The Net Zero Carbon Toolkit: Showcasing local climate action

LGA COP26 'Pass the Planet'
9th of November 2021

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Cotswold District Council

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COTSWOLD DISTRICT COUNCIL

Introductions

- **Cabinet Member** for Climate Change & Forward Planning: Cotswold District Council
- **Director**: Climate Guide Ltd
- **Doctoral researcher** on climate and democracy: Lancaster University

climateguide

Lancaster University

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The local context

- Cotswold District Council (pre-2019) had no focus on climate change in any department. No staff, no specialists, no budgets.
- Climate emergency declaration made shortly after May 2019 election
- Immediate commitment to update the Local Plan to make it 'Green to the Core'
- Development of Climate Strategy
- Recruitment of Head of Climate Action and Sustainable Transport Officer
- Change of culture to consider climate change on every report, alongside equalities and finance implications
- But HUGE constraints locally on building design and retrofit – 144 CA, 2nd Highest LB tally, and 80% AONB.

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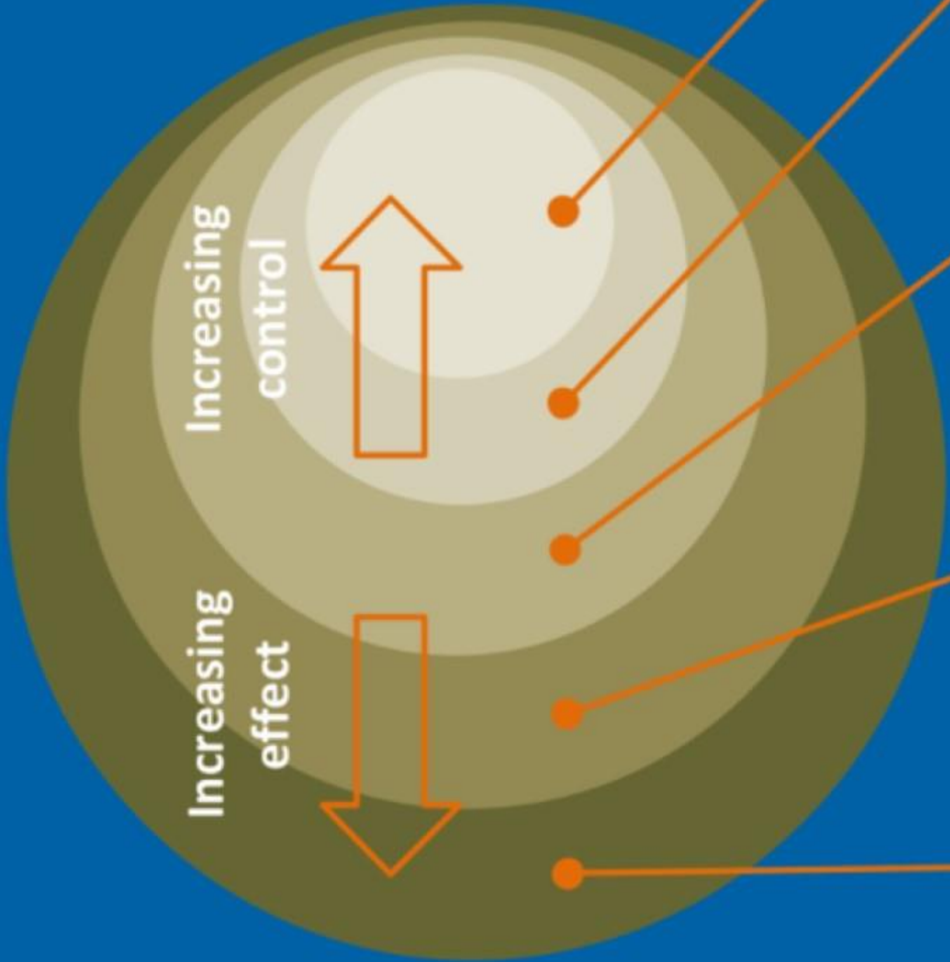
Cotswold District Council's levers of influence and scope to act



Direct control: Council's own buildings; operations; vehicle fleet

Indirect control: Procurement; commissioning; officers and Members travel and commuting; goods and services bought-in

Place shaping: Local Plan policies; using available powers to control how development happens; partnership with other statutory and non-statutory bodies to influence policy.

Enabling: Initiating; catalysing; networking; convening people and groups; building partnerships; supporting efforts by others; demonstrating; promoting; rewarding best practice; social norming

Engaging: Communication; consulting; interpreting global issues for Cotswold circumstances; inspiring action; providing civic leadership

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Focus on future-proofed buildings

Local Government Association

Housing Advisers Programme

WEST OXFORDSHIRE DISTRICT COUNCIL

COTSWOLD DISTRICT COUNCIL

Forest of Dean DISTRICT COUNCIL

PUBLICA

Etude

ELEMENTA

Passivhaus Trust

Levitt Bernstein People.Design

The story in brief

- LGA Housing Advisers Programme grant secured
- Analysis of publicly available information
- Analysis of consultancy market
- Collaboration in procurement, project management and dissemination with partner councils
- Publication and dissemination

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Net Zero Carbon Toolkit

July 2021

Etude ELEMENTA Passivhaus Trust Levitt Bernstein People.Design

How to adapt and use this toolkit

For local authorities:

In line with the intention of the LGA Housing Advisers Programme grant, please feel free to adapt this toolkit in any way you wish, to make it specific to your Authority, geography or other circumstances.

Please make sure you prominently acknowledge the toolkit authors in any amended version of the toolkit that you issue, in line with the requirements of the Creative Commons Licence.

For commercial organisations:

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Please attribute: Levitt Bernstein, Elementa, Passivhaus Trust and Etude commissioned by West Oxfordshire, Cotswold and Forest of Dean District Councils, funded by the LGA Housing Advisers Programme.

This Net Zero Carbon Toolkit

Who is it for?

This toolkit has been created to make Net Zero carbon new build and retrofit more accessible. It has been created for building professionals (developers, contractors, architects and engineers) and is also relevant to self-builders, planning officers and other housing professionals. Although it can be used by homeowners, it is aimed at those who already have some knowledge or experience of construction.

Both new homes and retrofit

The toolkit tackles new build homes and the retrofit of existing homes in separate chapters. So whatever your project, you will find relevant information here.

Small to medium scale housing

The primary focus is on small to medium scale housing projects, but the principles are generally applicable to projects of any scale.

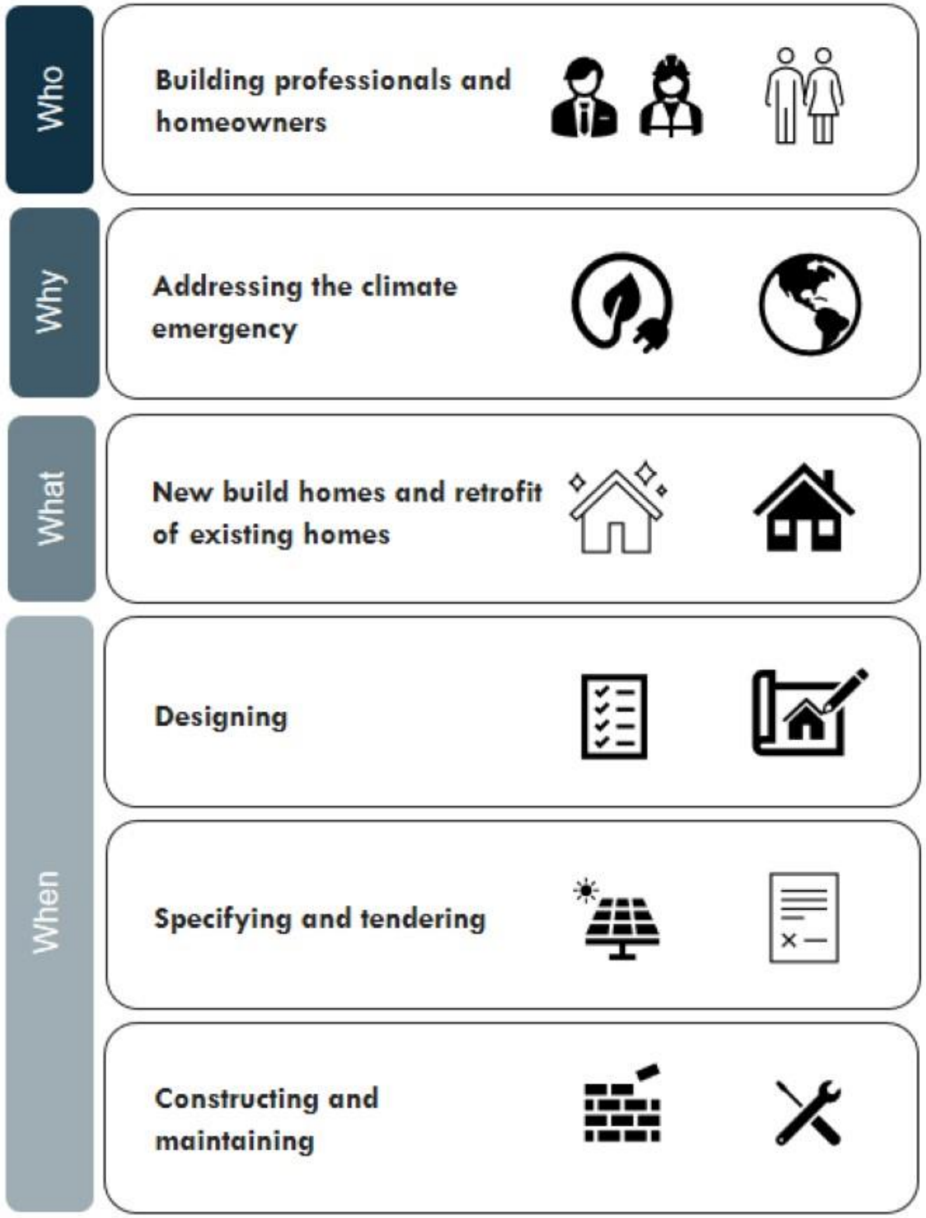
From site selection to construction to operation

It covers all stages of building design and construction, including maintenance and operation.

Understanding the complete picture

The toolkit aims to build the awareness and confidence of people implementing low or zero carbon projects and generally seeks to answer the following questions:

- Why?
- What to do and how to bring it all together?
- What does "good" look like?
- What to specify and how to choose products?



Core principles of Net Zero carbon buildings

Net Zero carbon buildings in operation are supported by three core principles: energy efficiency, low carbon heat and renewable energy.

Energy efficiency

Buildings use energy for heating, hot water, ventilation, lighting, cooking and appliances. The efficient use of energy reduces running costs and carbon emissions. It also reduces a building's impact on the wider energy supply network, which is also an important consideration.

There are different metrics we use to measure the efficiency of a building, including **Space Heating Demand** and **Energy Use Intensity** (both measured in $kWh/m^2/yr$). These are described on the next page.

Low carbon heating

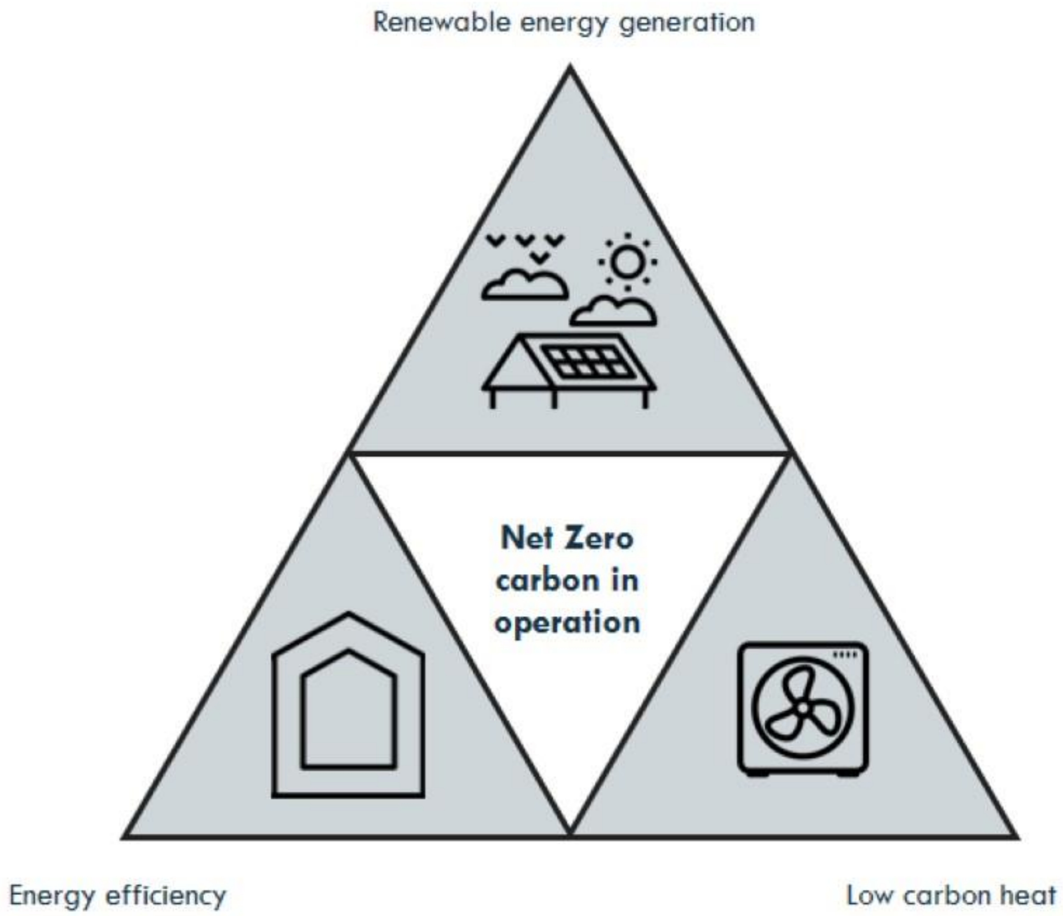
Low carbon sources of heat are an essential feature of Net Zero carbon buildings. All new buildings should be built with a low carbon heating system and must not connect to the gas network. Existing buildings need to transition away from gas and oil now.

Renewable energy generation

In new buildings, renewable energy generation should be at least equal to the energy use of the building on an annual basis for it to qualify as Net Zero carbon in operation. This is straightforward to achieve on site for most new homes through the use of solar photovoltaic (PV) panels. The roofs of existing homes should also be utilised for PV panels, to support the increased demand for renewable energy.

Embodied carbon

Operational carbon is only part of the story. Net Zero buildings should also minimise embodied carbon in materials.



The three pillars of a Net Zero carbon building in operation

Introduction to energy targets and Key Performance Indicators (KPIs)

What energy targets should I aim for?

We recommend the operational targets for new homes set out on this page, which are consistent with the *LETI Climate Emergency Design Guide*. Energy use targets are more transparent and robust than carbon reductions targets and are the best way to ensure zero carbon is delivered in practice.

What is an ultra low energy home?

An ultra low energy home is one which has a very low space heating demand. This requires a fabric efficiency and airtightness equivalent to that of a new Passivhaus home.

What is the most efficient form of heating system?

Heat pumps are considered the most efficient low carbon heat source keeping energy use to a minimum, while not using fossil fuels on site. Gas or oil boilers must not be used anymore.

Why set a renewable energy target?

Net Zero carbon in operation can only be achieved by increasing renewable electricity generation. Solar PVs represent a mature and easy to use technology.

Reducing the embodied carbon of a building

Limit the embodied carbon or emissions associated with the manufacture, transport, construction, repair, maintenance, replacement and deconstruction of building elements. This can be achieved by making informed design decisions based on quantified carbon reductions.

	KPIs New housing	KPIs Retrofit housing
Ultra low energy homes	Space heating demand **15** kWh/m²/yr	Space heating demand **65** kWh/m²/yr* *on average (range of 20-120 kWh/m²/yr)
Energy use and efficient heating	Energy Use Intensity **35** kWh/m²/yr	Energy Use Intensity **60** kWh/m²/yr *on average
Renewable energy	Electricity generation intensity **120** kWh/m^2_{fp}/yr m^2_{fp} : m² building footprint	Electricity generation intensity **120** kWh/m^2_{fp}/yr m^2_{fp} : m² building footprint
Embodied carbon	Embodied carbon benchmark **500** kgCO_{2e}/m²/yr	-

CIBSE TM59
Compliance with guidance on overheating risk

AECB
Good practice water standard

In-use performance
Collect data for the first 5 years

New housing

This section explains what can be done so that new housing forms part of the solutions to climate change, instead of adding to the problem.

The list of subjects it covers can be found on the following page.

Getting it right from the start: form, orientation and window proportions

Getting the design right from the start is key

Making informed decisions at an early design stage is key to delivering energy efficiency in practice. A building's form, orientation and window proportions are all aspects that do not add extra construction cost, but if optimised within the design can significantly improve the building's efficiency. For more details refer to the Passivhaus Design Easi Guide.

What should the building form look like?

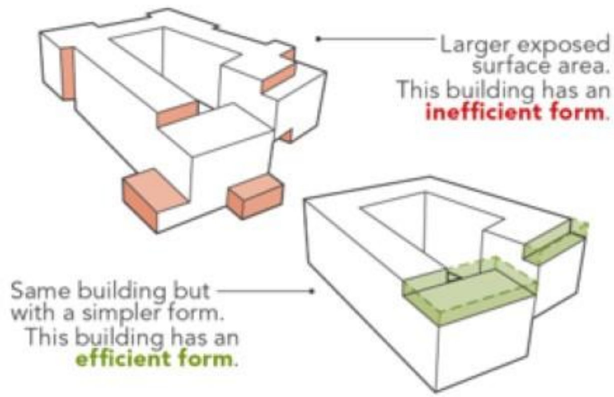
The building form should be as simple and compact as possible. This will reduce the exposed surface area for heat loss. Avoid or limit the use of stepped roofs, roof terraces, overhangs and inset balconies as these features will decrease the building's energy efficiency.

Which direction should the building face?

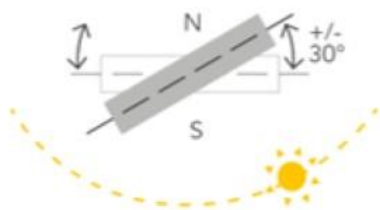
The orientation and massing of the building should be optimised if possible to allow useful solar gains and prevent significant overshadowing in winter. Encourage south facing dwellings with solar shading and prioritise dual aspect. Overshadowing of buildings should be avoided as it reduces the heat gain from the sun in winter.

How big should the windows be?

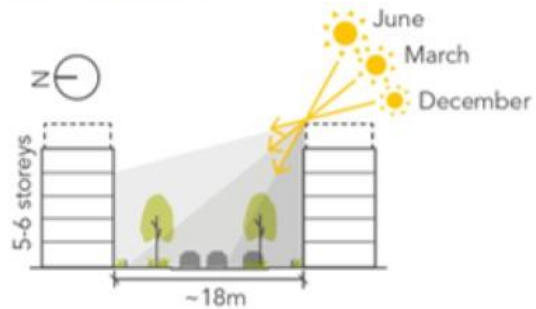
Getting the right glazing-to-wall ratio on each façade is a key feature of energy efficient design. Minimise heat loss to the north (smaller windows) while providing sufficient solar heat gain from the south (larger windows). It is much easier to design smaller windows facing access decks and larger windows facing balconies. Therefore, try to orientate access decks to the north and balconies to the south.



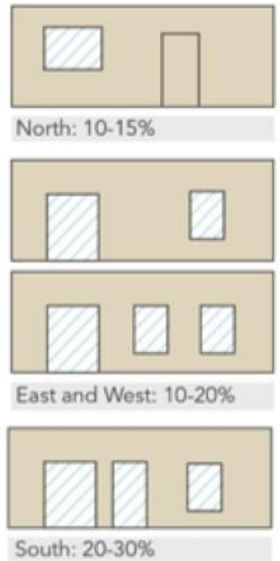
Designing the building to have an efficient form



Elevations facing +/- 30° south will benefit from useful solar gains in the winter



Allow a distance of 1-1.5 times the building's height between buildings



Recommended glazing percentages of each external facade

Embodied carbon

Embodied carbon includes the carbon emissions associated with the extraction and processing of materials, energy use in the factories and transport as well as the construction of the building and repair, replacement and maintenance. It also includes the demolition and disassembly of the building at the end of its life. Low embodied carbon design is not inherently more expensive or more complex, it just requires awareness and good design.

What can you do?

1 **Refurbishment over new build**
Only build new when existing homes cannot be reused or refurbished.

2 **Lean design**
Structural: Design structure for 100% utilisation. Use bespoke loading assumptions, avoid rules of thumb. Reduce spans and overhangs.
Architectural: Use self-finishing internal surfaces. Reduce the quantity of metal studs and frames.
Building services: Target passive measures (e.g. improved fabric) to reduce the amount of services. Reduce long duct runs, specify low Global Warming Potential (GWP) refrigerant (max. 150) and ensure low leakage rate.

3 **Material and product choice**
Prioritise materials that are reused, reclaimed or natural from local areas and sustainable sources and that are durable. If not available use materials with a high recycled content. Use the following material hierarchy to inform material choice particularly for the building structure;

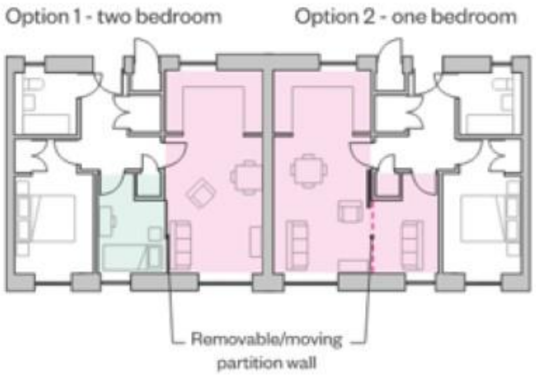
1. Natural materials e.g. timber
2. Concrete and masonry
3. Light gauge/Cold rolled steel
4. Hot rolled steel

Ask manufacturers for Environmental Product Declarations (EPD) and compare the impacts between products in accordance with BS EN 15804

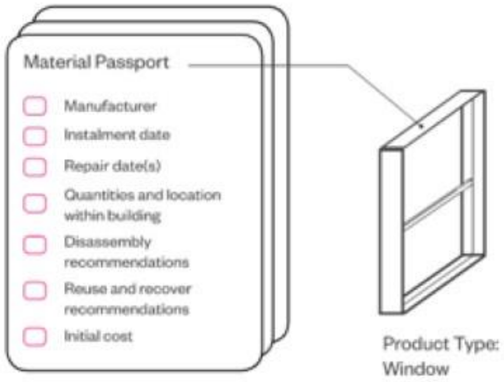
4 **Housing adaptation & flexibility**
Allow for flexibility and consider how a layout may be adapted in the future.

5 **Easy access for maintenance**
Maintained equipment will last longer.

6 **Design for disassembly**
Consider disassembly to allow for reuse at the end of life of the building. Create material passports for elements of the building to improve the ability of disassembled elements to be reused.



Design for adaptation using a flexible floor plan e.g. one bed flat can be converted to a two bed fat or a one bed fat with space for home working. Working to a regular grid with removable partitions will allow adaptation as well as creating soft spots in the structure

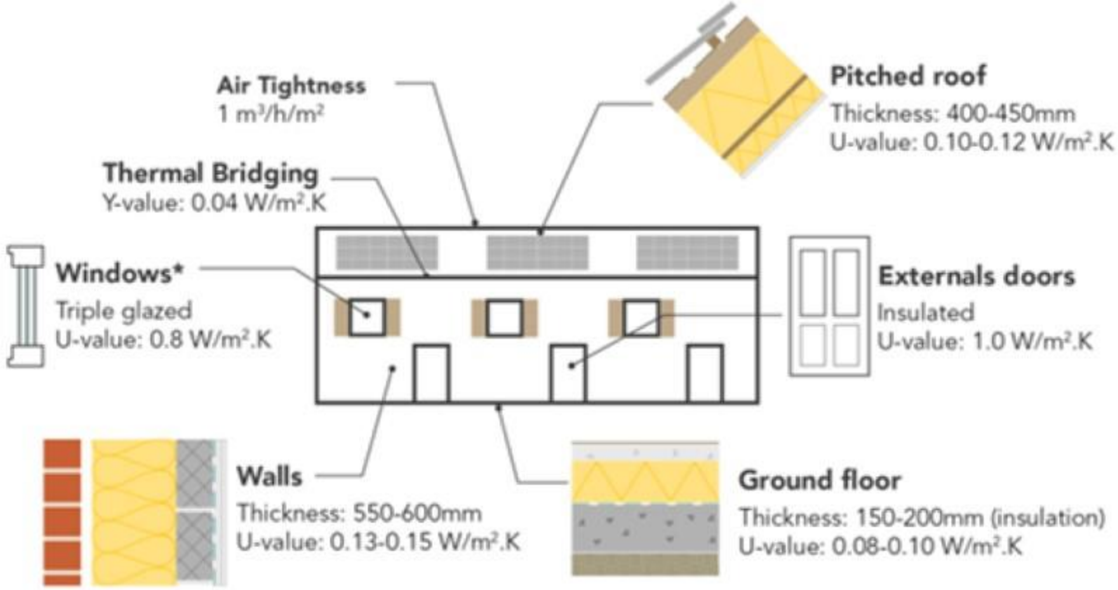


Create material passports for products: This will improve the ability of disassembled elements to be reused. A material passport provides identification of materials, components and technical characteristics with guidance for deconstruction and applicability of re-use. In this way the building becomes a material bank for future use.

How it comes together - new terrace house

Design checklist

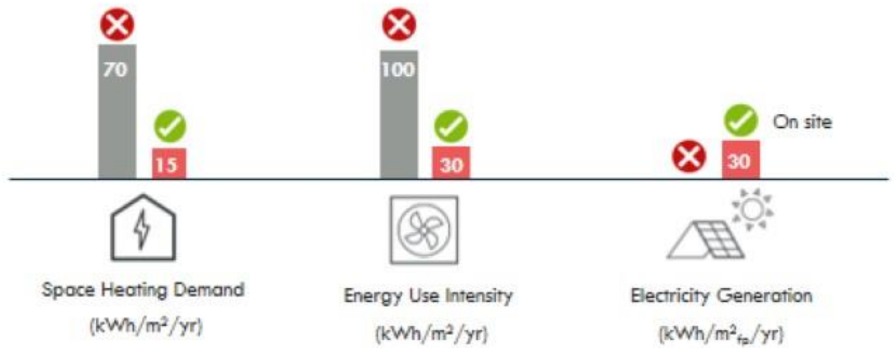
- **Form efficiency**
  Ensure the building form is as simple and compact as possible
- **Window proportion**
  Follow recommended ratio of window to external wall
- **Mechanical ventilation**
  MVHR 90% efficiency
  ≤2m duct length from unit to external all
- **Airtightness**
  Airtight building fabric
  < 1 m³/h/m² at 50 Pa
- **Heating system**
  Choose a low carbon heating system e.g. heat pump
- **Design out overheating**
  Carry out overheating analysis (as per CIBSE TM59 guidance) and reduce overheating through design e.g. external shading, openable windows and cross ventilation



Performance

As electricity generated on site with PVs is the same as the Energy Use Intensity (EUI) on an annual basis, the building is **Net Zero carbon in operation**.

- Typical terrace house built to comply with building regulations
- New zero carbon terrace house



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UK GBC
Together for a better built environment
ADVANCING NET ZERO

Building the Case for Net Zero:

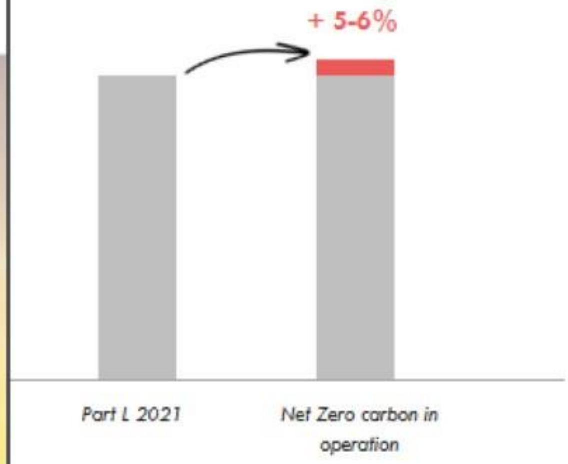
A feasibility study into the design, delivery and cost of new net zero carbon buildings

SEPTEMBER 2020

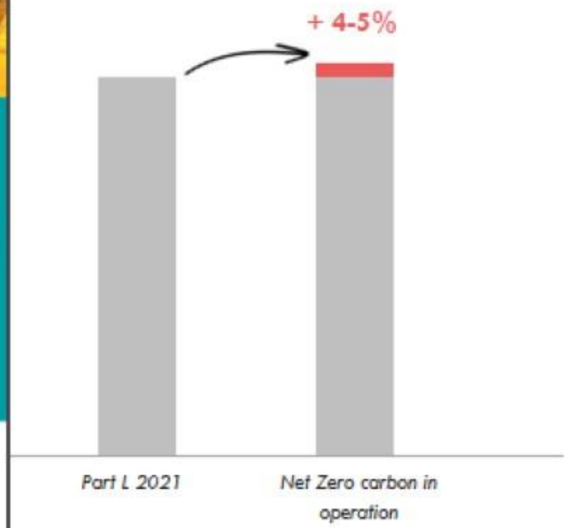
Advancing Net Zero Programme Partners

Lead Partner: REDEVCO FOUNDATION

Programme Partners: bam, Berkeley Group, GROSVENOR, HOARE LEA, JLL



ypical new terrace house



ypical new block of flats

Retrofit

Putting our existing homes on track towards Net Zero is a challenge but it can be done. This section explains how. The list of subjects it covers can be found on the following page.

Existing buildings are the real challenge

England currently has some 25 million homes. All of those will have to have some form of retrofit by 2050 while, in that time, we will have only built another six million homes. This means that 80% of the homes that will be present in 2050 have already been built. If we are to successfully decarbonise housing, retrofitting is where the real challenge lies: we need to increase their energy efficiency, change their gas or oil heating system for a low carbon heat system (e.g. heat pump) and generate more renewable energy on their roofs.

Reducing fuel bills alongside carbon emissions

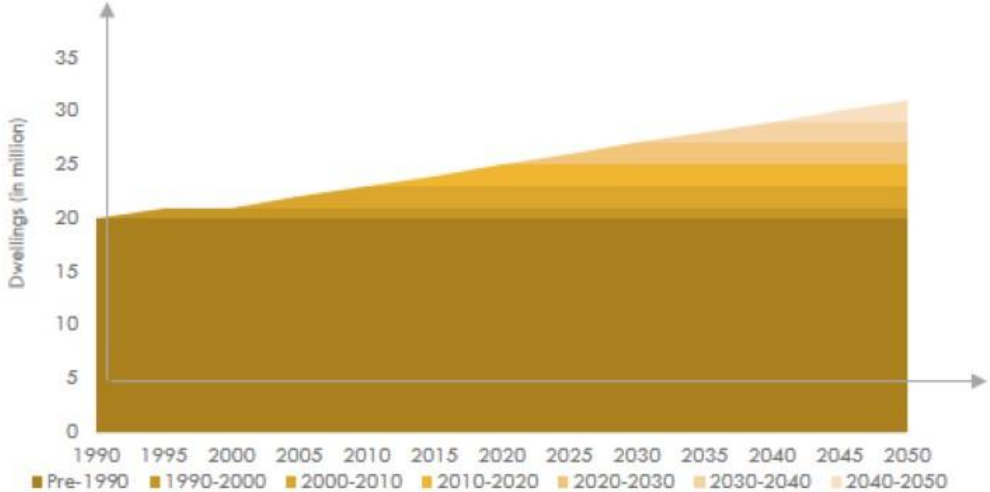
Whilst decarbonising homes is important to mitigate climate change, it is not the only reason to retrofit. In 2018, one in ten households in England were considered to be in fuel poverty. There is, unsurprisingly, a strong correlation between inefficient homes and fuel poverty with 88% of all fuel poor households living in properties with a Band D EPC or below. We can deliver lower bills as well as lower carbon emissions[1].

Health and wellbeing

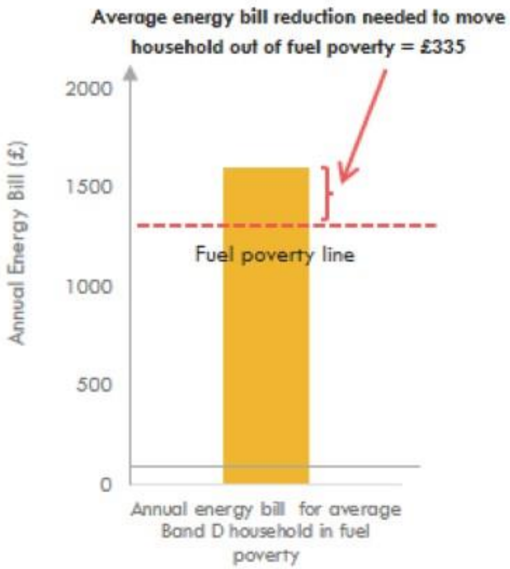
Improving the energy efficiency of a home is also likely to increase thermal comfort (both in summer and in winter) and improve indoor air quality through better ventilation. This will have a positive impact on everybody, but especially small children, the elderly and those with respiratory conditions. The International Energy Agency (IEA) and the OECD suggest health improvements might account for 75% of the overall value of improving the energy efficiency of buildings [2].

[1] The average Band D annual energy bill is £1600 and the average reduction needed to bring these households out of fuel poverty is £335

[2] Separately, the BRE have estimated that poor quality housing costs the NHS £1.4 billion in avoidable treatments.



England Housing Stock – 1990 to 2050 (Millions of dwellings)



Fuel poverty, health and wellbeing are all positive benefits of retrofit

How does a home produce carbon?

The vast majority (85%) of homes in the UK get their heating and hot water from a gas boiler and many other homes use other fossil fuels (e.g. oil). All the other energy uses in the home are drawn from the electricity grid. The emissions from the gas boiler are emitted on-site whilst the emissions associated with electricity use are emitted in a power station. Ten years ago, electricity was about 2.5 times more carbon intensive than gas, but things have changed a lot since then.

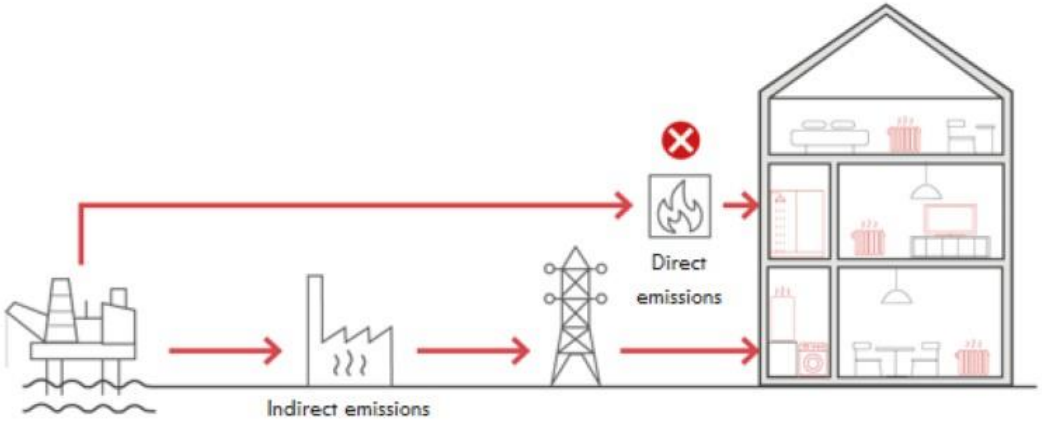
What has changed?

Over the past ten years, coal-fired power stations have been retired and the amount of renewable energy that feeds into our electricity grid has increased significantly. This means that the carbon intensity of our electricity has now dropped and is now about 30% lower than gas. As we add more renewables to our grid in the coming years, this will continue to drop until we approach a zero carbon grid.

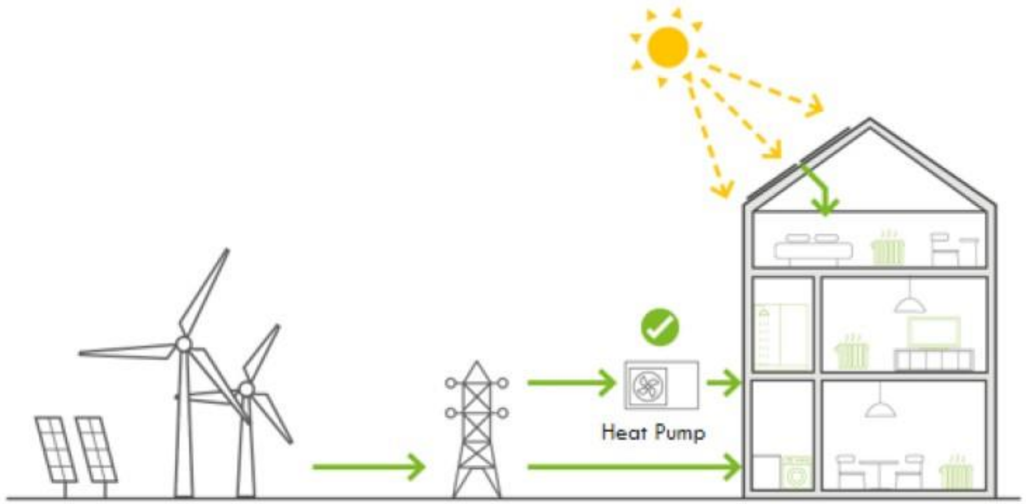
In contrast, a gas boiler installed today, will continue to emit carbon at the same rate until it is decommissioned – which could be another 25 years. This means that it has become a priority to move our homes away from gas to an electric-based system for heating and hot water.

Where do heat pumps fit?

Heat pumps will be discussed in more detail later, but they offer an excellent way of transitioning to electricity whilst reducing the load on the grid as they extract additional energy from the surrounding air or ground. Both the Government and the UK Climate Change Committee agree that they will form a major part of our future heating systems.



How most homes use energy now



How most homes should use energy now and in the future

A long term whole house renovation plan for a phased retrofit

An ambitious objective

The objective of a retrofit project should be to achieve Net Zero carbon by 2050 (or earlier). This means that:

- The home's energy efficiency is improved
- A low carbon heating system is installed
- Renewable energy is installed on-site
- The home is made smart ready

A whole house renovation plan is a useful tool to prepare and provides a pragmatic and coherent way to deliver this ambition.

Phasing improvements as part of coherent whole house plan

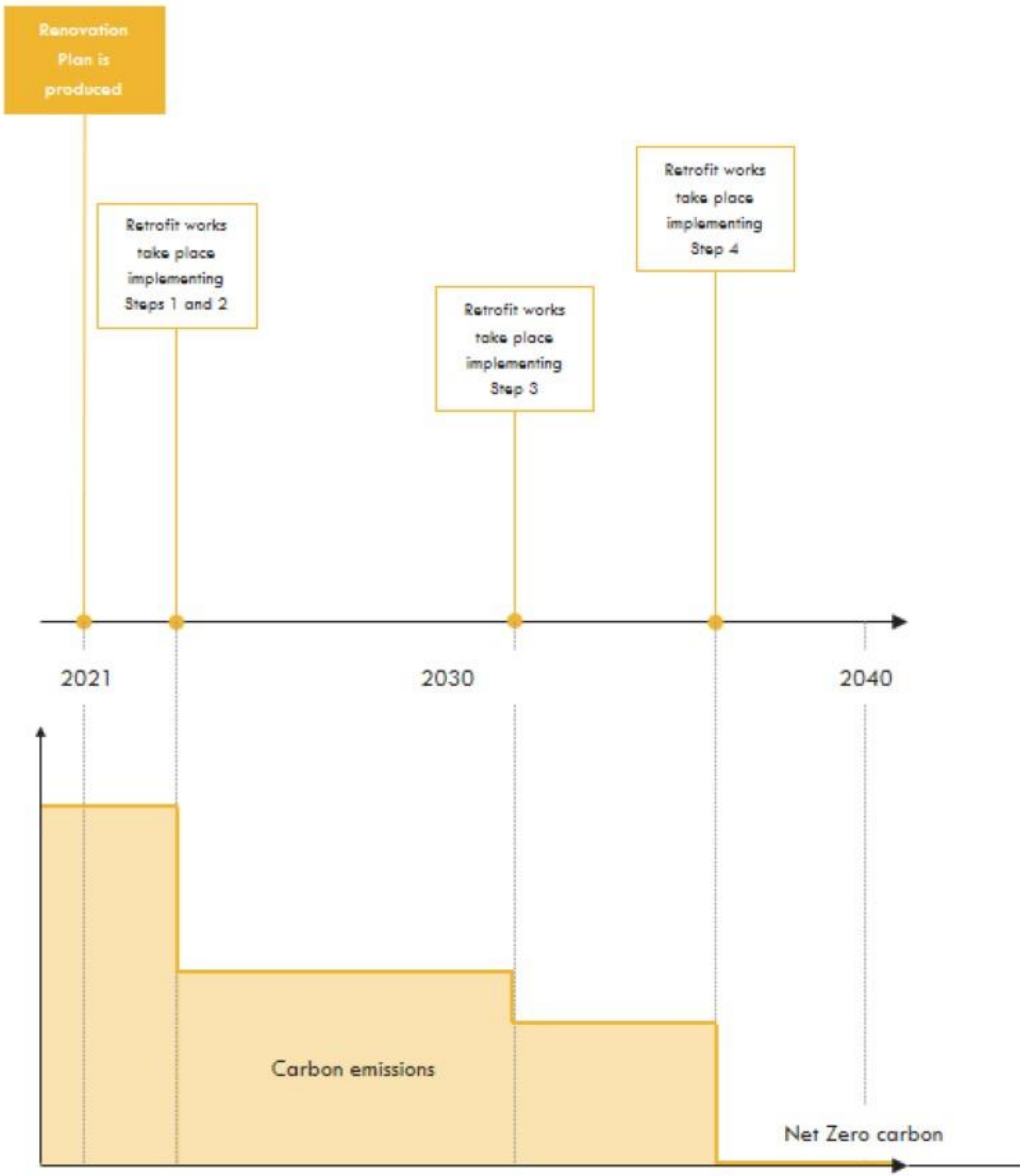
It may not be possible to implement all retrofit measures at once, but it is important to plan ahead so that packages of work are coherent and complementary. The preparation of a whole house plan is recommended to help in that planning.

This page shows how the measures can form part of a strategy for improvements. It would help landlord and residents to progressively save carbon and energy costs and avoid undertaking measures that conflict with planned future improvements.

A digital logbook

Alongside the whole house renovation plan, a building digital logbook can be developed to gather and retain all relevant information about the building.

Together, they form the **Building Renovation Passport**.



Note: the expected decarbonisation of the grid is not represented for simplicity but will also contribute to the reduction of carbon emissions over time.

It's all about moisture ...

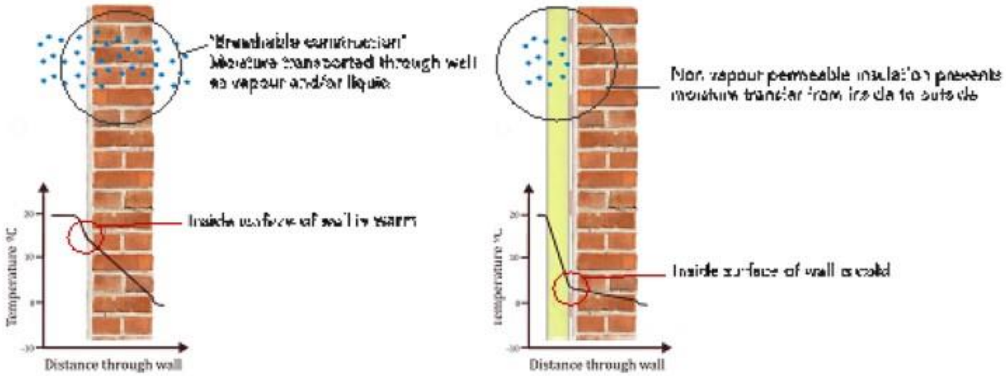
Our homes need to remain structurally sound, free from damp, mould and rot. Regrettably, many existing homes already suffer from excessive cold, damp, mould and condensation. A poorly planned and executed retrofit could actually make this worse. It is very important to understand this risk to mitigate and avoid it.

It may not be obvious, but our homes are constantly dealing with moisture. They are keeping out the rain and stopping the damp rising up from the ground. They are also dealing with the significant amounts of moisture that we generate inside the home from cooking, washing and breathing. Finally, if the building fabric does somehow get wet, they are designed to ensure that it will dry out without long-term damage. Interfere with any of these mechanisms, and we could end up doing damage to the health of both the building and its occupants.

Clear principles can address this risk

The risks of retrofit are well understood and can be overcome with sensible design and well-executed construction. Some key rules are:

- **No insulation without ventilation.** As you add insulation you are also likely to increase airtightness. This means less air moving through the building. You can counter this with opening windows and extract fans, but ideally by fitting a whole-house ventilation system like Mechanical Ventilation with Heat Recovery (MVHR).
- **External insulation is best**. Internal insulation means your external walls become cold and there is therefore a risk of condensation if the warm internal air reaches a cold surface. So, external insulation is preferred, but if internal insulation cannot be avoided, vapour open insulation (such as wood fibre) should be used. It is chemically fixed to the inside surface thus reducing the risk of condensation.



The risk of condensation with internal insulation

Installation of wood fibre insulation boards internally (© Back to Earth & ASBP)

What about heritage buildings and conservation areas?

Low carbon retrofit of heritage and traditional construction buildings in conservation areas is necessary and possible. There are a growing number of examples which show it can be done, and the PAS retrofit framework provides a suitable methodology.

Environmental and heritage conservation can go hand in hand

Heritage conservation is often given as an excuse to not improve energy efficiency and reduce carbon emissions. Proposals for those measures are sometimes refused by Local Planning Authorities particularly where they are not well thought through and do not form part of a whole building approach and therefore could cause damage to the structure of the building.

However, in addition to offering significant potential for carbon reductions, well-planned retrofit programmes can also contribute to conservation by incorporating maintenance and repair, and offering a new lease of life to buildings. They limit the risk of under-heating by occupants worried about energy bills, and associated risks of fabric degradation. By being more comfortable, buildings are also more likely to remain valuable and well looked after in the future.

Identifying relevant solutions for the context

Upgrading existing windows, and/or installing replacement double/triple glazed windows (subject to planning officer's support) can reduce heat loss by up to 40%. Recent advances in windows technology such as evacuated glazing offer the possibility of recreating traditional windows forms but with only a fraction of the heat loss. This technique can in some cases be applied to listed buildings.

Emerging products such as insulating plasters also offer the opportunity to insulate walls in a sensitive manner.

There is a growing library of resources for responsible retrofit of traditional and historic buildings, including the above Sustainable Traditional Buildings Alliance (STBA) and Historic England guidance

Recent examples of exemplar retrofits with heritage considerations: Grade I listed Trinity Student Halls in Cambridge (left, credit to Max Fordham), and Grade II early Victorian home in Clapham, London (right, credit to Arboreal). Both include the application of internal insulation, with attention to moisture movement and monitoring of interstitial moisture level.

An extension should trigger the improvement of the home (especially low carbon heat)

Grasping the opportunity

When considering the lifetime of a house, there are not many times when major improvements can be made. An extension is a fantastic opportunity to make a significant step towards Net Zero carbon and not locking in poor/high carbon decisions.

What to consider

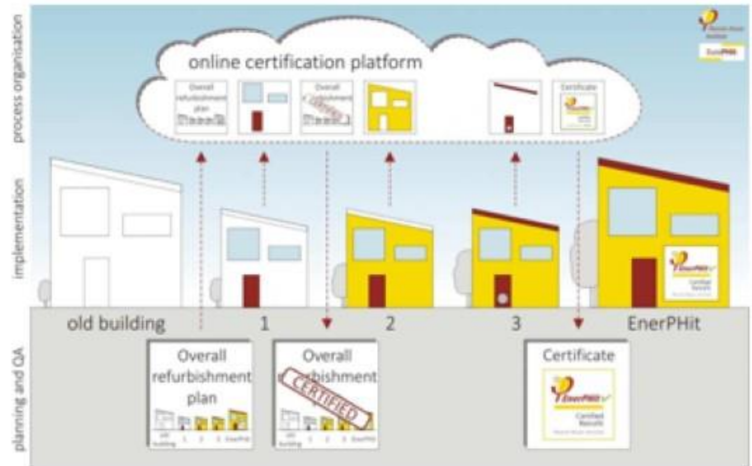
When considering the scope and costs of extending a home, the following opportunities should be considered:

1. Upgrading the heating system, and replacing the gas boiler with a heat pump.
2. Replacing existing windows with double or triple glazed windows
3. Upgrading the existing external fabric of the existing building (including both insulation and airtightness).
4. Installing Mechanical Ventilation with Heat Recovery (MVHR)
5. Installing solar PV panels to generate electricity

Staged retrofit – piece by piece

It is possible to undertake a staged retrofit when extending a home. A very useful resource and robust methodology is the EnerPHit Retrofit Plan. This scheme helps create a plan for taking a staged retrofit process, where the measures to improve the building fabric are put to a timeline. This allows the extension to be built and improvements to be made over time, and not just in a single phase. This can be an attractive and practical approach as often the capital costs of undertaking an extension and undertaking a major refurbishment all at once may not be affordable.

EnerPHit retrofit project with extension (Source: Passivhaus Plus)



EnerPHit staged retrofit improvement plan process (© PHI)

How much does it cost to retrofit and what are the results?

Retrofit costs depend hugely on the baseline building's characteristics and condition. A rough guide for an average semi-detached home is £5-15k for a shallow retrofit which, if starting with a poor baseline, could save around 30% in carbon emissions, through to £45-55k for a deep retrofit which would include significantly improving the building fabric, changing the heating system to a heat pump and fitting roof mounted solar PVs. This level of retrofit could achieve an 80-90% reduction in carbon emissions – particularly in the future as the heat pump makes use of a lower carbon grid.

Seeing retrofit as an additional cost to maintenance?

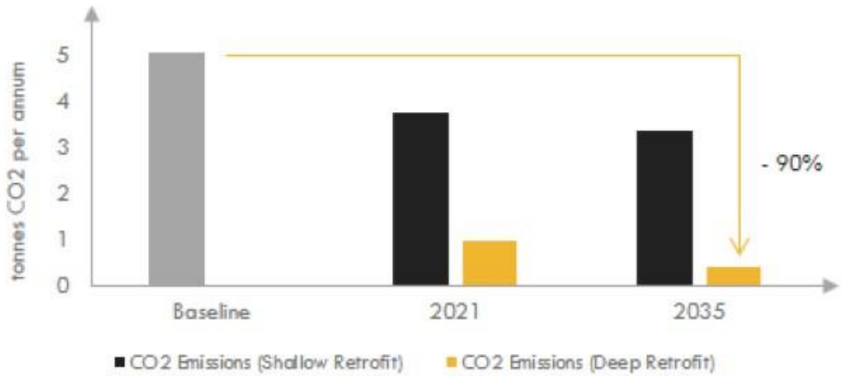
It is important to consider whether a measure is best undertaken as part of a planned or required maintenance activity. For example, re-rendering a wall would be an ideal time to apply external insulation and would mean the actual extra costs are just the insulation material and labour to secure the insulation to the wall.

And don't forget the co-benefits

Improved comfort, health and lower fuel bills are all valuable and important outcomes of retrofit. Prioritising measures using these different criteria is likely to produce a different order of priority for retrofit. For example, health and wellbeing is probably most improved by a Mechanical Ventilation with Heat Recovery (MVHR) system as this will dramatically improve indoor air quality and comfort. On the other hand, in most solid-walled dwellings, external wall insulation will offer the greatest net energy savings, and so the most significant reduction in fuel bills, despite being relatively expensive.

Measure	Shallow	Deep
Fit 100% low energy lighting	£ 20	£ 20
Increase hot water tank insulation by 50mm	£ 50	£ 50
Loft Insulation - add 400mm	£ 500	£ 500
Fit new time and temperature control on heating system	£ 150	£ 150
Improved draught proofing	£ 150	
100% draught proofing - improve airtightness		£ 2,000
Cavity Wall Insulation - 50mm	£ 600	£ 600
Floor Insulation - between & below suspended timber		£ 1,500
Insulate all heating and hot water pipework		£ 500
Fit Mechanical Ventilation and Heat Recovery (MVHR)		£ 7,000
Main Heating - High Efficiency Condensing Gas Boiler	£ 3,800	
Main Heating - Air Source Heat Pump and new HW tank		£ 9,000
Half Glazed Doors - Double Glazed (16mm argon)	£ 1,500	
Half Glazed Doors - Triple Glazed, High Performance		£ 2,000
External Wall Insulation - 160mm Expanded Polystyrene		£11,000
Double Glazing (16mm Argon Filled, Low E)	£ 7,000	
Triple Glazing (16mm Argon Filled, Low E)		£ 8,400
Photovoltaic Panels, 3kWp array, (21m² area)		£ 6,500
Miscellaneous and emabling works	£ 1,000	£ 5,000

Indicative retrofit costs for an unrenovated 90m² semi-detached dwelling



CO_2 reductions for an unrenovated 90m² semi-detached dwelling

Products

Achieving Net Zero on new and existing homes also relies on good quality products.

This section explains the level of performance to require from products which will help to reduce energy use and generate renewable energy.

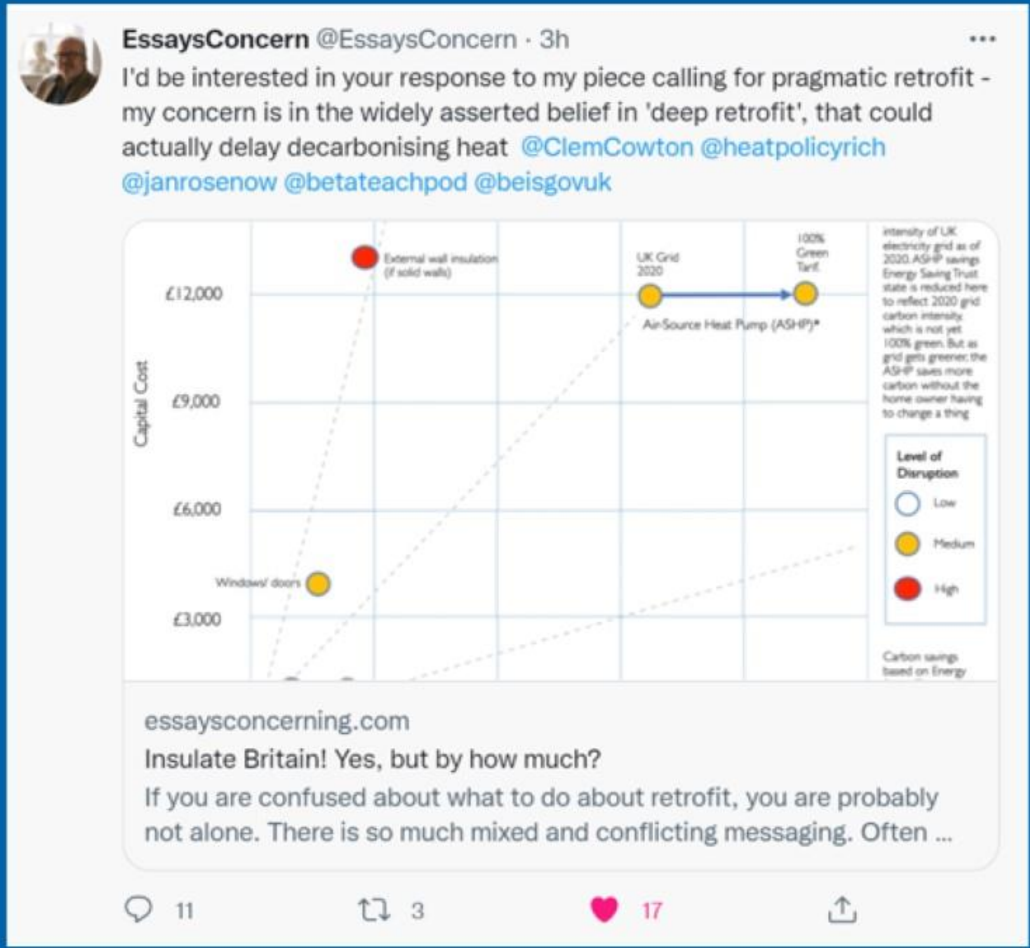
How to Specify

Delivering homes that will perform well in reality (and not just on paper) relies on a quality assured construction or retrofit process.

This section provides guidance on how to specify key elements.

Dissemination

- Lots of interest, and being used outside of local government too
- Several councils telling us they are in the process of copying or adapting it
- Circulated via a few county-level ALCs (parish and town councils)



COTSWOLD DISTRICT COUNCIL

Thank you

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07968 533286

https://www.cotswold.gov.uk/environment/climate-action/how-to-achieve-net-zero-carbon-homes/

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