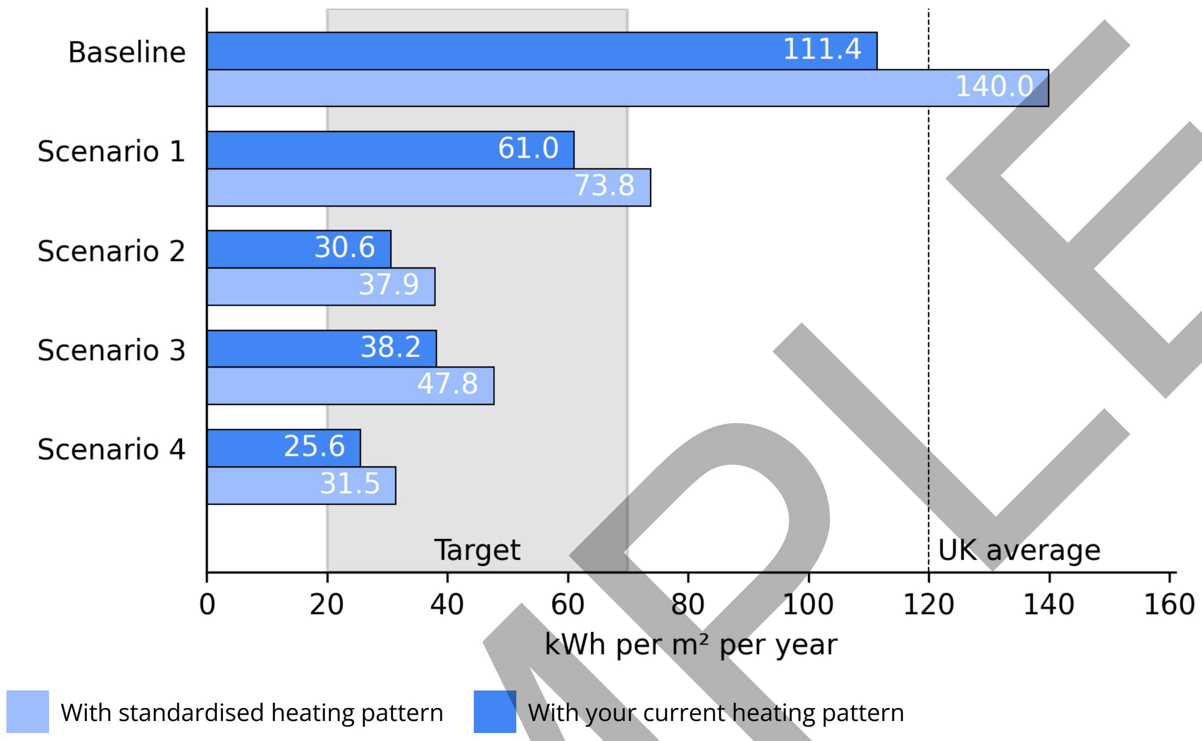
Space Heating Demand is affected by the shape of your home. If your home is complicated or has a large exposed surface area compared to its floor area (known as 'form factor'), it will need more energy to heat it than a simpler building with less exposed area of the same size, even if they are built 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: West Pennines Wales / West Pennines England
- Heating on for: 5 hours 30 minutes on weekdays and 7 hours at weekends (current); 9 hours each day (standardised)
- Baseline target temperature: 20°C (current), 21°C (standardised)
- Scenario 1 target temperature: 20°C (current), 21°C (standardised)
- Scenario 2 target temperature: 20°C (current), 21°C (standardised)
- Scenario 3 target temperature: 20°C (current), 21°C (standardised)
- Scenario 4 target temperature: 20°C (current), 21°C (standardised)

If your current thermostat setting is below 18°C, we have increased it in the retrofit scenarios to 18°C as a minimum, and to 20°C in deeper retrofit scenarios. We do this because we believe that health is as important as saving energy. 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

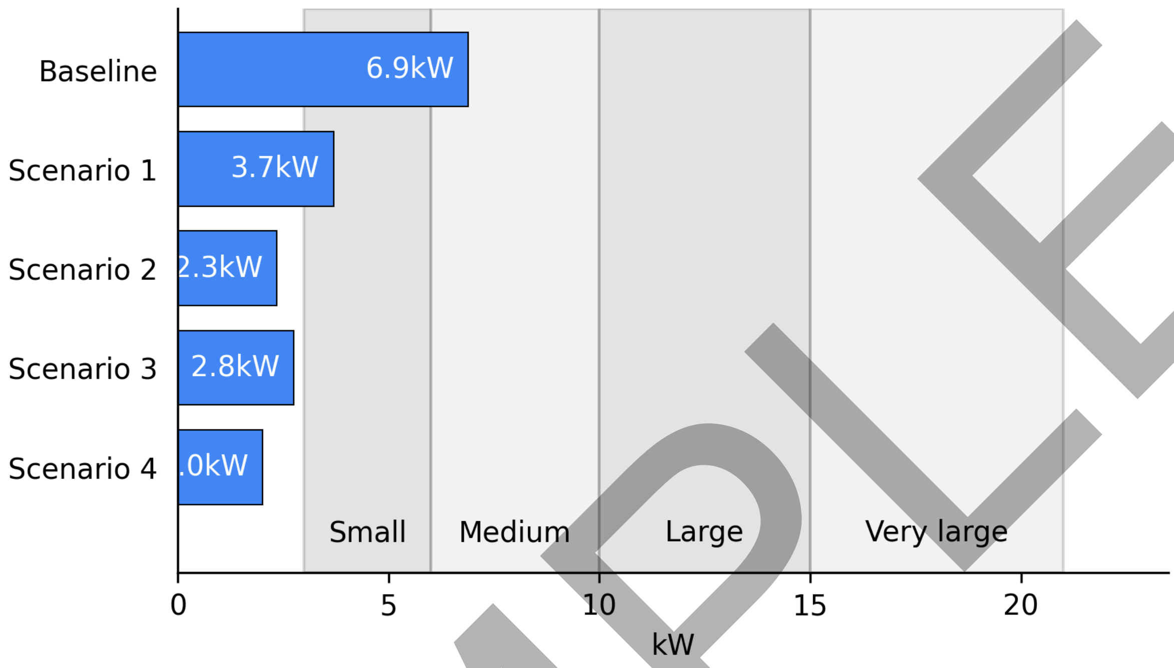
Peak heat load is an indicator of the heating power needed to maintain a comfortable temperature in your home on the coldest days of the year. It is important because it should be used to inform the design of your space heating system. An oversized heating system, capable of providing more heat than 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



Peak heat load per square metre

Baseline	88.0 W/m²
Scenario 1	47.0 W/m²
Scenario 2	30.0 W/m²
Scenario 3	35.0 W/m²
Scenario 4	26.0 W/m²

Key assumptions

- Lowest external temperature (design temp) assumed to be -4°C
- Internal target design temp assumed to be 21°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 loss 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.

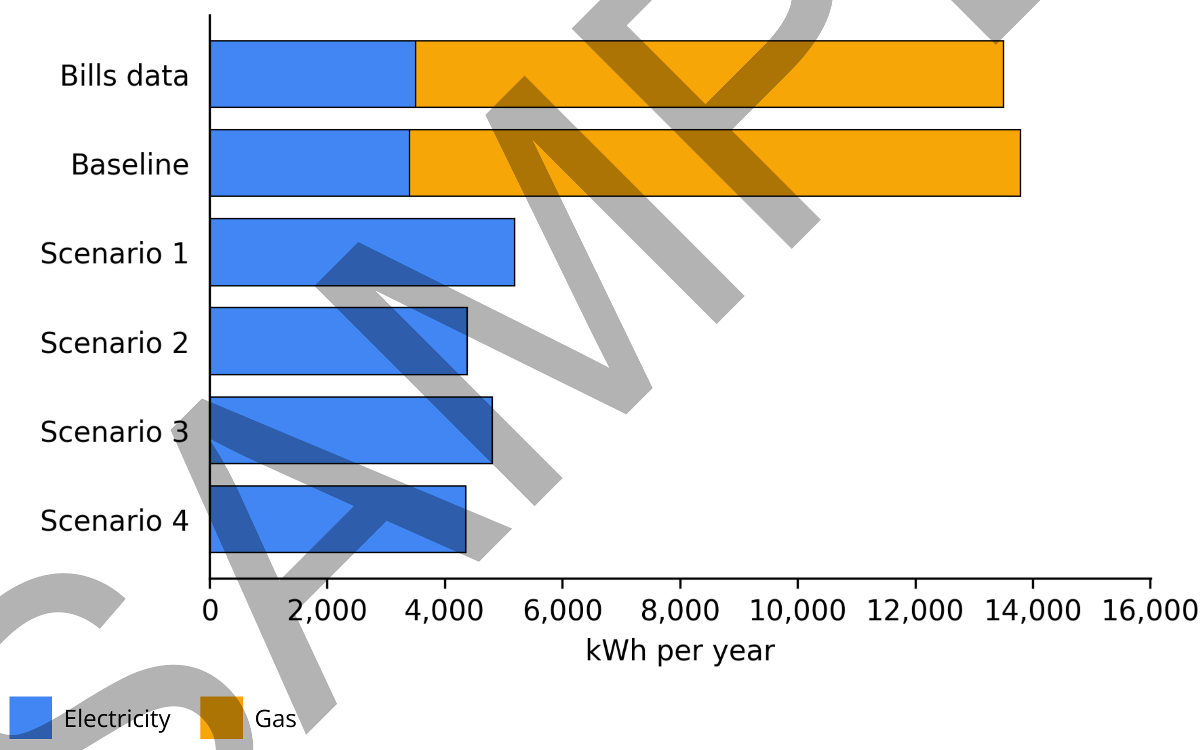
2.2.2 Fuel Mix

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

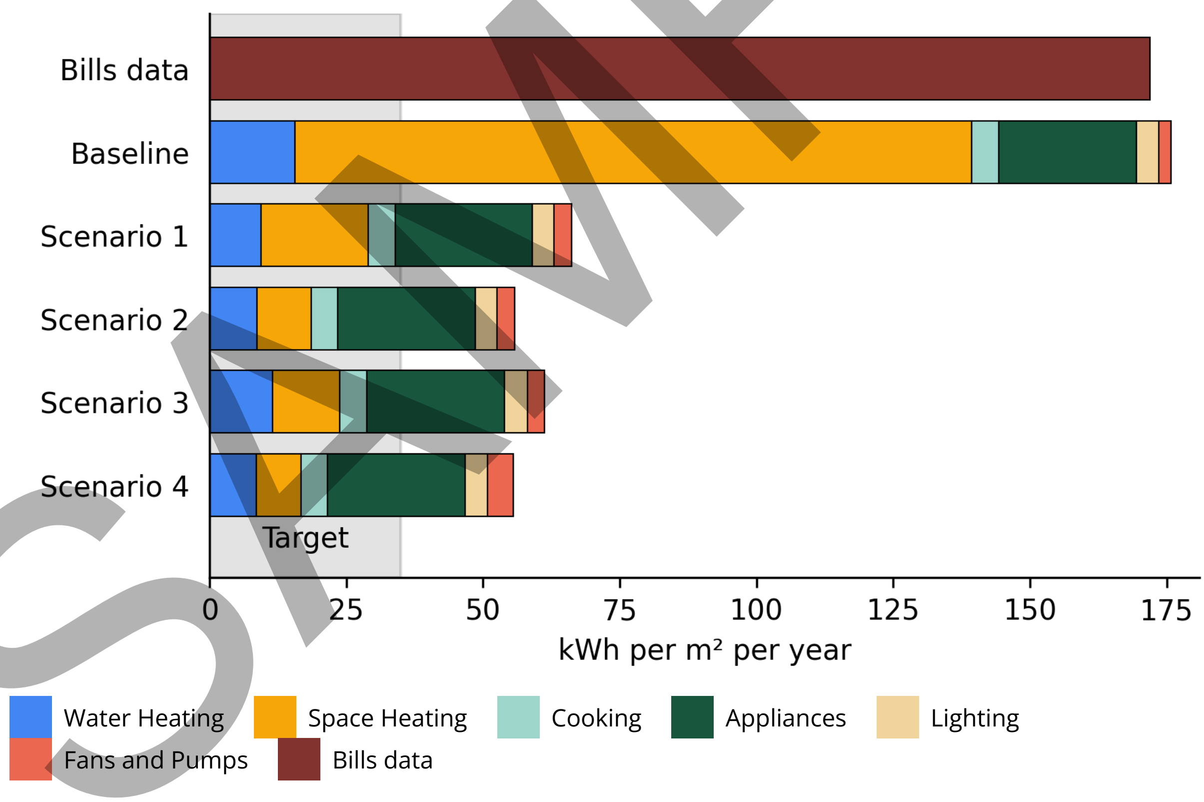
2.3.1 Energy Use Intensity

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 target zone is the LETI Zero Carbon target.

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.

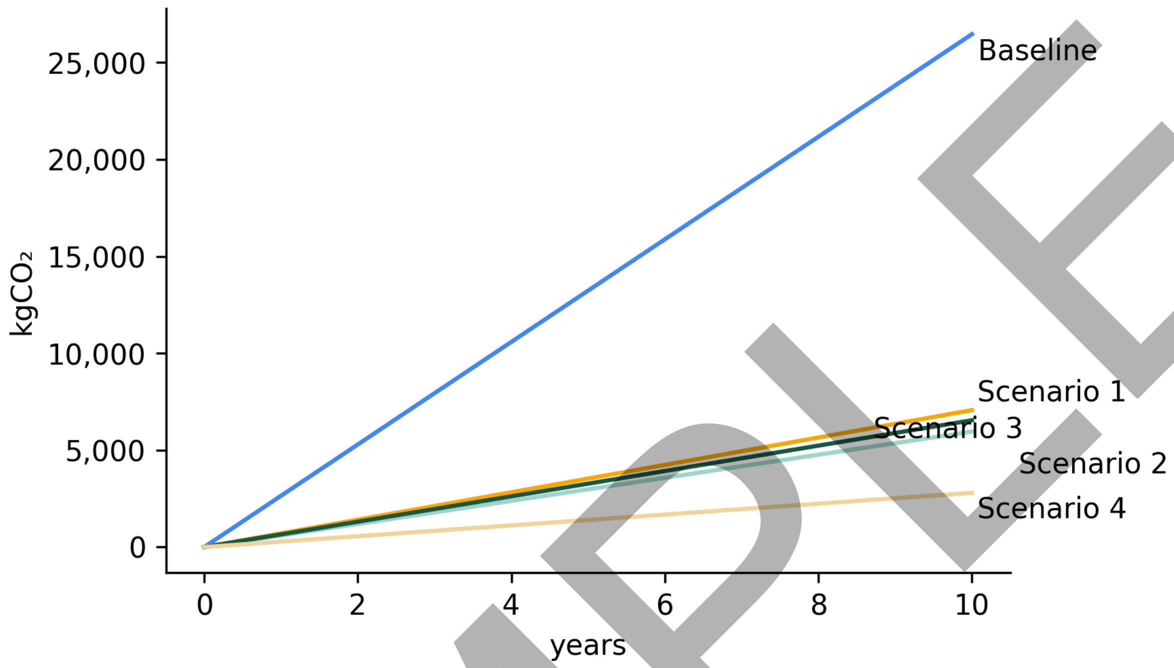
By applying an average 'carbon factor' to each of the fuels used in your home, we estimate that your home-related carbon emissions are:

	Whole home	**Per person**
Baseline	2646 kgCO2e/year	1323 kgCO2e/year
Scenario 1	706 kgCO2e/year	353 kgCO2e/year
Scenario 2	596 kgCO2e/year	298 kgCO2e/year
Scenario 3	654 kgCO2e/year	327 kgCO2e/year
Scenario 4	280 kgCO2e/year	140 kgCO2e/year

The figures above assume you have 2 people living in your home.

The graph below shows the approximate cumulative carbon dioxide emissions from the fuel used in your home over a ten year period 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 the fuels used is measured in kilograms of carbon dioxide per kilowatt hour of fuel used ($kgCO_2/kWh$). We base this on a projected future average 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:

- Standard Tariff - 0.136 $kgCO_2/kWh$
- Mains Gas - 0.21 $kgCO_2/kWh$
- generation - 0.136 $kgCO_2/kWh$

For gas, electricity and most other fuels these figures are published by the government and updated as change occurs in the system. They are a projected future average over 15 years, the assumed lifetime of the average heating system.

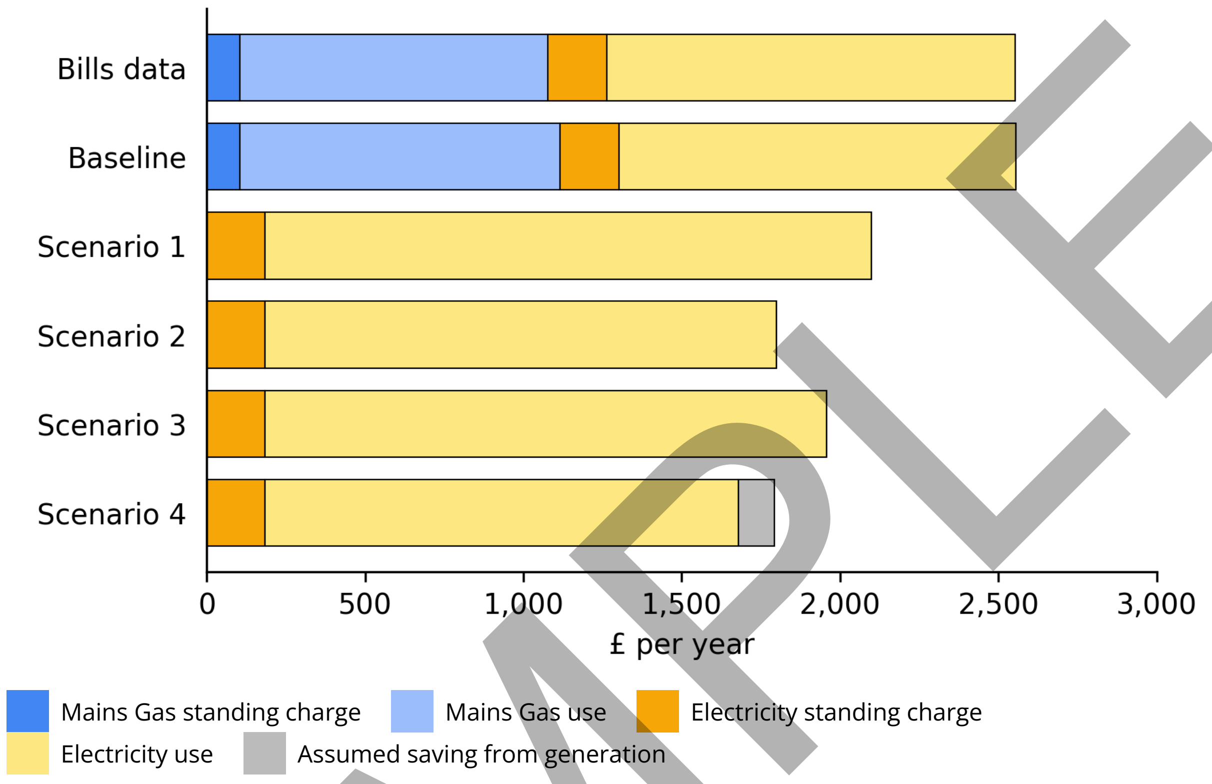
Note that any electricity 'generation' measures, such as solar panels, are also assigned a carbon factor. This is so that we can account for the electricity that you use directly from these sources at home, displacing grid electricity.

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: Standard Tariff, £0.37/kWh, standing charge £185.0
- Fuel Type 2: Mains Gas, £0.1/kWh, standing charge £104.0
- Fuel Type 3: generation, £0.19/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 4 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	Ground floor and disruptive works
Scenario 2	Front elevation works.
Scenario 3	Alternative - Internal wall insulation and suspended timber floor retained
Scenario 4	Sceanrio 2 plus MVHR and PV

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: Ground floor and disruptive works

- Estimated net budget cost of this scenario £30310 + VAT and on costs

ID	Name	Label/ location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
1.1	EWI to solid masonry wall (c. 120-150mm thick)	Ground Floor Rear Elevation	0.25 W/m2.K	Comfort, Carbon Emissions, Fuel Bills	£3350	Specialist Installer	HIGH
1.2	Top up loft insulation	Main Roof	0.11 W/m2.K	Fuel Bills Carbon Emissions Comfort	£800	DIY or General Contractor	MINIMAL
1.3	75mm rigid insulation between nominal 100mm rafters to pitched roof	Crooked Eaves	0.35 W/m2.K	Comfort Carbon Emissions Fuel Bills	£450	Roofing Contractor/ General Contractor/ DIY	HIGH/ MEDIUM (if fitted from above)
1.4	New insulated solid floor	Ground Floor	0.2 W/m2.K	Comfort Carbon Emissions Fuel Bills	£4650	General Contractor	VERY HIGH
1.5	Insulated Part-glazed External Door	Front Door	1.1 W/m2.K	Comfort Carbon Emissions Fuel Bills	£1600	General Contractor/ Joiner	MEDIUM
1.6	High Performance Double-Glazed Window	Fanlight	1.2 W/m2.K	Comfort Carbon Emissions Fuel Bills	£340	General Contractor/ Window Fitter	HIGH

ID	Name	Label/ location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
1.7	EWI to solid masonry wall (c. 120-150mm thick)	First Floor Rear Elevation	0.25 W/m2.K	Comfort, Carbon Emissions, Fuel Bills	£3350	Specialist Installer	HIGH
1.8	High Performance Triple Glazed Window	Various	0.9 W/m2.K	Comfort Carbon Emissions Fuel Bills	£1800	General Contractor/ Window Fitter	HIGH
1.9	Chimney Balloon/ Pillow (low level)	Front Bedroom		Comfort, fuel bills, carbon.	£35	DIY	MINIMAL
1.10	Chimney Balloon/ Pillow (low level)	Back Bedroom		Comfort, fuel bills, carbon.	£35	DIY	MINIMAL
1.11	Advanced Draughtproofing	Whole house	Air permeability approx 7.5 m^3/m^2.hr50pa	comfort, fuel bills, carbon.	£600	DIY/ General Contractor	MEDIUM
1.12	High Quality Whole House Mechanical Extract Ventilation (MEV)	Whole house	Detailed system specification required.	Indoor air quality, reducing risk of condensation and mould	£1500	Approved Installer	MEDIUM
1.13	New hot water cylinder, 130-170 litre, 120mm factory fit insulation	Whole house	--	Fuel bills, Carbon, Potential for Demand Response and Energy Storage	£500	Plumber	MEDIUM

ID	Name	Label/ location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
1.14	All primary circuit hot water pipes fully insulated.	Whole house	--	Fuel bills, comfort (overheating)	£100	DIY/ General Contractor	MEDIUM
1.15	Advanced controls to hot water store	Whole house	--	Fuel bills, comfort	£200	Plumber/ Electrician	MINIMAL
1.16	High Quality Air Source Heat Pump (ASHP)	Whole house	SPF of 3.1 or more	Carbon Emissions, Fuel Costs	£11000	MCS accredited installer	MEDIUM

Scenario 2: Front elevation works.

- **This scenario assumes the measures in scenario 1 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £14750 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £45060 + 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	IWI to masonry wall (c. 80mm)	Ground Floor Front Elevation (inc. bay)	0.4 W/m2.K	Comfort, Carbon Emissions, Fuel Bills	£2550	Specialist Installer	HIGH
2.2	Insulation to exposed timber floor (c.175mm)	Ground Floor	0.25 W/m2.K	Comfort Carbon Emissions Fuel Bills	£3100	DIY/General Contractor	MEDIUM/HIGH (depending on access)
2.3	High Performance Triple Glazed Window	Bay South	0.9 W/m2.K	Comfort Carbon Emissions Fuel Bills	£650	General Contractor/ Window Fitter	HIGH
2.4	High Performance Triple Glazed Window	Bay Middle	0.9 W/m2.K	Comfort Carbon Emissions Fuel Bills	£1000	General Contractor/ Window Fitter	HIGH

ID	Name	Label/location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
2.5	High Performance Triple Glazed Window	Bay North	0.9 W/m2.K	Comfort Carbon Emissions Fuel Bills	£650	General Contractor/ Window Fitter	HIGH
2.6	IWI to masonry wall (c. 80mm)	First Floor Front Elevation	0.4 W/m2.K	Comfort, Carbon Emissions, Fuel Bills	£2250	Specialist Installer	HIGH
2.7	High Performance Triple Glazed Window	Front Bedroom, Box Room	0.9 W/m2.K	Comfort Carbon Emissions Fuel Bills	£1650	General Contractor/ Window Fitter	HIGH
2.8	Cap and Fill Chimney	Front Bedroom		Comfort, fuel bills, carbon.	£350	General Contractor	MEDIUM
2.9	Cap and Fill Chimney	Back Bedroom		Comfort, fuel bills, carbon.	£350	General Contractor	MEDIUM
2.10	Cap and Fill Chimney	Living Room		Comfort, fuel bills, carbon.	£350	General Contractor	MEDIUM
2.11	Cap and Fill Chimney	Dining Room		Comfort, fuel bills, carbon.	£350	General Contractor	MEDIUM
2.12	Advanced air-tightness Works	Whole house	Air-permeability - $3m^3/m^2.hr50pa$	Comfort, fuel bills, carbon.	£1500	General Contractor	HIGH

Scenario 3: Alternative - Internal wall insulation and suspended timber floor retained

- Estimated net budget cost of this scenario £36120 + VAT and on costs

ID	Name	Label/ location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
3.1	Top up loft insulation	Main Roof	0.11 W/m2.K	Fuel Bills Carbon Emissions Comfort	£800	DIY or General Contractor	MINIMAL
3.2	50mm rigid insulation between nominal 75mm rafters to pitched roof	Crooked Eaves	0.5 W/m2.K	Comfort Carbon Emissions Fuel Bills	£350	Roofing Contractor/ General Contractor/ DIY	HIGH/ MEDIUM (if fitted from above)
3.3	Insulation to suspended timber floor (c.175mm)	Ground Floor	0.2 W/m2.K	Comfort Carbon Emissions Fuel Bills	£3100	DIY/General Contractor	MEDIUM/HIGH (depending on access)
3.4	IWI to solid masonry wall (c. 80mm)	Various	0.4 W/m2.K	Comfort, Carbon Emissions, Fuel Bills	£9500	Specialist Installer	HIGH
3.5	High Performance Triple Glazed Window	Various	0.9 W/m2.K	Comfort Carbon Emissions Fuel Bills	£7500	General Contractor/ Window Fitter	HIGH
3.6	Chimney Balloon/ Pillow (low level)	Front Bedroom		Comfort, fuel bills, carbon.	£35	DIY	MINIMAL

ID	Name	Label/ location	Performance target	Benefits (in order)	Cost	Completed By	Disruption
3.7	Chimney Balloon/ Pillow (low level)	Back Bedroom		Comfort, fuel bills, carbon.	£35	DIY	MINIMAL
3.8	Advanced air-tightness Works	Whole house	Air-permeability - $3m^3/m^2$.hr50pa	Comfort, fuel bills, carbon.	£1500	General Contractor	HIGH
3.9	High Quality Whole House Mechanical Extract Ventilation (MEV)	Whole house	Detailed system specification required.	Indoor air quality, reducing risk of condensation and mould	£1500	Approved Installer	MEDIUM
3.10	New hot water cylinder, 130-170 litre, 120mm factory fit insulation	Whole house	--	Fuel bills, Carbon, Potential for Demand Response and Energy Storage	£500	Plumber	MEDIUM
3.11	All primary circuit hot water pipes fully insulated.	Whole house	--	Fuel bills, comfort (overheating)	£100	DIY/ General Contractor	MEDIUM
3.12	Advanced controls to hot water store	Whole house	--	Fuel bills, comfort	£200	Plumber/ Electrician	MINIMAL
3.13	High Quality Air Source Heat Pump (ASHP)	Whole house	SPF of 3.1 or more	Carbon Emissions, Fuel Costs	£11000	MCS accredited installer	MEDIUM

Scenario 4: Sceanrio 2 plus MVHR and PV

- **This scenario assumes the measures in scenario 2 have already been carried out, and adds to them**.
- Estimated net budget cost of this scenario £12600 + VAT and on costs
- Estimated net budget cost of all works to this point **where scenarios are additive**: £57660 + 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	High Quality Mechanical Ventilation with Heat Recovery (MVHR)	Whole house	Detailed system specification required.	Indoor air quality, reducing risk of condensation and mould	£8000	Specialist Installer	HIGH
4.2	Solar Photovoltaic Panels - Medium System	Whole house	2.7kWp	Reduced Carbon Emissions, Fuel Cost Savings	£4600	Specialist Installer MCS accredited.	MEDIUM

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% might be more appropriate. 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 surveyor 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.gsa.ac.uk/media/486640/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 **long term (10 years plus)**.

You told us that you **do not** envisage any significant changes to your lifestyle.
Comment: One adult already mostly working from home.

You told us that you **are** planning other building works in your home.
Comment: Replacement bathroom and kitchen (incluidng induction hob). Knocking through from kitchen into dining room.

You hope to start retrofit work on your home in the next **3–6 months**.

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:

1. Save carbon
2. Improve comfort
3. Save money

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

You told us that you **wouldn't mind changing** the appearance of your home inside.
You told us that you **wouldn't mind changing** the appearance of your home outside.

Comment: Round the back easier to change than the red facing brick at the front.

4.3 Logistics

You told us that you plan to do the work **in phases**.
You told us that you **were** willing to do some of the work yourself.

When thinking about the disruption involved you told us that you would be willing to live with **moving out for several months**.
Comment: Would like to get the most disruptive work internally done before moving in.

You told us you **had a budget in mind**.
Comment: £30,000 or so for first phase of works.

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: Mid-terrace
Number of bedrooms: 3
Gross internal floor area: 78.5m²

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 survey, the general construction of the property is as follows:

Floors:

Suspended timber to whole ground floor. Void below of about 600mm.

Walls:

Solid brick to rear, facing brick with small cavity to front.

Roof:

Concrete tile - approx 40 years old - on original 19thC roof timbers.

Windows and doors:

Double glazed uPVC, varying ages installed over last 20 years.

Rainwater and drainage goods:
Original iron at front. Mix of plastic of various ages at the rear.

Evidence of moisture ingress or leaks (including internal):
Some dampness at low level next to bay window and in southern corner of dining room. Probably needs to be replastered.

4.4.3 Works already undertaken

You told us you had already made the following improvements to your home:
New condensing gas boiler fitted 3 years ago by previous resident. Double-glazed uPVC windows to the rear about 5 years ago - windows on the front when they first moved in about 20 years ago.

4.4.4 Past, Current and Potential Structural Issues

You told us: None known.

4.4.5 Damp, condensation or mould

You told us: Damp in corner at low level by bay window at front and in corner of dining room at rear.

We noted that: At front looks like this might be caused by external paving at front bridging DPC and bounding water up wall. At rear looks like could be to do with connection to gerden wall.

4.4.6 Heating and water services

Your space heating is currently provided by: Combi condensing boiler
Which you control by: Programmer and room stat.
Your hot water is currently provided by: Combi boiler plus electric shower.

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.

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 2.1.4 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. A couple of old fireplaces in first floor bedrooms, but not used.

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: **Outside in yard or in airing cupboard.**

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	OK
Temperature in summer	OK
Air in winter	OK
Air in summer	OK
Draughts in winter	OK
Draughts in summer	OK

You told us there were problem locations for thermal comfort.

Not lived through a winter yet, so not sure. But previous resident said bathroom and kitchen both quite cold.

4.6.2 Daylight

Amount of daylight	Too little

You told us there were problem locations for daylight.

Assessor comments: Dining room to rear - but plan to resolve by turning small window here into patio doors to yard and knocking through into kitchen.

4.6.3 Noise

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

Assessor comments: Sometimes from the street - traffic and studenty area.

4.6.4 General

Your favourite room?
Living Room - gets sun in evening.

Any rooms in your home you don't love?
Dining Room

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: 1892

The property is not in a conservation area.
The building is listed as Grade I.

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 low risk area for flooding from rivers and the sea.
Your home is in a low risk area for flooding from surface water.

Assessor comments:
Some surface flooding nearby in heavy rainfall - a risk in future years in high rainfall events?
Householder plans to install water butts and planting to reduce run off.

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.

Minimal - house faces south east to rear, north west to front. Windows not very large and some local shading.

4.9 Context and Other Points of Note

Is in the middle of a terrace with access to rear possible via a back lane, but some materials for roof and rear wall works will probably need to come through the house. Limited room to front for parking and skips etc - small front set back, not a garden or yard.

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.

5.2 How can People Powered Retrofit help?

People Powered Retrofit provides a not-for-profit service for householders that aims to help more householders retrofit their properties well. We offer clear, independent advice and support to help you plan, procure and deliver retrofit projects to a high standard.

We offer a range of services including decision making and in-house design support, to support with finding contractors, suppliers and external designers, assistance with quality assurance during construction and guidance on handover and monitoring.

Click on the links below to read more about the services we offer at each stage of the retrofit process.

1. Starting Out - If you're receiving this report you should have already completed this stage. It includes an initial consultation with a retrofit advisor and the creation of your retrofit project brief.

2. Making a Plan - This report forms the first part of this stage (2.1), providing you with a better understanding of how your home performs and presenting scenarios for its potential improvement. This can be followed up with Stage 2.2, a Home Retrofit Plan, that sets out the works you intend to carry out and any preparatory or associated work, more detailed surveys, and design work that is likely to be required.

3. Design and Contracting - This stage is about commissioning any detailed technical design needed to describe the work you'd like to do in full. This in turn informs a specification that contractors can price up with confidence.

4. Onsite - This stage is all about quality assurance during construction and installation. We can also provide on-site training through informal development sessions or toolbox talks with contractors.

5. Handover and evaluation - This stage of your retrofit journey is all about ensuring a smooth handover from your contractor and measuring impact. As the householder you need to understand how to operate and maintain your retrofit improvements.

Whether we're supporting you throughout the whole process or not, we also offer a wide range of online resources, training and networking opportunities to help you along with your retrofit.

People Powered Retrofit customers may also be able to access bulk discount offers, borrow thermal cameras and borescopes (in Greater Manchester only).

Our sister organisation, Carbon Co-op, also runs events and programmes that may be of interest and they share recordings of these on their website [https://carbon.coop/carbon-co-op-webinar-programme/]. Eco Home Lab, an initiative run by Carbon Co-op, is a good place to meet other householders interested in advanced monitoring, controls and open source smart home systems.

You can find out more on our website at retrofit.coop. You can also email us at info@retrofit.coop to find out more about any of the above.

Appendices