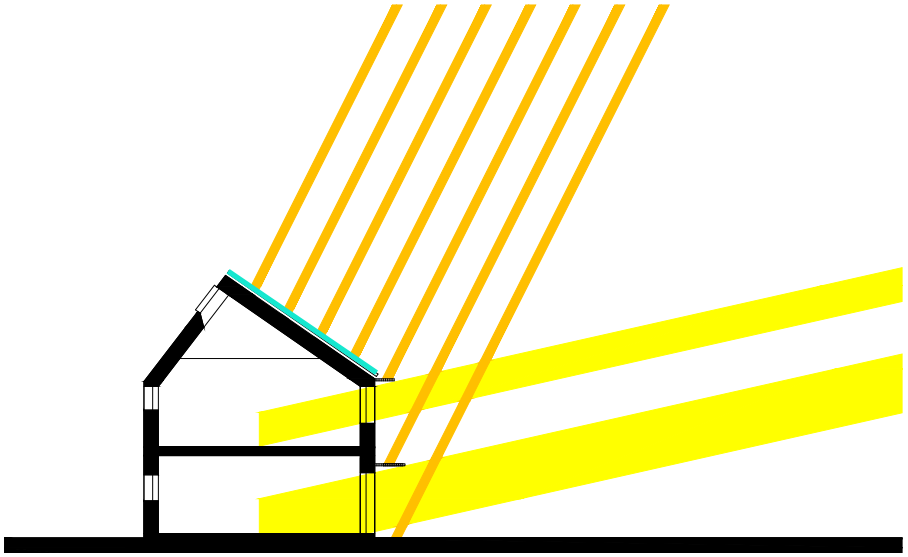
Herefordshire Council

HEREFORDSHIRE FUTURE HOMES



Net zero carbon affordable housing standard

D R A F T

September 2021

HEREFORDSHIRE FUTURE HOMES
CONTENTS

1. Preface
2. Executive Summary
3. Introduction
4. Challenge
5. Benefits & analysis
6. Recommendations
7. One Planet Living
   Inset: One Planet Living Action Plan
8. Passivhaus Plus
   Inset: Principles of Passivhaus construction
9. Renewable energy
10. Embodied carbon
11. Retrofit offsets
12. Excellence
    Inset: Passivhaus in practice - Exeter's experience
13. Review
14. Glossary
15. References & credits

Clayfield Suffolk, affordable & sustainable housing, Mikhail Riches architects.

1. PREFACE

In March 2019 Herefordshire Council unanimously declared a climate emergency, recognising the severe impacts of climate change and the need for urgent action. In December 2020 our Coalition administration made a major commitment to tackle the housing shortage by building affordable net-zero housing for local people.

This document outlines the Herefordshire Future Homes standards we will use when building these home. It represents a key step towards the Council's 2030 carbon reduction commitment, and a key step towards better housing for all.

Herefordshire Future Homes will be part of the solution to the climate crisis – reducing greenhouse gas emissions to net zero. The standards include a retrofit element which will help improve the quality of existing housing, too.

Herefordshire Future Homes will be healthy for residents – eliminating cold, mould and damp. We will build warm and cosy homes, in healthy neighbourhoods with space for kids to play, space for nature, and provision of sustainable transport options.

Herefordshire Future Homes will minimise energy use and fuel bills – tackling fuel poverty and making these homes truly affordable to live in. A small additional upfront investment will pay for itself through lower long-term costs.

These standards represent a triple win – for local people, for our economy, and for our planet.

We all know that we need to do housing differently. The housing crisis requires us to invest to ensure that everyone in our community has a warm and healthy home. The climate crisis

York City Council, Passivhaus

requires us to take action now to help cut emissions to net zero by 2030.

Put simply, we need to build houses today that are fit for future generations.

We hope that this Herefordshire Future Homes standard will inform and inspire better house-building standards across the whole county, creating a positive legacy for the future.

Councillor Ange Tyler *Councillor Ellie Chowns*
Herefordshire Council cabinet members

2. EXECUTIVE SUMMARY

Herefordshire Future Homes (HFH) sets recommended standards for the Council's net zero homes. 49% of UK CO_2 comes from buildings. Like Herefordshire, other progressive authorities want to "Build Net Zero Now". This will be five times cheaper than costly future upgrades.

90% savings in running costs, and 92% whole-life CO_2 savings are expected over 60 years. The capital cost uplift should be small, and falling, as measures become mainstream. Homes will be healthier, have higher values, and lower maintenance costs.

HFH includes broad sustainable criteria. A One Planet Living framework will cover health, local economy, community, land/ nature, water, food, travel, building materials, waste and zero carbon. Ambitious standards should be agreed for each site, with one Herefordshire apple tree planted for each home. Metrics cover non-toxic building materials, low water-use fittings and careful design to avoid summer overheating.

Recommendations are given for a 60-year Whole-life carbon and cost report, to demonstrate capital cost, energy use, and whole-life financial and carbon savings. It will be reviewed against actual costs and performance. Residents' training and post-occupancy monitoring is required to 5 years after completion.

Certified Passivhaus Plus standard is adopted for HFH. This will ensure highly energy efficient homes, which will have integrated PV solar electric panels - or other on-site renewable energy - and storage. The homes will therefore generate approximately as much renewable energy as they use.

Low embodied-carbon construction is recommended, aligned with LETI and RIBA 2030 targets. To achieve true net zero, residual embodied carbon emissions from the new homes will be offset, through a parallel programme of retrofitting local existing homes to Passivhaus EnerPHit or AECB standards.

Locally-distinctive excellent design quality is essential. This includes accessibility and Lifetime homes requirements, "tenure-blind" development, encouragement for 20mph pedestrian-priority speed limits / homezones, assessment against Building for a Healthy Life toolkit, and National space standards

HFH works alongside the National Model Design Code (NMDC) and Herefordshire's Environmental Building Standards SPD. Herefordshire Future Homes will be reviewed annually, without diluting its net zero carbon aims, to align with emerging research or legislation where appropriate.

The document is illustrated with best practice examples.

Accodia, Fielden Clegg Bradley Studios architects.

3. INTRODUCTION

Herefordshire Future Homes (HFH) sets standards for net zero homes developed by the Council and its partners across the county. It is aimed at all stakeholders involved in housing.

Detailed recommendations are given for Herefordshire's new - and existing - homes and communities. By embracing these principles, we can **drive net zero carbon development** in the region, create new jobs and skills, and support the local economy. Building **affordable homes** for those who need them will enable our communities to flourish for years to come. It is important that **existing homes are not left behind**, and are upgraded and properly insulated to make them fit for the future too.

Examples of best practice net zero carbon and Passivhaus schemes are illustrated throughout this document.

The standard is about **much more than just energy** use: it is a strong and wide-ranging design/sustainability/community framework to support this progressive and collaborative programme. Working alongside other Council policies, such as Herefordshire's Environmental Building Standards Supplementary Planning Document (SPD), the emerging Herefordshire Design Code and the **National Model Design Code** (NMDC), these standards should **raise expectations and inspire** the Council and others to provide the higher quality greener homes needed.

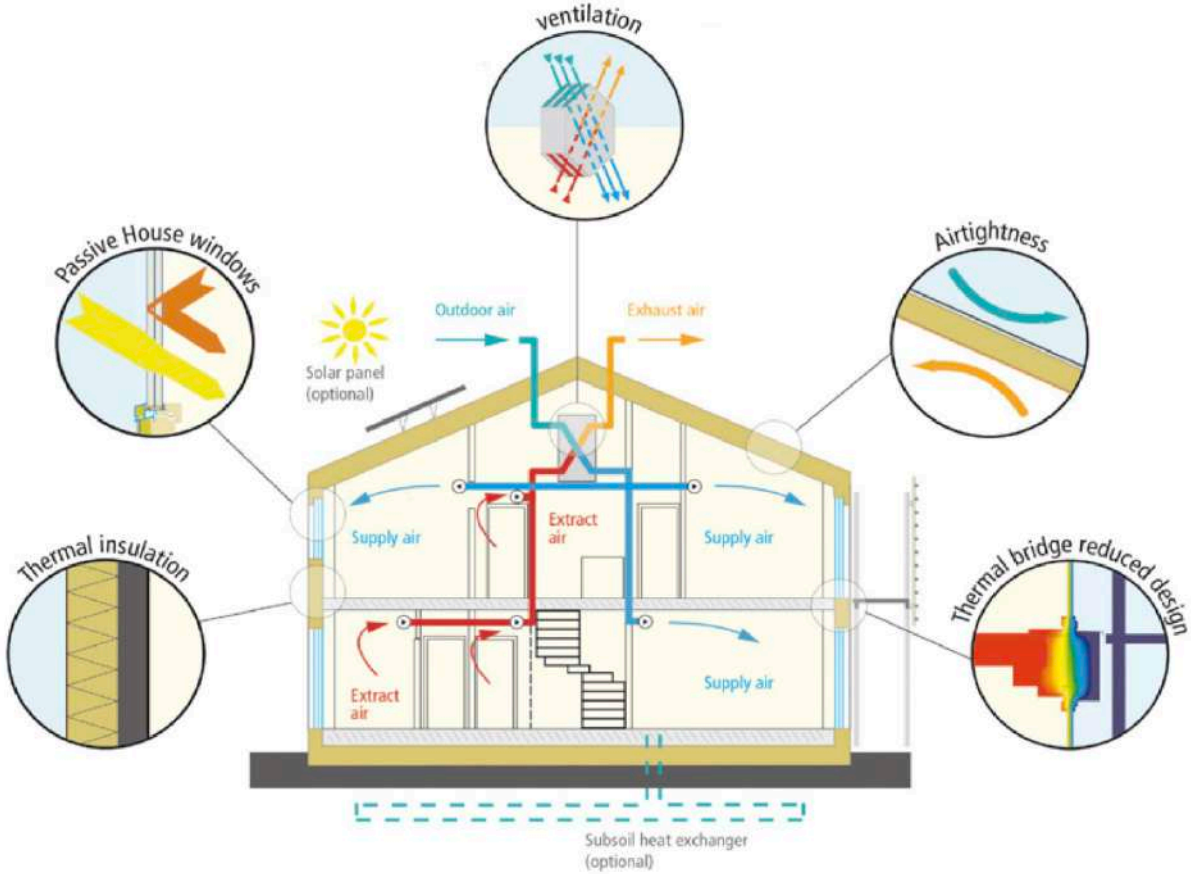
Top left: Parklands, N.Somerset, 64 zero carbon homes, LA-AC.
Centre & right: Callaughtons Ash, Shropshire, Connexus Passivhaus, Architype.
Bottom: Forthcoming Herefordshire SPD;
Eco-Vicarages, Passivhaus & zero carbon, Associated Architects.

Herefordshire Future Homes will have:

- **Healthy and comfortable** conditions, whatever the weather.
- Excellent **thermal insulation**, so hardly any heating is required, and heating costs reduced by around 90%, eradicating fuel poverty.
- Carefully designed **triple-glazed windows**, benefitting from useful winter sunshine (solar heat gains), while avoiding summer overheating.
- **No gas boilers** (which use polluting fossil fuels), but electric heat pumps for heating and hot water, which are highly efficient and safer.
- **Solar panels**, generating green electricity to balance the home's needs.
- **Heat recovery ventilation** (MVHR), avoiding cold window draughts in winter, saving energy and filtering the incoming air, which helps people with asthma, hay fever etc.
- **92% saving in carbon** emissions, compared with Building Regulations (see graph in section 5 below).

These are a combination of certified **Passivhaus Plus** performance and additional elements.

Similar standards have been adopted in other local authorities, and have been warmly welcomed by residents; Norwich City Council's Andrew Turnbull maintains: "our greatest advocates are our tenants" (Passivhaus Trust, 2019b). Passivhaus Plus details are explained in section 5 below, and full technical details are specified in Passive House Institute (2016) *Criteria for the Passive House, EnerPHit and PHI Low Energy Building Standard*.



PRELIMINARY GRAPHIC
TO EXPLAIN PASSIVHAUS / NET ZERO HOUSE

4. CHALLENGE

Buildings are responsible for 49% of UK CO_2e emissions.

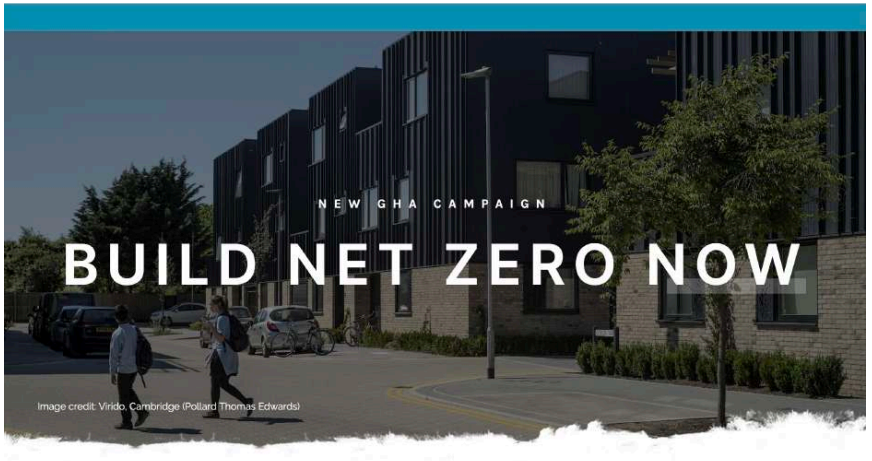
Following Herefordshire and other local authorities' **climate emergency declarations**, in April 2021 UK government committed to cut carbon emissions by 78% by 2035, a stepping stone towards 100% cut (zero carbon) by 2050.

However, the statutory Climate Change Committee have repeatedly made clear that national policies for new homes are not yet driving change at the required pace (CCC, 2019). The United Nations, IPCC, and other commentators consider 2050 **targets will be too late** to prevent irreversible climate change, missing the Paris target to limit global warming to 1.5degC (UNCC, 2021), (IPCC, 2021).

Homes account for **over 26%** of Herefordshire/UK carbon emissions, and have increased by more than a quarter over the past twelve years (RIBA, 2020).

Herefordshire is not alone in wanting better standards. The Good Homes Alliance Vanguard Network unites twenty local authorities. GHA's initiative is to **"Build Net Zero Now"**, rather than waiting for 2025 or 2030 (GHA, 2020a).

For a new home, the embodied carbon emissions from construction can be as much **as half the carbon footprint** measured over its 60-year design life. There is clear evidence that new homes built merely to minimum Building Regulations standards - ie not built to zero carbon standards - would be **five times more expensive** to retrofit a decade later (Currie & Brown, 2019). Construction is clearly the best point at which to make a home both energy efficient and low carbon.



Good Homes Alliance

VANGUARD NETWORK
For Local Authorities

NATIONAL ENERGY FOUNDATION

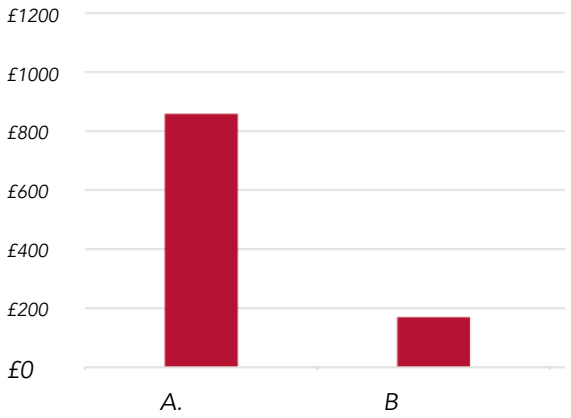
Government sets out targets for new Future Homes Standard

20 JANUARY 2021 . BY RICHARD WAITE

5. BENEFITS & ANALYSIS

Some benefits of Herefordshire Future Homes (HFH) net zero standards are outlined below.

- The **capital cost** uplift should be modest. Although actual building costs will depend on local factors, Passivhaus Trust show +8% on construction costs, expected to fall to +4% as ultra-high energy standards are adopted at scale. The additional costs of Passivhaus or equal standards with air-source heat pumps (ASHP) are approximately +5% on total build costs, excluding PV renewables (Passivhaus Trust, 2019a), (Currie & Brown, 2019).
- Whole-life cost analysis shows Passivhaus gives significant **whole-life savings (£5,000+)** against standard construction; across different fuels, construction types, and over 30/60/100 year periods (Price and Brown, 2014).
- Future-proofed construction requires less ongoing capital investment. The Government Climate Change Committee analysis shows it is **five times cheaper** to build to net zero standards now, avoiding costly and disruptive future upgrades (CCC, 2019).
- Net zero homes have **higher market values**, giving benefits to the Council (rent and sale capital) and/or to the resident (shared ownership value etc), and increasing as net zero finance advances.
- Depending on tenure, service charging and management, a premium could be charged on rent or a discount given to the occupants, offering **financial benefits** to landlords and residents.



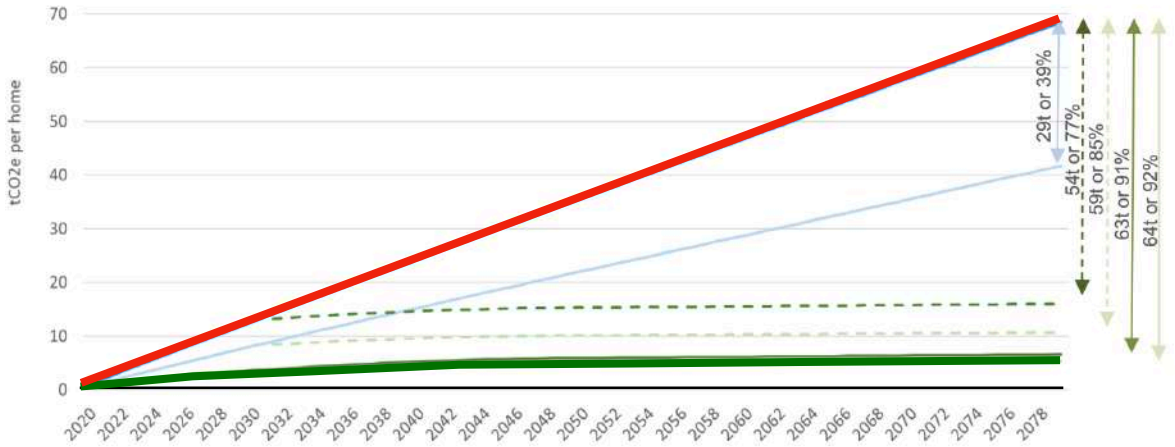
90% SAVING ANNUAL RUNNING COST

Predicted total operational running cost (annual average 2020-2080) for an optimised house form. Includes heating, hot water & appliances, repairs, maintenance and replacement (Currie & Brown, 2021).

A- Building Regulations insulation standard with gas boiler.
B- Passivhaus standard with heat pump and PV.

Bournville Village Trust eco-homes Homezone, Associated Architects.

- Maintenance and repair costs for net zero homes are lower than standard construction, as no boiler/gas costs are incurred, and higher quality construction and components, such as windows, have **longer life and lower maintenance** requirements.
- Triple-glazing, airtightness and whole-house ventilation (Mechanical Ventilation with Heat Recovery or MVHR) lead to **fewer resident noise complaints** and fewer site sensitivities (eg noisy roads).
- MVHR gives excellent **indoor air quality,** helping people with allergies and respiratory diseases. Warm homes help to improve residents' health (Passivhaus Trust, 2016). The impacts of energy-inefficient housing cost the NHS £2.5 billion/year, including increased asthma, bronchitis, and mental health problems (LGA, 2019).
- Heating demand can be **reduced by 90%**, with **lower running costs**, reduced carbon emissions and air pollution, warmer homes, and **reduced fuel poverty**. Optimised low energy designs - eg simple-form terraces rather than bungalows - also give financial efficiencies in land use and construction.
- **The performance gap** - difference between designed and built energy efficiency - shows typical homes can use 40-60% more energy than expected, partly due to lack of site quality control. By contrast, certified Passivhaus homes on average **perform as designed** (Mitchell and Natarajan, 2020).
- The proposals give **92% whole-life carbon savings** from Building Regulations (see graph opposite).
- **Net zero homes** help to meet both national and local carbon reduction targets and legal obligations - now and in the future.

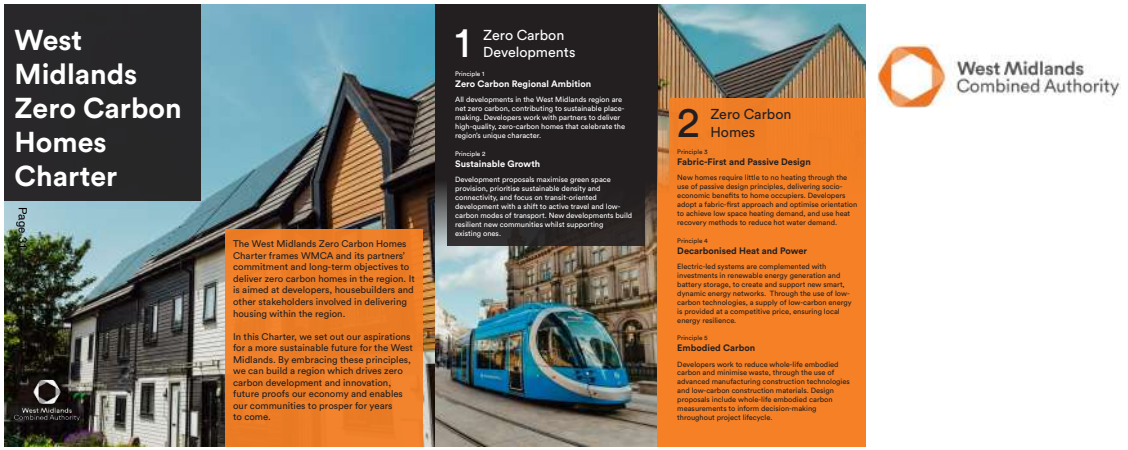


92% CARBON SAVINGS

Predicted operational carbon savings from a semi-detached house built to different insulation standards and with different heating systems.
Cumulative operational carbon savings over 60 years.
- Red line = Building Regulations Part L, gas-fired boiler.
- Green line = HFH standard: Passivhaus 15kWh/sqm.yr heating with air-source heat pump. 92% or 64 tonnes CO_2e saving per home over 60 years.
(Currie & Brown, 2019).

Poor construction quality - like gaps in insulation as shown - can lead to a "performance gap" in operation. This is not an issue in completed Passivhaus projects.

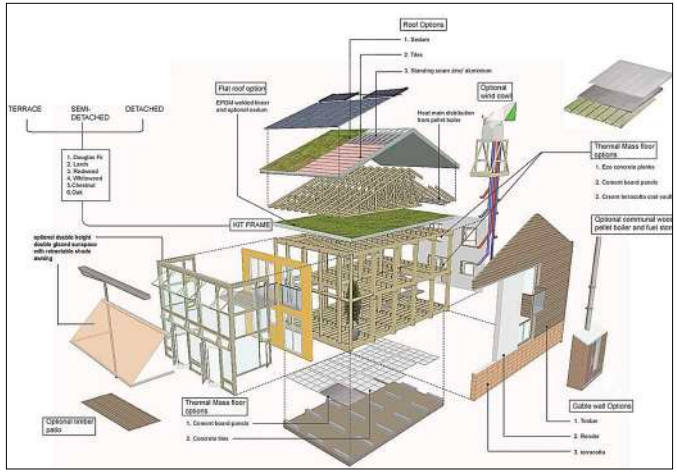
- The proposals are **in step with other UK leading local standards** under development or already operating, including Oxford, York, Norwich, West Midlands, and twenty local authorities forming the Good Homes Alliance Vanguard, see page 6 above (GHA, 2018).
- Poorly-designed houses can overheat, requiring costly and energy-intensive air conditioning, whereas HFH standard should **avoid these future costs** and carbon emissions.
- The proposed standards **increase local resilience**, by reducing energy supply needs, and reducing stress on the local electrical grid, both through lower energy demand and through smart grid renewables/on-site storage.
- The present **skills gap** in housing design and retrofit will be closed: as construction standards and new technologies are defined, these can be planned for and met locally, lifting skills and quality for the county.
- Each site will have a **One Planet Living** plan covering many broader factors, to help build sustainable communities and reduce carbon, avoiding tick-box approaches.

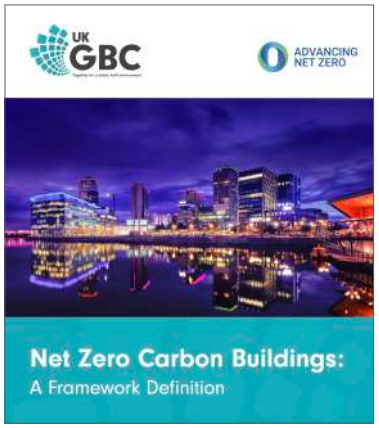


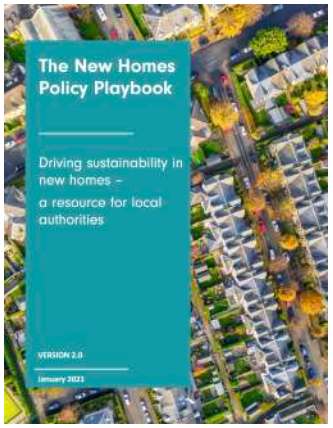
West Midland Combined Authority, Zero Carbon Homes Charter.

York City Council, Passivhaus development, Mikhail Riches architects.

- **Retrofit standards** are integrated, to target Herefordshire's least efficient existing homes and give large carbon savings. EnerPHit and AECB retrofit standards optimise financial and energy design for existing homes, giving both **maintenance/ resident benefits and real carbon/fuel savings.**
- HFH standards can be applied to third-party sites, even where planning permission may have been granted already. A **pragmatic but ambitious** approach will ensure long-term savings in energy, carbon, maintenance and future.
- **Education and training** of residents will help them to understand, manage and reduce their energy use effectively. This, allied to post-occupancy monitoring, will demonstrate **quantified positive results.**
- **Council leadership** will help to raise building standards of private sector and other local housing providers. **Clear, consistent and ambitious** HFH building standards from the outset will optimise building efficiency, minimise design and construction costs, and give **confidence for local industry** capacity-building.







Top: Manchester People Powered Retrofit scheme led by Urbed; The Architects' Journal RetroFirst campaign;
Centre: Rural-Zed zero carbon house, Bill Dunster Architects, exploded drawing & photograph;
Bottom: UK Green Buildings Council Net Zero Carbon Buildings and The New Homes Policy Playbook; Springfield Meadows, Oxford, Greencore

ANALYSIS

Some of the different building standards evaluated during development of HFH are below.

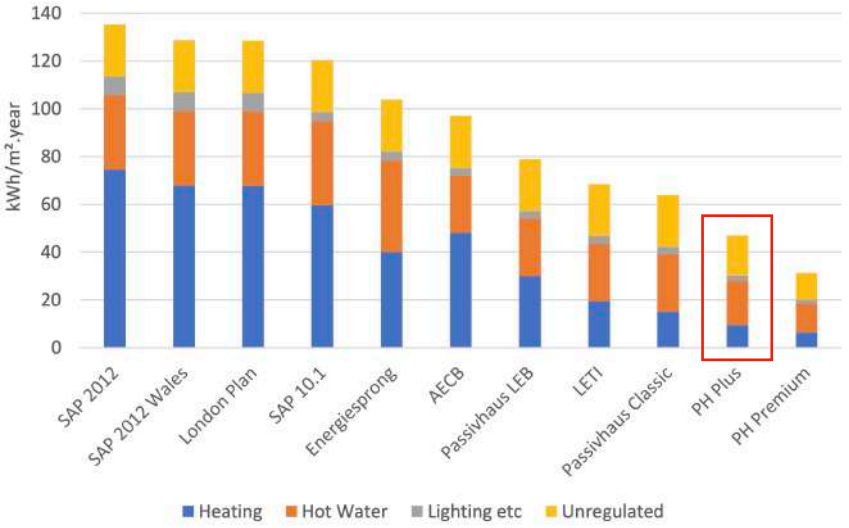
- UK Buildings Regulations (SAP).
- UK Future Homes Standard (consultation 2023, planned implementation 2025) (MHCLG, 2021).
- UK Green Buildings Council Net zero carbon buildings: a framework definition (UKBBC, 2019).
- Good Homes Alliance Build Net Zero Now (GHA, 2020a).
- RIBA 2030 Climate Challenge standard* (RIBA, 2021a).
- LETI Climate Emergency Design Guide and Embodied Energy Primer (LETI, 2020a and 2020b).
- Energiesprong retrofit standard (Energiesprong, 2021).
- AECB Building and retrofit standards (AECB, 2017 and 2021).
- Passivhaus standards: Passivhaus LEB, Classic, Plus and Premium standards (Passive House Institute, 2016).
- BSRIA Life Cycle Costings (BSRIA, 2016).
- Whole Life Carbon Network Improving Consistency in Whole Life Carbon Assessment and Reporting (WLCN, 2021).
- RICS Whole life carbon assessment for the built environment (RICS, 2017).

Comparative analysis of selected performance criteria and cost is shown in the graphs opposite: HFH is Passivhaus Plus standard.

** This is a reporting standard against design targets set out for 2025 and 2030. A number of its points are covered by Herefordshire Future Homes standards. Its metrics may be incorporated into future UK standards, and it is expected that all architects for Herefordshire Council's homes will have joined the scheme. Design teams will therefore report against RIBA 2030 Carbon Challenge standards as part of the architects' services, and where possible all designs should aim to meet RIBA 2030 levels. See section 5 below for discussion of operational energy standards.*

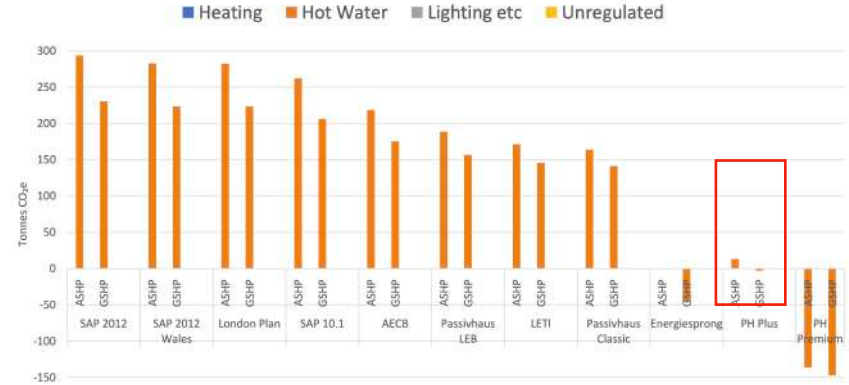
ENERGY

Analysis of selected comparative energy use for different building standards:
Total energy use/sqm of house floor area, including performance gap (GHA, 2020b).



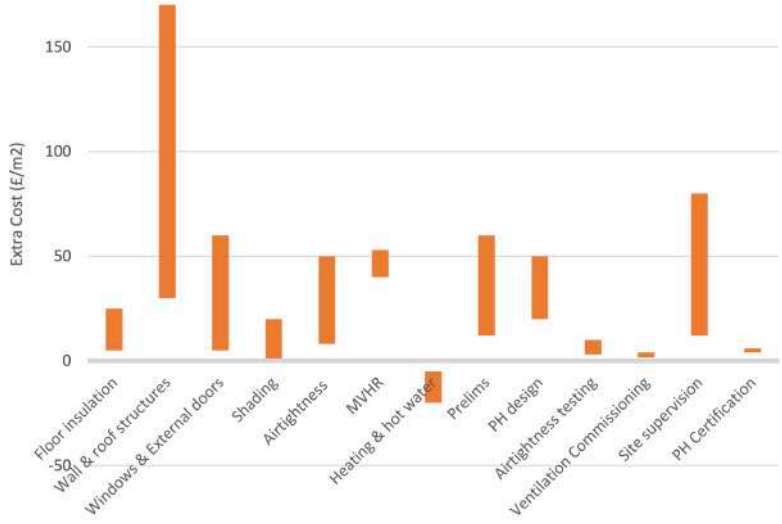
CARBON

Analysis of selected comparative carbon emissions, tonnes total CO_2e emissions over 30 years, for different building standards, with assumed heating by air source heat pump (ASHP) or ground source heat pump (GSHP) (GHA, 2020b).



COST

Analysis of selected comparative capital cost variance (£/sqm) from current 2013 Building Regulations for Passivhaus standard, excluding heat-pumps and PV (GHA, 2020b).



6. RECOMMENDATIONS

For ease of reference, the recommendations of Herefordshire Future Homes (HFH) are summarised below:

A. All sites should have a **One Planet Living Action Plan** describing how exemplary environmental practice is included across ten principles, including ecology, water, green travel, and zero carbon. One **Herefordshire apple tree** will be planted for each home (see 7.6 below). Materials should be low impact, low VOC < 0.3 mg/m3 and low formaldehyde < 0.1 mg/m3 (see 7.8). The Action Plan will be specific for each site, and peer-reviewed by Bioregional (see 7 below).

B. **Water usage** of <75 litres/person/day (see 7.5 below).

C. A **Whole-life carbon and cost report** should compare 60-year predictions for all capital, maintenance, running and other financial costs, and carbon emissions, for the proposed development, and for a 2019 Building Regulations compliant scheme (WLCN, 2021), (see 7.10).

D. All homes should be certified to **Passivhaus Plus** standard (see 8), with predicted total energy use <45kWh/sqm.yr. Heat-pumps or other low carbon heating should be used, with no gas boilers, gas cookers or other fossil fuels.

E. All homes should have on-site **renewable energy** (eg PV) to Passivhaus Plus standard, and a renewables strategy including storage and management (see 9).

F. All sites should have **embodied carbon** <625 kgCO_2e/sqm for RICS whole life carbon stages A-C. Sites of five or more houses will be supported by detailed embodied carbon calculations (see 10).

G. To achieve true net zero, all residual embodied carbon emissions should be offset through a parallel programme of **home retrofits**, certified to Passivhaus EnerPHit or AECB Carbonlite Standards, or other agreed offsets (see 11).

H. The highest award-winning **design standards** are required, including pedestrian/cycle priority 20mph/5mph speed limits (see 7.7). Building for a Healthy Life (Birkbeck et al, 2020) standard will be used for assessment (see 12).

I. An agreed proportion of homes for each site should be to **accessible standards for wheelchair users** as Building Regulations document M categories 2 & 3, and Lifetime Homes standard (see 12).

J. All developments should be designed as **"tenure blind"** and to National Space Standards (see 12).

Parc Hadau Gardens, 35 zero carbon homes, Rhydyfron, Wales Serio architects

K. **Overheating:** To ensure homes are resilient to future climate change, and will stay comfortable even in the hotter summers predicted in the future without requiring expensive and energy-intensive air conditioning, overheating will be assessed. All developments of five homes or more should pass CIBSE TM59 criteria, using 2080 predicted weather files and without mechanical cooling. For smaller developments, GHA's overheating tool should be used (GHA, 2019). This is likely to require external summer shading to south-facing windows. For all sites, the Mechanical Ventilation Heat Recovery (MVHR) system should be designed to optimise peak summer cooling. Secure night-time low level and high level openings (eg rooflights) should be provided to give excellent natural ventilation and occupant control.

L. **Resident induction:** To help occupants benefit most effectively from living in zero carbon housing, regular induction, training and problem-solving sessions should be planned with residents over the first year. This should cover matters such MVHR filters, which could be changed by the residents for many social-rent tenants, and in all other tenures.

M. **Post-occupancy monitoring** should be carried out on at least 50% of the homes at 1, 2 and 5 years from completion, to ensure proper performance. Energy use, carbon emissions, running, maintenance and other costs, and occupants' satisfaction should be monitored, completing all "essential activities" in sections 3, 4, 5 ,8 & 9 of RIBA Post-Occupancy Primer (RIBA, 2016). Note the WLC report (see 7.10 below) will be reviewed against actual costs and performance at 2 years and 5 years post-completion.

Goldsmith Street Passivhaus , Norwich City Council, Mikhail Riches architects

7. ONE PLANET LIVING

If everyone consumed the natural resources of an average UK citizen, we would need three planets to support us. One Planet Living is a simple framework designed to help people live well with the **resources of the one planet** we have. It has been used over twenty years in both public and private sector housing and elsewhere, and is aligned with the UN Sustainable Development Goals (UNDESA, 2015).

The climate/ecological emergency is understood in very different ways at present. A narrative of **environmental excellence**/ net zero carbon is needed to connect with different audiences: communities in Hereford, market towns and rural areas may have different priorities. Communication is a two-way process of explaining, listening, and responding to local needs. Narrow technical standards alone are not enough if they don't connect with reality of daily life. The One Planet Living framework is not a prescribed standard, certification or accreditation system - there is no pass or fail - but it makes it **easy to "do the right thing"**, requires ambitious standards, and will be peer-reviewed by Bioregional. One Planet Living is:

- grounded in science.
- **easy to understand**, with a common language that works for both construction and operation, and with other stakeholders.
- proven to increase satisfaction and reduce costs.
- flexible, with long-term sustainability goals, designed to respond to the complex and ever-changing world.
- a tool to reach **hearts as well as minds** - the One Planet Living principles provide a simple way to engage and inspire diverse stakeholders.

The ten One Planet Living principles, which will be developed into a One Planet Living Action Plan for each site, are outlined below (Bioregional, 2011).

Health and happiness	Encouraging active, social, meaningful lives to promote good health and wellbeing
Equity and local economy	Creating safe, equitable places to live and work which support local prosperity and international fair trade
Culture and community	Nurturing local identity and heritage, empowering communities and promoting a culture of sustainable living
Land and nature	Protecting and restoring land for the benefit of people and wildlife
Sustainable water	Using water efficiently, protecting local water resources and reducing flooding and drought
Local and sustainable food	Promoting sustainable humane farming and healthy diets high in local, seasonal organic food and vegetable protein
Travel and transport	Reducing the need to travel, encouraging walking, cycling and low carbon transport
Materials and products	Using materials from sustainable sources and promoting products which help people reduce consumption.
Zero waste	Reducing consumption, re-using and recycling to achieve zero waste and zero pollution
Zero carbon energy	Making buildings and manufacturing energy efficient and supplying all energy with renewables

7.1 HEALTH AND HAPPINESS

Active lives will be encouraged to promote good health and wellbeing, with specific measures for each site. Good design, daylighting, etc can help with this in many ways. The aim, recognised more than ever following Covid, is for high levels of physical, social, mental and emotional **health and wellbeing**. This can be supported with Herefordshire's health and wellbeing strategy.

7.2 EQUITY AND THE LOCAL/RURAL ECONOMY

The new homes and their occupants will help to boost the **local rural economy**. Vibrant and resilient neighbourhoods have a significant proportion of their money spent locally, fairly and without exploitation.

Herefordshire's strong culture of local craftspeople can be engaged, raising the quality of the homes and increasing a sense of **local pride.** Active engagement with local construction training providers is encouraged to improve skill levels in sustainable design, construction and retrofit.

Equity also means those living in **existing homes are not left behind** - see section 11 below - and every development will be designed as "tenure blind" - see 12 below.

7.3 CULTURE AND COMMUNITY

Each community/site should be explored to nurture **local identity, history and heritage**. The new developments should reinforce this (see 12 below) and promote a culture of real sustainable living, developing Herefordshire's environmental traditions to a **new level of local community** engagement.

Encouraging sustainable homes for all, Herefordshire welcomes contact from self-build and community-build individuals or groups who share Herefordshire Future Homes' net zero values.

7.4 LAND AND NATURE

Site-specific opportunities should be explored to protect and restore land and water systems for people and wildlife. The One Planet Living Action Plan will collaborate on ideas to increase **local biodiversity,** and maximise carbon sequestration in the soil, agriculture, and forestry. People can be helped to recognise the value of nature, including its value to human health. Herefordshire Wildlife Trust and others can help and support.

Mellor Primary School,
Wildlife habitats designed with the children,
Sarah Wigglesworth Architects

7.5 SUSTAINABLE WATER

Efficient water use should be promoted on every site, protecting local water resources and **reducing flooding and drought.** Very low water-use appliances will be carefully specified for all internal fittings, possible grey water recycling, rainwater harvesting and garden water butts. Water usage should be **<75 litres/person**/day as CIBSE Guide G standards. Permeable surfaces, green roofs and sustainable drainage should be used where appropriate to reduce demand and manage water run-off. Working with local communities and planning policies, this will contribute to sustainable water management and reduce flood risks in local areas (Herefordshire Council, 2015).

7.6 LOCAL AND SUSTAINABLE FOOD

Herefordshire is well known for its agriculture, apple and pear orchards, food, cider, etc. It will come naturally to promote sustainable, humane farming and healthy diets, high in local seasonal organic food. Opportunities for **communal gardens** and food growing such as **urban orchards** and allotments should be maximised, with one **Herefordshire apple tree** to be planted for each home. The One Planet Living plan should also reduce or eliminate waste for each site, supported by the sustainable food strategy in Herefordshire. (Brightspace Foundation, 2010).

7.7 TRAVEL AND TRANSPORT

A green travel plan will be produced for each site. The need to travel can be reduced, **encouraging walking, cycling** and low-carbon transport, while recognising rural Herefordshire life may require some car use. With the Council's planning and transport departments, appropriate transport/walking/cycling/parking facilities and standards will be developed for each site, recognising future trends, and noting some sites have better access to local facilities and sustainable transport choices. **20mph or "Homezone" 5mph** traffic speeds are encouraged wherever possible to prioritise and encourage walking, cycling, safe children's play and socialising.

Good design can minimise unnecessary car journeys. Well-integrated easy-access **cycle storage** will be planned throughout, typically two spaces per 2-bed home, with more for larger homes.

The transition, from petrol to electric car and cycle use, will be supported with **electric vehicle charging points** for all parking - see section 9 below. Sustainable transport choices will be encouraged with site facilities and support for **electric car clubs**, car-sharing, and public transport.

7.8 MATERIALS AND PRODUCTS

Materials from **sustainable sources** can help people to reduce consumption. Products in the home can be non-toxic to humans or wildlife at every stage of their lifecycle, from raw material through to manufacturing, use and end-of-life. The same is true for building materials. Very low embodied carbon materials for the new homes and infrastructure is included in section 7 below. Building materials will also be PVC-free and generally have very low environmental impact, low VOC, and zero or low formaldehyde. Total VOCs should be < 0.3 mg/m3 as Approved Document F; Formaldehyde < 0.1 mg/m3 as BREEAM.

7.9 ZERO WASTE

Reducing consumption, reusing and recycling will help drive towards **zero waste and zero pollution**, aiming for zero waste to landfill. UK consumes 600 million tonnes of products a year, and generates 200 million tonnes of waste, over 60% from the construction industry. (DEFRA, 2021).

A site waste management plan (SWMP) should be developed to minimise this for each construction site, together with a plan for helping residents to reduce and manage waste, which might include a local community repair cafe, tool library, etc.

7.10 ZERO CARBON

This HFH standard looks at two zero carbon components: operational carbon and embodied carbon - together making up **true whole-life carbon** homes and communities.

Operational carbon is the footprint of **energy used in running** a home: for heating, hot water, cooking, lighting, electricity etc.

CITU Leeds, Climate Innovation District, Ollier Smurthwaite architects

Springfield Meadows, Oxford, Greencore

In simple terms, a home with net zero operational carbon does not use fossil fuels (ie oil, coal, gas - or electricity generated from them), and its energy use is balanced with 100% renewable energy.

Embodied carbon is the **carbon in construction materials**, their transport and installation on site, maintenance and end-of-life recycling or disposal (RICS, 2017).

Taken together, operational carbon and embodied carbon can be expressed as whole life-cycle, or **whole life carbon (WLC)**, measuring the carbon emissions from both the home's construction and use of over its entire life, assumed as 60 years.

A Whole-life carbon and cost sustainability report should be produced at RIBA stage 2, to be reviewed/updated at RIBA stages 3, 4 and 7, using Whole Life Carbon Network recommended methodology (WLCN, 2021). It should report 60-year figures for all capital, maintenance, running and other financial costs, and carbon emissions, for each proposed development. It should compare these with a 2019 Building Regulations-compliant scheme. The report should demonstrate the capital cost, relative energy use, **whole-life financial and carbon savings**, etc. It is to be reviewed against actual costs and performance at 2 years and 5 years post-completion.

Reduced operational carbon is described further below in sections 8 and 9, Passivhaus Plus and Renewable Energy. Embodied carbon is described in section 10.

Carrowbreck Meadow, Norfolk, Passivhaus development, Hamson Barron Smith

ONE PLANET LIVING ACTION PLAN

A One Planet Living Action Plan will be developed for each site. The document will be co-created by the development partners and invited stakeholders. Building on the excellent work already taking place in the county, it will respond to the opportunities and challenges of One Planet Living outlined in section 7. The Action Plan is a dynamic document to be modified and improved as the world and our knowledge change. It can be monitored, reported and reviewed periodically.

The Action Plan will be published on-line when it goes live, to share experience, learn from each other and crowdsource solutions. The aim is to unlock the collective potential to tackle humanity's greatest challenge - how to live happily and sustainably on our one planet.

One Brighton

Each One Planet Action Plan will contain a comprehensive set of actions, as outlined in section 7 above. The Action Plans will be peer-reviewed, aiming for leadership-recognition by Bioregional.

One Planet Living is a commitment to a journey rather than a tick-box certification system. It's aligned with UN Sustainable Developments Goals (UNDESA, 2015) and targets can be set which are particularly useful and meaningful for the communitty.

But sustainability isn't just about measurement of targets: it's engaging people's hearts and minds. The human element is just as important - local success stories, anecdotes, etc help to communicate progress, inspire others and build sustainable communities.

Two examples of One Planet Living schemes are shown below.

ONE PLANET LIVING ACTION PLAN EXAMPLE 1

***One Brighton** is a scheme of apartments, community space and a café in central Brighton, giving a greener, healthier lifestyle and radically reducing CO_2 and water consumption.*
Bioregional used the ten One Planet Living principles to draw up a sustainability action plan from design and construction into use. The highly insulated, triple-glazed buildings were designed with architects Feilden Clegg Bradley Studios and built by Denne. Electricity is sourced from a green power provider through the development's own energy services company, One Brighton Energy Services (OBES), a not-for-profit company set up to supply 100% renewable energy on an affordable basis to the residents of One Brighton. The company operates and maintains the photovoltaic array and communal energy distribution system.

ONE PLANET LIVING ACTION PLAN EXAMPLE 2

Springfield Meadows, Oxford *is a mixed development of 23 affordable and for-sale homes, built "tenure-blind"to the same high standards throughout.*
It's designed to help residents lead happier and healthier lives with a very small carbon footprint, engaging with nature and creating a strong sense of community.
The homes are built using local labour and natural materials with 90% reduction in embodied carbon emissions.
All homes are zero carbon in operation, with solar panels and connection to green power for any surplus demand. A car-club operates with electric vehicles. Residents benefit from large gardens, giving the opportunity to grow their own food, a central green space to enjoy as a community, a wildlife pond, a community orchard, and a herb garden.

Springfield Meadows, Oxford, Greencore.
Left: Net zero carbon homes, powered by renewable PV electric solar panels.
Above: Wildlife pond and planting.
Below: UN Sustainable Development Goals.

8. PASSIVHAUS PLUS

All homes will be Certified to **Passivhaus Plus** standard.

Since the UK Code for Sustainable Homes was withdrawn in 2015, a confusion of environmental building standards have evolved. BREEAM, Passivhaus (three different standards), AECB, UK Green Buildings Council, RIBA 2030 Climate Challenge, LETI (London Energy Transformation Initiative), LEED (Leadership in Energy & Environmental Design, originally a USA standard), and a forthcoming **UK Future Homes Standard** consultation in 2023, ahead of implementation in 2025 (MHCLG, 2021).

Passivhaus is an existing standard, now widely recognised in the UK, which has already been adopted for Council-developed social housing in Exeter, Norwich, York, and elsewhere.

Passivhaus principles are explained below. Passivhaus Plus will verify the home's designed heating needs <15 kWh/sqm.yr, and its total **energy consumption <45 kWh/sqm.yr**. By contrast, current UK Building Regulations cover only part of the energy used. Note LETI and RIBA standards require total energy <35 kWh/sqm.yr. (LETI, 2020a) (RIBA, 2021). Where possible, designs should aim for 35 kWh/sqm.yr, and in all cases achieve Passivhaus Plus standard of <45 kWh/sqm.yr. (See example, 9 below).

Passivhaus has a requirement to limit overheating, but HFH includes a higher standard, see section 6K above.

The Passivhaus Plus standard for Herefordshire Future Homes requires **60kWh/yr.sqm on-site renewable energy**, which could be PV solar electric panels on south-facing roofs (Passive House Institute, 2016) (see 9 below). Full Passivhaus technical details are in Passive House Institute (2016) *Criteria for the Passive House, EnerPHit and PHI Low Energy Building Standard* (see References).

Carrowbreck Meadow, Norfolk Passivhaus development, Hamson Barron Smith architects

Hastoe Housing Association, Passivhaus, Ditchingham, Norfolk

PRINCIPLES OF PASSIVHAUS CONSTRUCTION

- The first Passivhaus building from 1991 is now **30 years old**. Building scientist Wolfgang Feist investigated why previous low-energy houses hadn't performed as expected, and the lessons learnt evolved into a set of principles for very low energy building design. Passivhaus is a thorough standard, and the science and monitoring of thousands of completed projects **prove that it works**. (Mitchell and Natarajan, 2020)
- **90% less heating** is needed than an average house. Typically Passivhaus heating bills may be £100 a year or less. This contrasts with the £700 to over £3000 energy bills for UK homes. Heating is measured at the design stage by **PassivHaus Planning Package software (PHPP)** to verify the heating need: Passivhaus requires <15kWh/m².yr. Passivhaus Plus requires the home's total energy use to be <45kWh/sqm.yr, including heating, hot water, cooking, electrical appliances and lighting.
- **Super-insulation** is required to achieve this very low heat loss - highly insulated walls, roofs, floors, triple-glazed windows (which can also improve sound insulation), and no compromises (known as thermal bridges) which could create cold spots.
- **Airtightness** is around 20x better than typical UK homes. At completion, the rate of air leakage from the building is measured (Q50>0.60). This ensures **no cold draughts,** which can radically reduce a home's energy performance.
- Mechanical ventilation with heat recovery (MVHR) provides **constant fresh air,** while retaining heat inside the house. The outgoing air pre-warms the fresh incoming air, **reclaiming 80-90% of its heat.**
- Minimal heat loss from the home. A **compact simple built form**, such as a terraced house or flat, has less external surface area, and therefore less heat loss, than for instance a single-storey detached bungalow.
- Solar orientation. Passivhaus analyses all the home's windows and measures the useful **heat gains from winter sunshine**, which can provide as much as a third of the home's total heating needs. Another third can come from ambient heat gains - the energy used in the home for cooking, lighting, hot water, and from the occupants which ends up as "waste" heat. Typically that leaves just a third of the heating to be provided by a small number of radiators or similar.
- The points above apply to all three Passivhaus standards - Classic, Plus and Premium - which should guarantee minimal energy/heating demand. However, the original Passivhaus Classic standard does not specify where that energy comes from, so fossil fuels could still result in significant carbon emissions. The **renewable energy** required for Passivhaus Plus fills this gap.

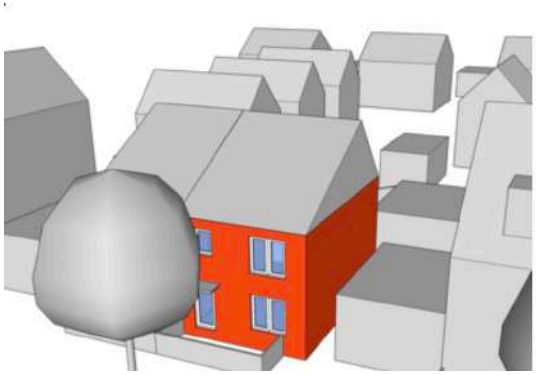
9. RENEWABLE ENERGY

Herefordshire Future Homes should use no fossil fuels, but 100% renewable zero carbon heat & power.

The two components of operational carbon and embodied carbon were outlined at 7.10 above. 100% of operational carbon should be balanced with renewables, contributing positively to both UK and Herefordshire carbon reduction targets.

All homes should have heat pumps or other low-carbon heating. As outlined in section 8, Passivhaus Plus requires on-site renewable energy, probably **PV solar electric panels** on south-facing roofs of **60kWh/yr.sqm** or other renewables. (Note the sqm area here is the building footprint, not floor area). Although the actual energy used in each house will vary according to the number of its occupants, their lifestyle etc, research shows homes will **average net zero** operational energy, ie generating roughly as much energy on site as they use. Connecting to a low carbon heating network (LCHN) may also be cost-effective where the site proximity and scale enable efficient operations, and is encouraged.

Although theoretically net zero could be achieved with an inefficient building powered by PV, this would not be sustainable or replicable generally, and would be wasteful of both natural and financial resources. Herefordshire Future Homes have highly insulated Passivhaus building fabric, sometimes referred to as a **"fabric first" approach**, and very low energy requirements. Therefore it is sensible to look at meeting their needs with renewable energy. **Local energy generation** and smart grids can have several advantages, including lower electricity transmission losses than the national grid and local resilience.



Space heating demand kWh/m²/yr	Fabric and ventilation specification		Metered energy use kWh/m²/y	PV generation (for net zero)	Net zero on-site?	Potential surplus PV generation (20 panels) kWh/yr
15	Floor U-value	0.11 W/m²K	Air source heat pump: 27	55 kWh/m²fp (8 panels)	Yes	4,681
	Wall U-value	0.13 W/m²K				
	Roof U-value	0.11 W/m²K				
	Window U-value	0.9 W/m²K	Direct electric: 43	83 kWh/m²fp (12 panels)	Yes	3,077
	Thermal bridging	2 kWh/m²/yr				
	Ventilation	MVHR 88%				
	Airtightness	<0.6m³/m²h				

Optimised house design with simple built form and larger south-facing roof for PV. Space heating demand 15 kWh/sqm.yr, total energy use <45 kWh/sqm.yr, meeting Passivhaus Plus standard. Net zero operational carbon with on-site renewable electricity. Note additional PV panels could generate potential surplus electricity. (CLJSP, 2021)

RENEWABLE ENERGY

PV solar electric panels will be **integrated into the design**, certification, tender and construction process: it will be less expensive to include them from the start than to retrofit post-completion. The renewables could be separately financed and operated or leased by a third-party provider, either independently or as a community share offer renewable energy project run by a local organisation.

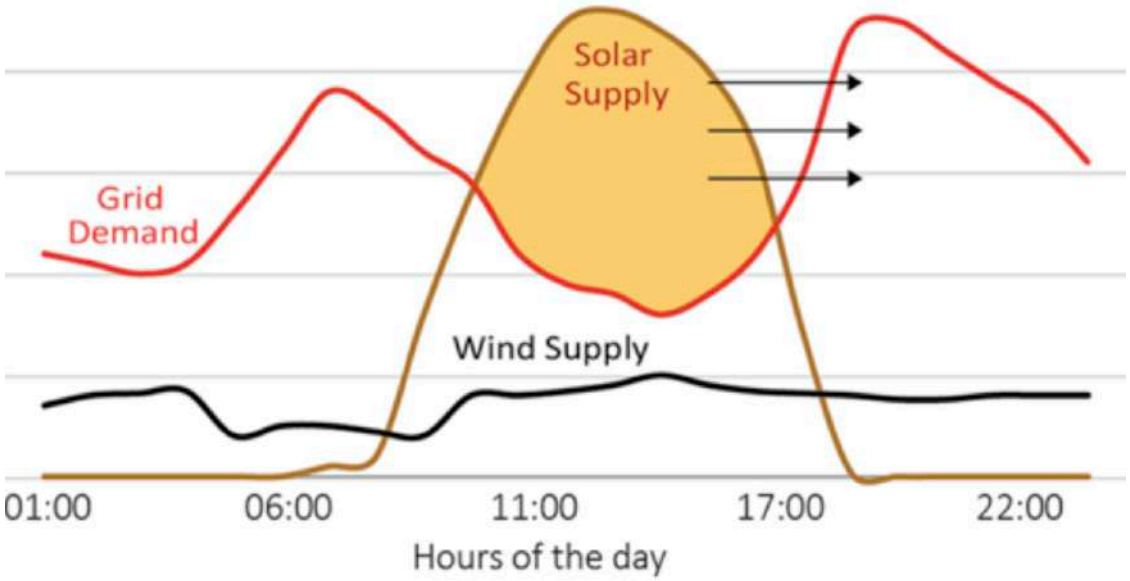
STORAGE AND ACTIVE DEMAND RESPONSE

Each site should have appropriate management of the generation, storage and metering of its renewable electricity, including smart metering. The principle of an off-peak electric tariff is well understood, and has recently been developed as a more flexible time-of-use or agile tariff. Battery and other storage should be used to **manage peak supply** from renewables and peak demand from the homes. Excess solar-generated electricity can be battery-stored - either by a third party provider and/or by the user - or stored as hot water via an immersion heater in the user's cylinder. Appropriate in-home displays should make the energy generated and used **easy for residents** to understand.

In addition, electric vehicles can be used to help balance electricity demand. Electric vehicle use in Herefordshire is increasing - and each electric car contains a sizeable battery, which can be helpful in two ways. Firstly, vehicles can be charged efficiently and economically to **store excess site-generated renewable electricity.** Secondly, reverse-charging technology will allow the vehicle's battery to supply the building itself. As long as it has sufficient charge, the car battery can **provide power to the home**, rather than using the grid supply, especially during peak electricity demand periods.

Technical options for storage, smart metering and smart grid technology are advancing. Each site, and third-party operator where relevant, should develop an appropriate and ambitious generation and storage design/procurement strategy, assessing the most cost-effective, user-friendly and carbon-reducing renewables option.

The local plan and early engagement with the electricity district network operator Western Power, and the energy supply company, should facilitate expansion of renewable energy as far as possible and ensure resilience.



Diagrammatic graph showing how daytime-generated solar electricity can be stored for use in the evening. (CLJSP, 2021)

10. EMBODIED & WHOLE-LIFE CARBON

Embodied carbon is the carbon used in a home's construction materials, transport and building operations on site. It also factors in maintenance/refurbishment over 60 years, and material recycling or disposal when a building is disassembled at its end of life (RICS, 2017).

Some commonly used building materials require significant energy to produce - eg concrete, plastic, steel, aluminium, brick - while others from far away may have high transport costs.

All homes should have **very low embodied carbon** in their construction and infrastructure. As the building industry is beginning to understand embodied carbon in more detail, a different approach will be taken for larger and smaller sites.

All schemes, irrespective of size, will use simple and cost-effective pragmatic measures for embodied carbon reduction, which can also reduce costs. Considerations should include reducing or eliminating steel, concrete and other high energy materials, lower carbon concrete where unavoidable, increased use of natural low-energy materials, reclaimed/recycled materials where appropriate, and higher recycled content products and finishes generally. See LETI Embodied Carbon Primer (LETI, 2020b) for guidance.

Herefordshire has a **strong tradition of timber building** , so wood-based materials could be considered for insulated panels, frame, flooring, and cladding etc. Herefordshire's **NMITE college** includes a Centre for Advance Timber Technology (CATT) which can support off-site fabrication, local supply chains and innovation. Some natural building materials can be carbon-negative, locking in carbon from the atmosphere: these are encouraged wherever possible. Careful consideration of the whole-life embodied carbon of materials should use RICS methodology.

For developments of five or more homes, detailed embodied carbon calculations should be produced, targeting <625 $kgCO_2e$/sqm for RICS whole life carbon stages A-C.

Lower embodied carbon is encouraged where feasible, and will result in lower carbon offsetting requirements (see 8 below).

LETI Net zero carbon: ten key requirements

By 2030 all new buildings must operate at net zero to meet our climate change targets. This means that by 2025 all new buildings will need to be designed to meet these targets. This page sets out the approach to operational carbon that will be necessary to deliver zero carbon buildings. For more information about any of these requirements and how to meet them, please refer to the: UKGBC - Net Zero Carbon Buildings Framework; BBP - Design for Performance initiative; RIBA - 2030 Climate Challenge; GHA - Net Zero Housing Project Map; CIBSE - Climate Action Plan; and, LETI - Climate Emergency Design Guide.

Low energy use

1. Total Energy Use Intensity (EUI) - Energy use measured at the meter should be equal to or less than:
   - **35 kWh/m²/yr** (GIA) for residential[1]

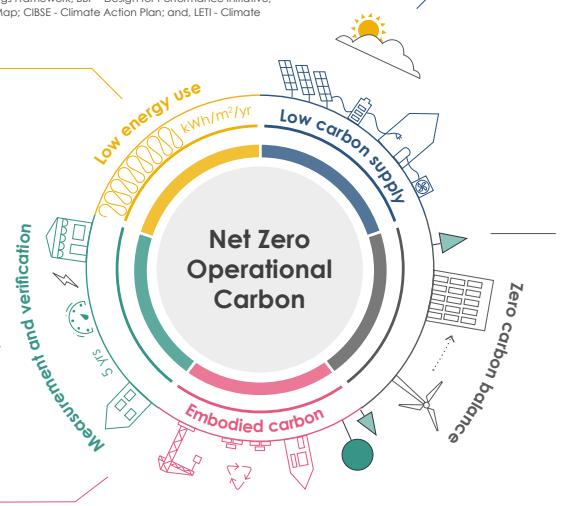
   For non-domestic buildings a minimum DEC B (40) rating should be achieved and/or an EUI equal or less than:
   - **65 kWh/m²/yr** (GIA) for schools[1]
   - **70 kWh/m²/yr** (NLA) or **55 kWh/m²/yr** (GIA) for commercial offices[1,2]
2. Building fabric is very important therefore space heating demand should be less than **15 kWh/m²/yr** for all building types.

Measurement and verification

3. Annual energy use and renewable energy generation on-site must be reported and independently verified in-use each year for the first 5 years. This can be done on an aggregated and anonymised basis for residential buildings.

Reducing construction impacts

4. Embodied carbon should be assessed, reduced and verified post-construction.[3]



Low carbon energy supply

5. **Heating and hot water should not be generated using fossil fuels.**
6. The average annual carbon content of the heat supplied (gCO_2/kWh) should be reported.
7. On-site renewable electricity should be maximised.
8. Energy demand response and storage measures should be incorporated and the building annual peak energy demand should be reported.

Zero carbon balance

9. A carbon balance calculation (on an annual basis) should be undertaken and it should be demonstrated that the building achieves a net zero carbon balance.
10. Any energy use not met by on-site renewables should be met by an investment into additional renewable energy capacity off-site OR a minimum 15 year renewable energy power purchase agreement (PPA). A green tariff is not robust enough and does not provide 'additional' renewables.

Notes:

Note 1 – Energy use intensity (EUI) targets
The above targets include all energy uses in the building (regulated and unregulated) as measured at the meter and exclude on-site generation. They have been derived from: predicted energy use modelling for best practice; a review of the best performing buildings in the UK; and a preliminary assessment of the renewable energy supply for UK buildings. They are likely to be revised as more knowledge is available in these three fields. As heating and hot water is not generated by fossil fuels, this assumes an all electric building until other zero carbon fuels exist. (kWh targets are the same as $kWh_{(PE)}$). Once other zero carbon heating fuels are available this metric will be adapted.

Note 2 – Commercial offices
With a typical net to gross ratio, 70 kWh/m² NLA/yr is equivalent to 55 kWh/m² GIA/yr. Building owners and developers are recommended to target a base building rating of 6 stars using the BBP's Design for Performance process based on NABERS.

Note 3 – Whole life carbon
It is recognised that operational emissions represent only one aspect of net zero carbon in new buildings. Reducing whole life carbon is crucial and will be covered in separate guidance.

Note 4 – Adaptation to climate change
Net zero carbon buildings should also be adapted to climate change. It is essential that the risk of overheating is managed and that cooling is minimised.

Developed in collaboration with:

Supported by:

11. RETROFIT OFFSETS

The majority of carbon emissions from Herefordshire's existing homes - 77% - come solely from space heating. Currently the UK has the **least energy efficient housing** in Europe, Herefordshire being no exception, and it is expected that 85% of current homes will still be in use in 2050. At least **90% of existing buildings** need energy efficient retrofits to meet zero carbon targets (CCC, 2019).

An ambitious retrofit programme for existing local homes is therefore an essential part of the transition to net zero (Herefordshire Council, 2016). This will be supported by emerging local and national policy initiatives. Building new net zero homes on their own will not be enough: the contribution of real energy/carbon/fuel bill savings from properly insulating existing homes can be considerable - and those living in existing homes, especially near new developments, must not be left behind. Retrofitting as many local homes as possible to excellent standards will keep them in step with the new net zero homes (UKGBC, 2017 and 2021b).

A whole-house retrofit can **reduce home energy use by 50%-80%** with wider benefits in health, reduced NHS spending, skills and job creation. Retrofitting homes for the 16.5% of Herefordshire people in **fuel poverty** is essential for a just transition (LGA, 2019), UKGBC, 2017), (DBEIS, 2019).

Why is retrofit included in the Herefordshire Future Homes standard? There is increasing recognition that, especially for the embodied carbon of new homes described in section 7, net zero cannot be reached at present without **offsetting residual carbon emissions.** Offsetting schemes are sometimes controversial, with questions over their transparency. Woodland planting and carbon capture and storage schemes (CCS) can be effective if carried out responsibly, but may be remote from the new homes constructed.

For all developments to achieve net zero it is therefore recommended, subject to a viability assessment, that 100% of embodied carbon emissions are offset, in order of preference, by:

People Powered Retrofit partnership, led by Urbed, Greater Manchester

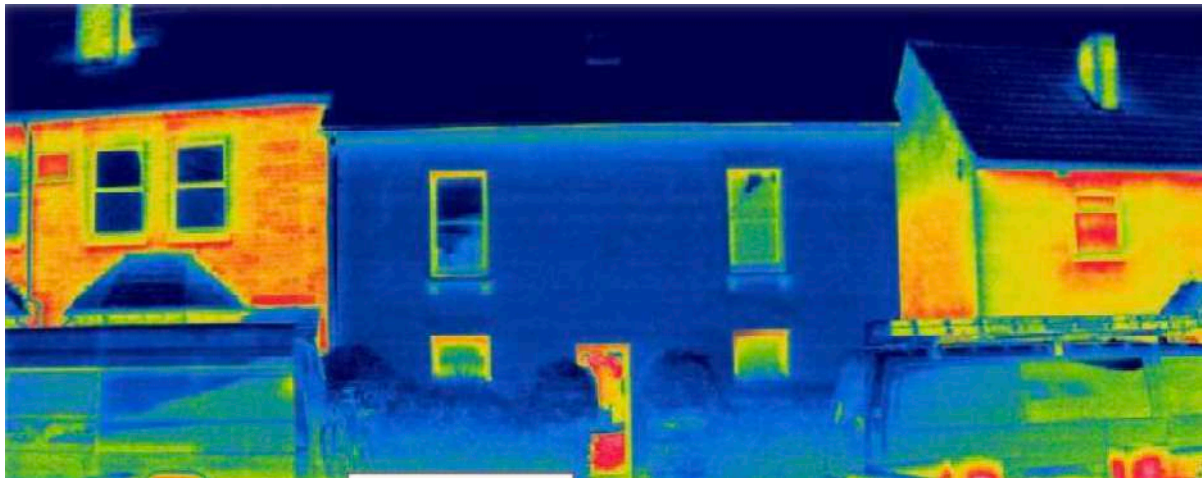
1. WHOLE-HOUSE RETROFITTING of local homes, benefitting existing residents and at the same time balancing residual embodied carbon from the new homes.

Retrofits should be certified to recognised high standards, either **EnerPHit**, the Passivhaus retrofit standard, or **AECB Retrofit** standard where that is not possible (Passive House Institute, 2015); (AECB, 2021). These have space heating requirements of <25 and <50 kWh/sqm/yr respectively, and other criteria and methods of compliance. In some cases - for instance if new windows have recently been fitted - a phased retrofit programme may be sensible, working to full certification at a future date. Gas and other fossil fuel heating should be removed and replaced with **heat pumps or other low-carbon heating.** Note EnerPHit allows a progressive approach: where it might not be sensible to carry out full retrofit in one phase - eg because new windows had recently been fitted - a **phased approach** could be adopted, working towards an agreed EnerPHit-compliant design.

2. WOODLAND PLANTING, following an accredited scheme such as the Forestry Commission's Woodland Carbon Code (WCC, 2021) or another scheme approved by Herefordshire Council. Local woodland planting is preferred wherever possible.

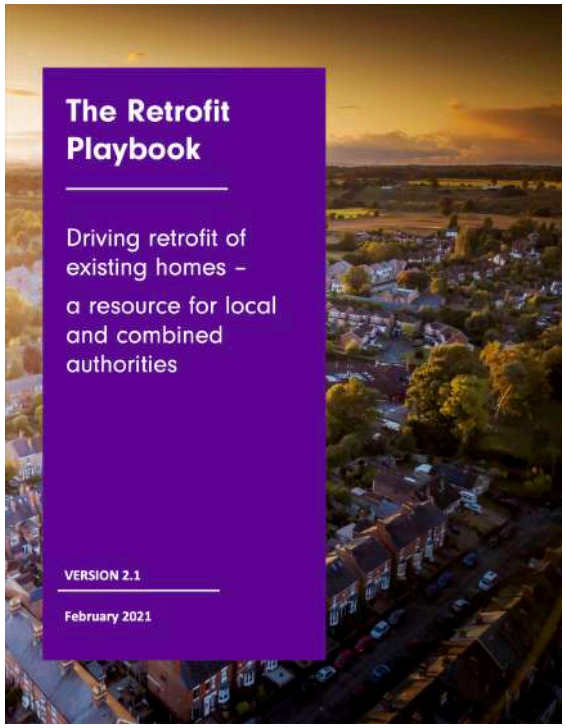
3. PAYMENT to Herefordshire Council's local carbon offset fund, for retrofitting or other carbon reduction works, if 1 & 2 above are not possible. A carbon price at least equal to HM Treasury Green Book non-traded central scenario is recommended. For 2021, this is priced at £70/tCO_2e. (HM Treasury, 2020).

For 1, 2 and 3 above, UK Green Buildings Council carbon offsetting recommendations and at least minimum reporting requirements should be followed (UKGBC, 2021a).



EnerPHit retrofit, Hereford, Simmonds Mills Architects. Thermographic image.

UKGBC Retrofit Playbook (UKGBC, 2021b)



Woodland planting

12. EXCELLENCE

Locally-distinctive beautiful homes and places of the highest design quality are an essential part of a sustainable future, not an optional add-on. Herefordshire expects **award-winning quality**. Homes measured merely to technical standards could end up as second-rate designs, and even be prematurely demolished: unsustainable both environmentally and economically.

Development partners should carefully select architects/design teams/design concepts and procurement/building contract methods, dovetailing with commercial and other project constraints, to ensure the highest standards of design quality, as well as sustainability, are embedded from the start.

- **Design quality:** To give Herefordshire excellent architectural quality, the design approach should be informed by a thorough analysis of the physical, historical and cultural context of each site.
- **Accessibility:** To meet the needs of wheelchair users and others, an agreed proportion of homes for each site should be built to accessible/wheelchair standards, as defined in Building Regulations document M categories 2 & 3, and Lifetime Homes standard.
- **Tenure:** To avoid social discrimination, every development will be designed as "tenure blind" without differentiating between rented and other homes, in siting, standards, external material or design.
- **Design toolkit:** Building for a Healthy Life (previously published as Building for Life 12) standard will be referenced for assessment. This is supported by the NHS, Homes England - in its evaluation of bids - and others. It gives a red/amber/ green traffic light on twelve underlying design principles. Note 20mph/5mph "Homezone" traffic speeds and walking/ cycling priority are encouraged (Birkbeck et al, 2020).
- **National Space Standards:** These will be required as a minimum - creating comfortable and spacious homes which are naturally light and bright with access to private outdoor space.

The **power of excellent design** throughout will help to inspire people, build local pride, and engage even those who hadn't thought themselves particularly green, to help ensure Herefordshire Future Homes lasting success.

PASSIVHAUS IN PRACTICE - Exeter's experience

An interview with Emma Osmundsen, Exeter City Council.

Exeter City Council has been leading the way with Passivhaus environmental homes for over ten years. The approach has been quiet but consistent, starting small and growing in ambition but reaching global recognition for adopting stringent environmental factors that form the core of all the Council's developments, both commercial and residential. Exeter's efforts may have gone largely unnoticed in the UK but its achievements have been picked up globally, with Exeter cited as one of the leading global sustainable developers, providing advice and inspiration to North America, New Zealand, Canada and mainland Europe.

The interest derives from the fact that for the last decade all new Council buildings in the city are:

Very low energy – certified to the Passivhaus Standard

Healthy – meeting the German Biology (IBN 2015) Principles

Climate Ready – designed to be climate resilient to at least 2080

Integrated within a sustainable landscape – buildings are set within a permaculture integrated landscape.

What does this all mean? In reality Exeter has council homes and a pipeline of council buildings, including a leisure centre and swimming pools, extra-care village and offices. These buildings are healthy for residents and occupants, comfortable regardless of the weather and extremely cost effective to run (thereby helping to eradicate fuel poverty). From a Council perspective we have reduced operating and lifecycle building costs, with happier and healthier tenants, reduced rent arrears and anti-social behaviour, and exemplar buildings that are performing way beyond comparable building regulation compliant assets.

Exeter City Council is proud of its environmental credentials but more importantly they are driven by delivering best value. Built assets are invariably one of the most expensive investments councils need to make and by adopting a triple-bottom line approach to new developments, Exeter has proved that it can deliver developments that are truly environmentally, socially and financially sustainable.

Over the last decade the Council have developed over a hundred certified Passivhaus homes, with 500 more in the pipeline. These have all been affordable homes meeting the City's ever increasing housing need. Of these homes, over 60% of residents have not needed to switch on their heating since the homes were occupied – whatever the weather! This has helped transform some households who can now afford a family holiday or extra-curricular activities for their children.

The healthy features of all the new developments mean that residents have reported measurable health improvements and continue to be surprised by the quality of their surroundings, not least good sleep as a consequence of the low electro-magnetic radiation in the homes and the exemplar air quality with a constant supply of fresh air.

Reproduced with permission from Association for Public Service Excellence (APSE, 2018) edited/updated.

13. REVIEW

Herefordshire Future Homes is developing against a fast-moving backdrop of post-Covid economic recovery, the build-up to Glasgow's COP26 climate summit in November 2021, and evolving Government policy and initiatives.

This document will therefore be reviewed annually, allowing flexibility to respond to the changing landscape. For clarity, reviews will not dilute the net zero standards, but where appropriate these may be re-aligned with emerging best practice/research/legislation, if this is sufficiently robust, to minimise duplication of effort, cost and risk, and facilitate compliance for all involved.

As an example, in March 2021 the Environmental Audit Committee launched an inquiry into low carbon construction methods, commenting: "For decades we have been constructing homes and buildings with concrete and steel, with little thought to the carbon footprint involved." There are currently no Government standards for embodied carbon, but if policy on low-carbon and sustainable building materials appears, the embodied carbon standards in section 10 would then be reviewed.

York City Council, Passivhaus development, Mikhail Riches architects

14. GLOSSARY

AECB: The Association for Environmental Conscious Building is an independent not-for-profit UK network of individuals, building contractors, building industry professionals, academics etc who develop, share, train and promote sustainable building best practice. Their standards for new buildings and retrofits have self-certified performance levels, slightly more relaxed than Passivhaus levels but measured in a similar way. See AECB publications included in the References below.

Airtightness: A measure of the air leakage from a building. Even a small gap in the airtight construction layer would let warm air from inside a house leak away very quickly; especially critical with highly insulated buildings which need very little heat.

ASHP: An Air Source Heat Pump extracts low grade heat from the outside air and converts it to heat at a useful temperature for running a building. It's usually powered by electricity, ideally renewable electricity; and as an example 1 kWh of electric input might give 3.5kWh of heat output. See also GSHP.

Biodiversity: The complex variety of plant, animal and micro-organism life in an area or habitat. Wildlife numbers have fallen dramatically - 70% over 50 years - but are important for many reasons including protecting our environment and soil formation, freshwater, agriculture, health and climate stability.

Building Regulations: The legal requirements for all new buildings, and for some work to existing buildings. Approved Documents set detailed technical standards for structural, fire, ventilation, drainage and other building performance. These include Document L covering energy conservation standards.

Carbon footprint: The amount of carbon dioxide(CO_2) resulting from an activity, product, person etc. It is usually expressed in $kgCO_2e$, ie the weight of carbon dioxide - a gas causing the climate crisis. The "e" stands for "equivalent", so other emissions are converted back to a CO_2 equivalent measure. See also Embodied carbon and Operational carbon.

Carbon vs energy: Both are used to measure building performance. Carbon emissions (CO_2e) directly impact climate change. Focussing solely on carbon, however, can skew our thinking. A poorly performing building, which met all its needs with renewable energy, could still technically be zero carbon - but very expensive and wasteful of resources. Therefore the first aim must be to reduce a home's annual operational energy use to a very low level, measured against its floor area (kWh/sqm.yr). It then becomes sensible to meet that greatly reduced need with renewable energy, which will mean very low or ideally net zero carbon performance ($kgCO_2e$/sqm.yr).

Carbon neutral or net zero: A building that generates as much energy from renewable resources as it uses. This energy could come from on site or elsewhere, and could be calculated as a "net" balance. The term is sometimes used to refer just to a building's operational carbon (see separate entry below), but should also include embodied carbon (see below) as UKGBC, LETI and RIBA definitions, see References.

COP26: International UN Climate Change summit negotiations, to be held in Glasgow, November 2021. COP stands for Conference of the Parties. See also Paris Agreement.

CCC: The UK's Climate Change Committee was set up in 2008 by the Climate Change Act, and gives independent analysis,

monitoring and advice on the UK Government's progress in meeting statutory targets.

Embodied carbon: The carbon emissions from a building's construction and maintenance. They include materials, their production, transport and installation on site, as well as planned maintenance, replacement and disposal at end of life, taken over a theoretical 60 year building life for consistency. Although embodied carbon can be as much as 50% of a home's total carbon footprint, it is not covered by UK regulations.

Energiesprong: A framework from the Netherlands, now being used in UK, to retrofit (see below) existing homes to net zero standards, with a financial model which meets the initial capital cost with the savings in running costs.

EnerPHit: A high performance building standard for retrofitting existing buildings. "PH" indicates it's a Passivhaus standard, but requires a lower performance than for a new building. Certification can be for a complete retrofit carried out at one time or for a programme of work phased over a number of years.

Energy use/energy intensity: The total energy used in a building's operation, usually measured in kilowatt hours per square metre of internal floor area per year (kWh/sqm.yr). Sometimes referred to as energy intensity. See also Carbon vs energy and Operational carbon.

Future Homes standard: A forthcoming UK standard for more energy-efficient housing. Government has promised consultation in 2023, ahead of implementation in 2025 (MHCLG, 2021).

GSHP: Ground source heat pump. Like ASHP (see above), this extracts low grade heat, in this case from a coil or borehole in the ground rather than from the outside air. Typically more expensive, but also more efficient, than ASHP.

Heat pump: see ASHP and GSHP above. An experienced designer and installer are essential to ensure proper operation.

Herefordshire apple tree: Herefordshire has for centuries been recognised as the leading county for apples, with many of its own orchards, community orchards, nurseries, apple varieties & ciders.

IPCC: The Intergovernmental Panel on Climate Change, a UN panel of international scientists who assess peer-reviewed research on climate change and its likely impacts, risks, and mitigation options. Their partial report published in August 2021 (IPCC, 2021) was headlined "Code Red for Humanity".

LETI: London Energy Transformation Initiative is a network of London-based building professionals who have published progressive voluntary standards and explainers, see References.

Low carbon building materials: Some common building materials release much more CO_2 in their production and use than others. Cement, for example, is responsible for 8% of global carbon emissions. Trees absorb CO_2 when they grow, so even after accounting for the carbon released during production, timber is a low carbon material.

MVHR Mechanical ventilation heat recovery: A Passivhaus base requirement. Typically a central fan unit extracts warm and humid air from kitchens and WCs, and reclaims 90% of the heat to pre-warm filtered incoming air supplied to other rooms. It avoids the significant heat losses from opening windows in winter.

National Space Standard or NDSS: A minimum floor area standard, based on the number of people and bedrooms in a home. Although this Government standard widely used, it is not mandatory. See Reference (MCHLG, 2015).

Net zero energy/net zero carbon: See carbon vs energy, and also Carbon neutral or net zero above.

Offset: A reduction in carbon emissions made in one place to compensate for unavoidable carbon emissions in another place. see section 11, Retrofit offsets.

One Planet Living: A voluntary non-prescriptive framework which covers a wide range of environmental issues. Developed by Bioregional; see section 7.

Operational carbon: The carbon emissions from operating a building each year. A new building with net zero operational carbon does not burn fossil fuels, and is 100% powered by renewable energy. See also Carbon vs energy.

Overheating: The hotter summers caused by climate change are making uncomfortably hot buildings an increasing problem. Fitting air-conditioning would just consume more energy, fuelling climate change. A well-designed building should design the problem out - eg with summer shading to windows, night-time ventilation, etc. See section 6K.

Paris agreement: An international UN treaty on climate change agreed by 196 countries in Paris in 2015 (COP 21). It aims to limit global warming to below 2 degC, and preferably below 1.5 degC, compared with pre-industrial levels. See also COP 26.

PAS 2035: See Retrofit. PAS 2035 is a new code which defines the stages and skills needed in the process of a retrofit. It does not define a performance standard - see AECB and EnerPHit.

Passive solar design: Useful winter sunshine , typically through south windows, which can provide a third of the heating needed in a highly insulated house. Passive solar design is one component of the Passivhaus standard.

Passivhaus: An energy-efficient building standard, now widely recognised in the UK, which has been adopted for Council-developed social housing in Exeter, Norwich, York, and elsewhere. An independent consultant is required to certify the design and construction. See section 8, diagram in section 2, and publications by the Passivhaus Trust and Passive House Institute in References.

Passivhaus Plus: Developed from the original Passivhaus standard, this includes an additional requirement for on-site renewable energy; for a detail description see section 8.

Performance gap: The gap between a building's designed and measured energy performance. This can be as much as 60% or more in UK mainstream buildings.

PHPP Passivhaus Planning Package: A piece of software used in Passivhaus, AECB and other building performance design, evaluation and certification.

Post-occupancy monitoring: Assessment of a building's energy use, carbon emissions, running costs, occupants' satisfaction etc at one or more points after completion. See 6M and (RIBA, 2016).

PV, Photovoltaic: See solar panels.

Regulated and un-regulated energy: Energy such as space heating is covered by Building Regulations and known as regulated energy. But unregulated energy - that used by other appliances and not covered by Building Regulations - can be very significant too, and is included in total energy use.

Renewable energy: Energy generated from solar, wind, hydro, biomass and other sources, which are naturally replenished and so have no carbon emissions at source. The opposite is energy

from fossil fuels - coal, oil and gas - which can never be replenished, and are causing the climate crisis.

Retrofit: Making an existing home much more energy-efficient. This should include insulating all its walls, floors, roof, windows and doors, improving airtightness, and controlling ventilation and condensation risks. It could also have heat recovery ventilation (MVHR), a heat pump, solar panels, efficient lighting, plumbing etc. See also AECB, EnerPHit and PAS2035.

RIBA Climate Challenge 2030: A reporting standard against design targets set out for 2025 and 2030. A number of its points are covered by Herefordshire Future Homes standards. Its metrics may be incorporated into future UK standards, and it is expected that all architects for Herefordshire Council's homes will have joined the scheme, See (RIBA, 2021a).

Solar panels: Usually roof-mounted panels which convert light - even from cloudy skies - into renewable electricity. Also called photo-voltaic or PV panels.

Solar thermal: Using the sun's energy to make heat. Typically roof-mounted panels or tubes supplying hot water.

Storage of energy: Important for renewable energy. For instance solar electricity generated by day can be stored in a battery for use during the evening.

Sustainability: The Brundtland report's 1987 definition is that sustainable development meets the needs of the present, without compromising the ability of future generations to meet their own needs. Another definition is the seventeen UN sustainable development goals, illustrated on p.20 (UNDESA, 2015).

Tenure blind: Homes build for private sale, affordable rent and shared ownership that are designed to be similar in appearance, and mixed together in layout. This helps to build communities which are more integrated and cohesive.

UK Green Buildings Council: A membership organisation collaborating over best practice, knowledge and advocacy. It includes professionals, contractors, developers and manufacturers from across the building industry, committed to better environmental building standards and practices.

Whole life carbon: All the carbon emissions resulting from a building's construction, maintenance and end of life (see embodied carbon); plus its running (see operational carbon).

Whole life costing: The total financial cost of a building over its lifetime. This includes construction capital cost, maintenance, end of life, and annual running costs over a theoretical 60-yearbuilding life. Low energy buildings might typically have slightly higher initial construction costs, but (much) lower running and maintenance costs. Comparison of whole life costs and whole life carbon emissions gives the full picture.

Whole life carbon: All the carbon emissions resulting from a building's construction, maintenance and end of life (see embodied carbon); plus its running (see operational carbon). See section 7.10 and References (WLCN, 2021), (RICS, 2017).

Whole life costing: The total financial cost of a building over its lifetime. This includes construction capital cost, maintenance, end of life and annual running costs over a theoretical 60 years building life. Low energy buildings might typically have slightly higher initial construction costs, but (much) lower running and maintenance costs. Comparison of whole life costs and whole life carbon emissions gives the full picture.

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