VALE OF GLAMORGAN

REPLACEMENT LOCAL DEVELOPMENT PLAN

2021 - 2036

NET ZERO BUILDINGS

November 2025

BACKGROUND PAPER - BP33A

RLDP CDLN

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This document is available in Welsh / Mae’r ddogfen hon ar gael yn Gymraeg

Executive Summary

i. The Vale of Glamorgan Council declared a Climate Emergency in 2019. In response to this, the Council has adopted a Climate Change Challenge Plan. Within it, a need to investigate the feasibility of achieving net-zero buildings and creating more energy efficient buildings through planning policy is identified. The work summarised within this Paper is the manifestation of seeking to comply with that commitment and the Council's wider responsibilities to mitigate the impacts of climate change.

ii. The Paper summarises outcomes of work carried out to investigate whether policy that seeks to decarbonise new buildings can feasibly be included within the RLDP. Specifically, this work investigated the feasibility of delivering buildings that are net-zero in operation and have reduced embodied carbon. The work looked at residential and non-residential buildings, reviewing and modelling the impacts of the policy on 3 common residential typologies in the Vale and a school and office building.

iii. In completing this work, Spring Design were instructed to produce a series of reports investigating the policy context, technical feasibility and financial viability implications of such an intervention. In providing the context for this work, the Paper also justifies the need to consider standards better than current Building Regulations.

iv. In achieving operational net-zero, following principles of the Energy Hierarchy, energy metrics are used to reduce overall demand and then renewable energy is employed to deliver energy commensurate to the residual, reduced, demand. The paper identifies that best practice energy metrics are to be pursued in the RLDP, in respect of space heating demand and energy use intensity.

v. A number of energy efficient building standards were evaluated and it was found that it was technically feasible to achieve the most stringent LETI standards of 15 kwh/m2/year for space heating demand and a slightly relaxed standard of 40 kwh/m2/year for energy use intensity, on the common residential house typologies and that in doing this it would be cost neutral versus the anticipated costs of achieving 2025 AD:L (Wales) standards. In view of this work the Paper includes a policy requiring new dwellings to be net zero in operation.

vi. Alongside the evidence base that Spring Design have prepared, the Social Landlord sector have also launched Tai ar y Cyd, which is a pattern book approach to delivering standardised net zero carbon homes in the affordable housing sector. There are two standards set out in the design guide – a baseline standard which is broadly equivalent to AECB Carbonlite with targets of a space heating demand of 40 kwh/m2/year and an energy use intensity of 75 kwh/m2/year, and an enhanced standard that is broadly equivalent to the LETI standards above. Technical specifications are

available for developing LAs and RSLs to bring forward developments under each standard, both of which are operationally net zero.

vii. Through engagement with the development industry, it was highlighted that there is a need for the industry to upskill and for supply chain to respond to this change in order to deliver homes to the standards required. There will be an expectation that the industry responds to this emerging policy but to allow for an appropriate lead in time, it is proposed that the operational net zero policy be phased in to become increasingly more stringent over the plan period.

viii. In the first part of the plan period following adoption, it is proposed that new dwellings be required to meet the AECB Carbonlite standard, which is equivalent to the Tai ar y Cyd baseline standard, and then from a set date later in the plan period, the targets will be reduced to reflect LETI, which is broadly in line with the Tai ar y Cyd enhanced standard.

ix. Evidence that achieves higher standards for non-residential buildings was also produced. It was concluded that given the limited typologies modelled, and the wide range of typologies that may come forward, that an intervention into non-residential development would not be pursued.

Contents

Glossary

ASHP	Air source heat pump: heating and hot water from electrical source.
CO_2e Emissions	Equivalent carbon dioxide emissions calculated using the global warming potential (GWP) of exhaust gases.
Embodied Carbon	‘Embodied Carbon’ emissions of an asset are the total greenhouse gas emissions and removals associated with materials and construction processes throughout the whole life cycle of an asset (Modules A0-A5, B1-B5, C1-C4, with A0 assumed to be zero for buildings). Sequestered carbon from biogenic materials (e.g. atmospheric carbon absorbed by trees, converted into wood and then ‘locked’ into timber construction materials) must always be declared separately from embodied carbon emissions.
Energy Use Intensity (EUI)	A measure of energy use per square metre of a given development.
Form Factor	Expresses the relationship between the treated floor area and area of the thermal envelope. A better form factor, illustrated by a lower number, demonstrates a more efficiently designed building.
MVHR	Mechanical ventilation with heat recovery: ventilation systems that ensure a constant throughput of fresh, filtered air. ‘Waste’ heat is transferred from outgoing exhaust air to incoming fresh air to pre-warm it and reduce heating demand.
Net Zero Operational Carbon - Energy	A ‘Net Zero Operational Carbon - Energy’ asset is one where no fossil fuels are used, all operational energy use (WLCA Module B6) has been minimized, meets the local energy use intensity (EUI) target or limit (e.g. kWh/m²/a) and the equivalent of all annual energy use is generated on- or off- site using renewables that demonstrate additionality. Direct emissions from renewables and any upstream emissions are ‘offset’.
Operational Carbon - Energy, Buildings	‘Operational Carbon - Energy’ (Module B6) are the greenhouse gas emissions arising from all energy consumed by an asset in-use, over its life cycle.
RICS WLCA	Whole life carbon assessment (WLCA) methodology for the built environment, produced by Royal Institute for Chartered Surveyors and adopted as best practice globally.
Regulated Energy	Energy consumed by a building for controlled, fixed services and systems including heating, cooling, hot water, ventilation, fans, pumps and lighting.
Space Heating Demand	The latent requirement of a building to consume heat energy to maintain a consistent internal temperature throughout the year. Expressed as kWh/m²yr, this measure does not factor the in- or efficiency of the heating system
Unregulated Energy	The energy consumed by a building resulting from fixtures or appliances, these are not limited by Building Regulations. For example, this can include energy consumption from appliances integral to the building’s operation/habitation e.g., lifts, escalators, refrigeration, external lighting, I.T equipment, general electrical items such as, TVs, kettles, microwaves, ovens, hobs etc.

1. Introduction

1.1 The Decarbonised Buildings Topic Paper is one of several background documents prepared as part of the evidence base to support the Vale of Glamorgan Replacement Local Development Plan (RLDP).

1.2 The purpose of this Paper is to summarise the outcomes of work that has been carried out to investigate whether policy that seeks to decarbonise new buildings can feasibly be included within the RLDP. This work investigated the feasibility of delivering buildings that are net-zero in operation and reducing the overall embodied carbon of buildings.

1.3 In completing this work, Spring Design were instructed to produce a series of reports investigating the policy context, technical feasibility and financial viability implications of such an intervention. In providing the context for this work, the Paper also justifies the need to consider standards better than current Building Regulations. The Vale of Glamorgan Council declared a Climate Emergency in 2019. In response to this, the Council has adopted a Climate Change Challenge Plan. Within it, a need to investigate the feasibility of achieving net-zero buildings and creating more energy efficient buildings through planning policy is identified. The work summarised within this report is the manifestation of seeking to comply with that commitment and the Council's wider responsibilities to mitigate the impacts of climate change.

1.4 Estimates show that from 2020, greenhouse gas emissions need to decline by 7.6% every year to 2030 or the opportunity to limit global warming to 1.5°C will be missed. Overall, emissions in Wales have fallen by 25% since 1990; however, dramatic reductions will be needed in the next decade, with a target of a 45% reduction set by the Welsh Government for 2030.

1.5 Most national carbon emission reduction strategies and plans, such as the Welsh Government's Net Zero Wales Carbon Budget 2 (2021-2025)[1], recognise that new buildings need to be energy efficient and use non-fossil fuelled energy sources and systems of operation. However, there is currently no legislative requirement to do this. It is understood that forthcoming changes to Building Regulations will require further reductions in carbon emissions beyond 2014 and 2022 standards but there is no clarity at this stage on how far these will go.

1.6 Buildings are responsible for almost a half of the UK's carbon emissions, half of water consumption and about a quarter of all raw materials used in the economy. With the climate emergency as a priority, attempts to address these factors and ensure they are not further exacerbated must be made. Thus, reducing the environmental impact of new development through planning policy should be investigated to mitigate the potential additional emissions from buildings.

[1] Welsh Government, 2021. *Net Zero Wales Carbon Budget 2 (2021-25).* Online. Available at: 42949 Second All Wales Low Carbon Delivery Plan (2021-2025). [Accessed: 29/10/24].

1.7 The Replacement LDP will allocate new land for development up to 2036 to meet identified demands. There is a need for new development in order to achieve other priorities, such as ensuring the Vale remains an attractive place for investment, protecting against demographic imbalance, meeting the significant need for affordable housing and ensuring jobs are available. However, without an intervention, the industrial and domestic emissions from new housing and employment developments would exacerbate existing emissions. Given the Council's declared Climate Emergency, it is not considered acceptable to continue to add building stock that will only further exacerbate emissions without considering how to negate this. In the absence of national requirements on this, this intervention is being considered through the RLDP.

1.8 Through its policies the Replacement LDP can influence the detail of the delivery of new development. Traditionally, this influence would include site layout, open space provision and car parking provision, for example. However, this paper introduces net-zero in operation and embodied carbon as further considerations.

2. Policy Context

UK Government Policy

Climate Change Act 2008

2.1 The Climate Change Act 2008 forms the basis of the UK's approach to tackling and responding to climate change. It requires that emissions of carbon dioxide and other greenhouse gases are reduced and that climate change risks are adapted to. The Act also establishes the framework to deliver on these requirements. The 2008 Act was amended in 2019 to require net zero by 2050 and further amended in 2021 to require a reduction in carbon emissions of 68% from 1990 levels by 2030.

Planning and Energy Act 2008

2.2 The Planning and Energy Act 2008 provides a legislative basis for requiring energy efficiency standards that go beyond Building Regulations. Specifically, Section 1 (1) states the following:

> *'…a local planning authority in Wales may in their local development plan, include policies imposing reasonable requirements for—*
>
> *(a)a proportion of energy used in development in their area to be energy from renewable sources in the locality of the development;*
>
> *(b)a proportion of energy used in development in their area to be low carbon energy from sources in the locality of the development;*
>
> ***(c)development in their area to comply with energy efficiency standards that exceed the energy requirements of building regulations.'***

Welsh Government Policy

Well-being of Future Generations (Wales) Act 2015

2.3 The Well-being Act sets the framework for improving the well-being of Wales by ensuring that sustainable development is at the heart of government and public bodies. The Well-being Act sets out a 'sustainable development principle' and places a well-being duty on public bodies, including local authorities, to 'act in a manner which seeks to ensure that the needs of the present are met without compromising the ability of future generations to meet their own needs'. Sustainable development is at the heart of the RLDP.

2.4 The Well-being Act also requires all public bodies to apply the sustainable development principle in decision making through the adoption of 5 ways of working. These are:

- Taking account of the long term
- Helping to prevent problems occurring or getting worse

- Taking an integrated approach
- Taking a collaborative approach; and
- Considering and involving people of all ages and diversity.

Environment (Wales) Act 2016

2.5 The 2016 Act placed a duty on Welsh Ministers to set targets for reducing greenhouse emissions and also to set carbon budgets. Statutory targets were implemented as these were considered a more robust governance framework allowing for certainty and better evaluation of progress.

Climate Change (Wales) Regulations 2021

2.6 The Climate Change (Wales) Regulations 2021 update The Environment (Wales) Act 2016 and enshrine in law the requirement to reduce Welsh net emissions by 100% by 2050.

Welsh Climate Emergency Declaration

2.7 In response to growing evidence on the impacts that climate change will have, the Welsh Government declared a 'climate emergency' in April 2019. The announcement was made to draw attention to the magnitude and significance of the evidence continually being presented by the Intergovernmental Panel on Climate Change. The declaration was made to send a clear signal that the Welsh Government will not allow the process of leaving the European Union to detract from the challenge of climate change.

Net Zero Wales Carbon Budget 2 2021

2.8 The Net Zero Wales Carbon Budget 2 is a Plan that was required to set out how the Welsh Government seek to achieve Carbon Budget 2, which required a 37% reduction in emissions from the baseline. The document sets out that Wales needs to exceed the emissions reduction targets of Carbon Budget 2 (37%) in order to reach net zero. Therefore, action to reduce emissions is imperative.

2.9 In this context, notably, within the building sector ambition statement the document states that: '*By 2025 all new affordable homes in Wales will be built to net zero carbon, and our ambition is that our net zero standards are adopted by developers of all new homes regardless of tenure by this date.'*

Planning Policy Wales (Edition 12)

2.10 Planning Policy Wales (Edition 12) (PPW) provides the overarching planning policy context for Wales. Section 5.7 focuses specifically on Energy and paragraph 5.7.13 introduces the 'Energy Hierarchy for Planning', which is displayed in Figure 1 and mandates the reduction of energy demand as the highest priority for development, followed by improving energy efficiency and only then by generating renewable energy. PPW states that it *'expects all new development to mitigate the causes of climate change in accordance with the* *energy hierarchy for planning' and* goes on to identify that *'Reducing energy demand and increasing energy efficiency, through the location and design of*

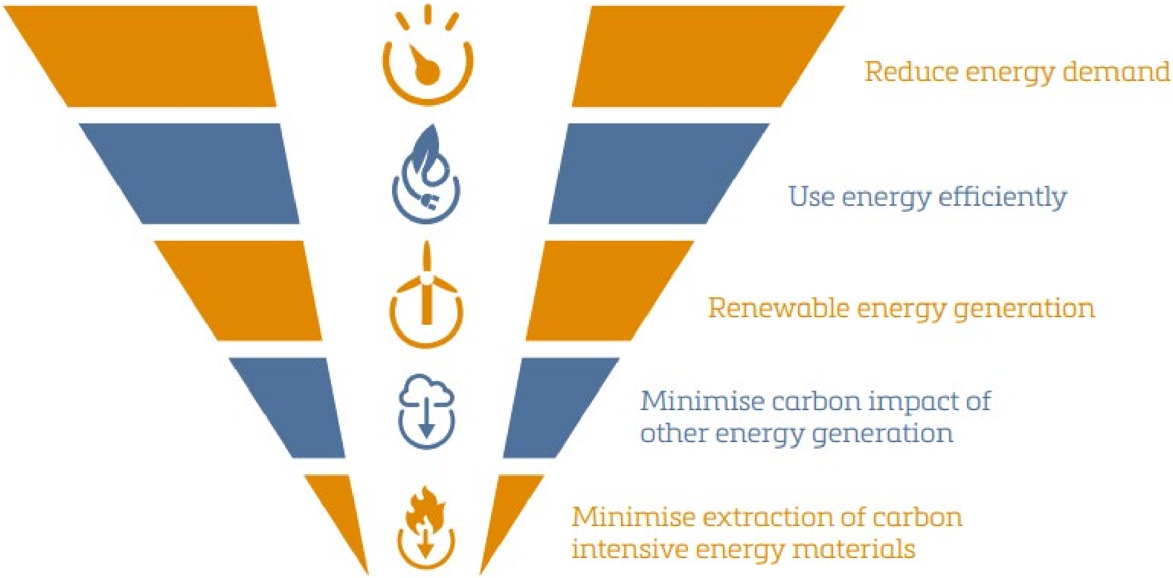

Figure 1: The Energy Hierarchy for Planning

new development, will assist in meeting energy demand with renewable and low carbon sources.'

2.11 Section 5.8 focusses on Sustainable Buildings. Here, PPW is explicit in its support of securing zero carbon buildings, with paragraph 5.8.2 stating:

'*The Welsh Government's policy is to secure zero carbon buildings while continuing to promote a range of low and zero carbon technologies as a means to achieve this.*'

2.12 Paragraph 5.8.4 goes on to identify the need for Energy Reports to be submitted for major developments and that these should include recommendations on the energy efficiency of development and renewable energy technologies that could be incorporated. PPW puts significant importance on this, with paragraph 5.8.4 stating that *'If planning authorities feel that insufficient consideration has been given to energy issues in project design, they may refuse planning permission.'*

2.13 Paragraph 5.8.5 begins by identifying that higher standards should be sought on strategic sites: '*Planning authorities should assess strategic sites to identify opportunities to require higher sustainable building standards, including zero carbon, in their development plan*.' And goes on to stipulate that '*In bringing forward standards higher than the national minimum, which is set out in Building Regulations, planning authorities should ensure the proposed approach is based on robust evidence and has taken into account the economic viability of the scheme*.' Therefore, standards higher than building regulations are endorsed, subject to their associated approach being based on robust evidence that has considered the economic viability of a scheme.

Letter to Chief Planning Officers 05/06/14

2.14 On the 5th of June 2014 the Welsh Minister for Housing and Regeneration wrote to Chief Planning Officers in relation to sustainable building standards. This was anticipating the adoption of Building Regulations that improved energy efficiency levels, which came into effect later that year. The Letter set out the following in relation to policies for sustainable building standards and planning policy:

> *'I do not expect local planning authorities to develop policies for the use of local sustainable building standards in LDPs which would apply to all developments outside of strategic sites. If this were to occur it would lead to inconsistencies across Wales which would not provide any certainty and again, goes against the thrust of Positive Planning.'*
>
> *I am committed to ensuring that all new development in Wales is sustainable. My aim is that the majority of the environmental criteria required by the present national sustainable building standards will be reflected in Building Regulations and planning policy in the longer term.*
>
> *The next review of Part L, planned for 2016, will consider further steps in energy performance towards meeting the EU Directive target of nearly zero energy new buildings by 2019 for the public sector and 2021 for all new buildings.*

Approved Document L (AD:L (Wales)

2.15 AD:L (Wales) is the Building Regulations Approved Document relevant to energy efficiency. It forms a part of the wider Building Regulations regime, which comprises of a set of procedural requirements that must be followed by anyone intending to undertake any proposal defined under the regulations as building work.

2.16 AD:L (Wales) Volume 1 - Dwellings and 2 - Buildings other than dwellings - Conservation of fuel and power 2022 were produced to align with national policy objectives of reducing emissions. They mandated reductions of 31% for dwellings and 27% for non-domestic builds beyond 2014 AD:L (Wales) standards. Consultation documents for AD:L (Wales) 2025 suggest a 75% reduction in operational carbon emissions beyond 2014 standards.

Welsh Government consultation on Building Regulations Part L 2025 Review

2.17 In August 2025, Welsh Government launched a consultation on Changes to Part L (conservation of fuel and power), Part O (overheating) and Part F (ventilation) of the Building Regulations for dwellings and non-domestic buildings. The consultation closed on 17th November 2025 and the responses are currently being considered. it is estimated that the amended Part L regulations will be amended in Early 2026 and come into force from Summer/Autumn 2026.

2.18 For new dwellings, the proposed changes include an uplift in the energy efficiency standard with low carbon heating systems become integral to the building specification. New dwellings built to the standard should require no further work to reach zero carbon emissions in the future as the electricity grid decarbonises.

2.19 It also proposes a change to the current performance metrics. The previous metric of Dwelling Energy Efficiency Rate (DEER) within the NCM is proposed to be withdrawn and replaced with Energy Use Intensity (EUI) to protect dwelling occupants from high annual regulated fuel bills.

2.20 The consultation focuses on two Options:

- Option 1 includes: Air source heat pumps; dMEV; Improved air tightness; increase in solar photovoltaic;
- Option 2 includes: Air source heat pumps; MVHR; Improved air tightness; increase in solar photovoltaic.

2.21 The consultation states that Option 1, which is the least stringent of the two options is the preference.

<u>Prosperity for All: A Low Carbon Wales</u>

2.22 Prosperity for All: A Low Carbon Wales sets the foundations for Wales transitioning to a low carbon nation. It emphasises that cutting emissions and moving toward a low carbon economy can produce opportunities around clean growth for business, as well as wider benefits for people and our environment. Notably, the document states that:

> *'Our **highest priority is to reduce demand** wherever possible and affordable'*

Local Policy

<u>Vale of Glamorgan Declaration of Climate Emergency</u>

2.23 In July 2019 the Vale of Glamorgan Council joined with Welsh Government and other Councils across the UK in declaring a global 'climate emergency'. The Council made a commitment to:

- Reduce the Council's carbon emissions to net zero before the Welsh Government target of 2030 and support the implementation of the Welsh Government's new Low Carbon Delivery Plan;
- Make representations to the Welsh and UK Governments, as appropriate, to provide the necessary powers, resources and technical support to Local Authorities in Wales to help them successfully meet the 2030 target;

- Continue to work with partners across the region; and
- Work with local stakeholders including Councillors, residents, young people, businesses, and other relevant parties to develop a strategy in line with a target of net zero emissions by 2030 and explore ways to maximise local benefits of these actions in other sectors such as employment, health, agriculture, transport and the economy.

2.24 In doing this, the Council acknowledged the *Special Report on Global Warming of 1.5°C,* produced by the Intergovernmental Panel on Climate Change (IPCC). The IPCC report highlights the heightened risk of global warming and that this was induced by human action. Specifically, it identifies that limiting global warming to 1.5°C may still be possible with ambitious action from local and national government, organisations and businesses, and local people and their communities.

Vale of Glamorgan Climate Change Challenge Plan

2.25 Project Zero is the Vale of Glamorgan Council's response to the climate change emergency. Project Zero brings together the wide range of work and opportunities available to tackle the climate emergency, reduce the Council's carbon emissions to net zero by 2030 and encourages others to make positive changes. Within this, the following challenge is set out:

> *Ensure our planning policies and regeneration activities support work to adapt to and mitigate the effects of climate change and reduce negative impact on the environment.*

this is supported by the following steps:

- *Work with developers to develop zero carbon buildings;*
- *Create more energy efficient buildings through planning policy.*

Vale of Glamorgan Local Area Energy Plan

2.26 The Vale of Glamorgan Local Area Energy Plan (LAEP) has been produced to identify the most effective route for the Vale of Glamorgan to reach a net zero energy system. The pathway set out for achieving net zero cannot be achieved by the Council alone and involves commitments and responsibilities for partner organisations and companies at national, regional and local levels. As set out in the document's Vision, the LAEP '*represents our collective commitment to shaping a future where energy is clean, accessible, and equitable for all residents and businesses, and considerate of future generations'.*

2.27 The RLDP plan period encompasses a significant period within which action will need to be taken to achieve net zero. Indeed, the LAEP envisions the late 2020s and early 2030s as being a period where deployment of technologies required to meet net zero accelerates. The RLDP will set out the local planning framework during this period.

2.28 Within the Vale's LEAP Action B.5.4. commits the Council as the lead stakeholder to *'Produce planning policy for improving home energy efficiency'*.

3. The Need for Action

3.1 As set out in Section 2, there is a strong policy context for taking action to mitigate the impact of climate change. In declaring a climate emergency and adopting the Climate Change Challenge Plan, the Vale of Glamorgan Council have set out to be ambitious in responding to the challenges faced. This is reflective of Welsh Government policy. Where necessary, responding meaningfully does mean breaking with the status quo.

3.2 Notably, the Vale has committed itself to exploring net zero buildings with the development industry and creating more energy efficient buildings through planning policy. Furthermore, the Vale's Local Area Energy Plan (LAEP) sets out that improving energy efficiency is a required action to work toward the modelled route for reaching net-zero by 2050. Therefore, action to meet these policy ambitions is required.

3.3 These Council policy ambitions align with national policy. Notably, reducing energy demand wherever possible, which is set out as high priority. Furthermore, the Welsh Government's ambition for net-zero standards to be adopted by developers by 2025 has not been achieved through Building Regulations and will not be without an intervention such as this. This is included as a target for allowing Wales to meet its carbon budget and therefore net-zero buildings are essential.

3.4 In announcing the work needed to meet the Net Zero Carbon Budget 2 (2025), the Welsh Government announced a *'decade of action'*, with then First Minister Mark Drakeford setting out:

> *'We need to make more progress in the next ten years than we have in the last 30 years'.*

The comments from the former First Minister set out the seriousness of the situation. Failure to pursue an intervention such as this, especially as the associated evidence shows that it is feasible, would be an unacceptable continuation of Business as Usual, and would fail to deliver on the change needed this decade.

3.5 National planning policy, and specifically the energy hierarchy, also strongly endorse the need for net zero buildings. Particularly through the reduction of demand in the first instance. By requiring Energy Reports, PPW also sets out that energy use on major development sites is an important consideration. PPW suggests strategic sites should be assessed for standards higher than Building Regulations and that any intervention should be based on robust viability evidence. PPW does not suggest such an intervention should be limited to strategic sites only.

3.6 The letter to Chief Planning Officers dated 5th June 2014 is acknowledged. However, it is considered that the context within which this was written has since dramatically changed. Evidence setting out the implications of climate change has expanded, and both the Welsh Government and the Vale of

Glamorgan Council have declared climate emergencies. Legal targets for carbon reductions have also been mandated. Furthermore, the letter was published in anticipation of Building Regulations that mandate for ‘nearly’ net zero buildings by 2021. Fundamentally, the Building Regulations that are now in place do not achieve those standards. Furthermore, as set out within this document, there is a need for net zero buildings now and there is a means of achieving them.

3.7 It is recognised that Welsh Government have recently launched a consultation on amendments to Building Regulations. This consultation has only recently ended and the outcome is not known, but the preferred option, if selected, will only go some way towards improved energy efficiency and delivering net zero homes.

4. Evidence Base

4.1 A consortium of consultants led by Spring Design and including JB Sustainable Building Consultancy and RPA were instructed to produce the evidence base. This included testing the technical feasibility of the proposed interventions and identifying the financial viability implications.

4.2 The work was split into four key stages:

- Stage 1: Research and Policy Formulation;
- Stage 2: Establishing a Net-Zero Methodology and Technical Feasibility;
- Stage 3: Cost Analysis; and
- Stage 4: Practical Implications.

These stages are expanded upon below. The completed work is summarised and the full work is available for review in the referenced background documents.

4.3 Terms are defined within the glossary, however, embodied carbon, operational carbon and net-zero operational carbon are commonly used throughout the remainder of the report. Therefore, as set out below, it is prudent to define these:

- 'Embodied Carbon' emissions of an asset are the total greenhouse gas emissions and removals associated with materials and construction processes throughout the whole life cycle of an asset (Modules A0-A5, B1-B5, C1-C4, with A0 assumed to be zero for buildings). Sequestered carbon from biogenic materials (e.g. atmospheric carbon absorbed by trees, converted into wood and then 'locked' into timber construction materials) must always be declared separately from embodied carbon emissions.
- 'Operational Carbon - Energy' (Module B6) are the greenhouse gas emissions arising from all energy consumed by an asset in-use, over its life cycle.
- A 'Net Zero Operational Carbon - Energy' asset is one where no fossil fuels are used, all operational energy use (WLCA Module B6) has been minimized, meets the local energy use intensity (EUI) target or limit (e.g. kWh/m²/a) and the equivalent of all annual energy use is generated on- or off- site using renewables that demonstrate additionality. Direct emissions from renewables and any upstream emissions are 'offset'.

Stage 1: Research and Policy Formulation

4.4 The purpose of Stage 1 was to review evidence bases and policy approaches elsewhere, in order to formulate an approach for the Vale of Glamorgan. Then, the required evidence base to inform that approach was to be determined.

4.5 This review took place in late 2023/early 2024. It begins by examining the high level national and local context for approaches to decarbonising buildings. It then goes on to identify policy hooks that facilitate planning interventions for doing this. It reviews all net zero planning and decarbonisation policies that were in line with the scope of work and published in other Local Planning Authorities (LPAs) at the time the work took place. This included a review of adopted policies and also those being progressed toward examination and adoption.

4.6 The review found that there were several policy approaches to decarbonising buildings that had been adopted. Specifically, at the time of the review there were 5 LPAs with operational net-zero targets and of these 3 also had targets for reducing embodied carbon[2]. Other Authorities were identified as having policy approaches that support decarbonisation, but these were discounted as they did not align with the scope of work. i.e. they did not achieve net-zero in operation and sufficiently address embodied carbon, in line with national targets. Along with the LPAs that had adopted policies, several further LPAs were identified as progressing policies to the same end and had reached advanced stages in the adoption of these. In some cases, these have now been adopted.

4.7 In relation to operational net-zero an approach of setting energy use metrics and breaking this down specifically for heat was the preferred option, with the majority of LPAs seeking to take this approach. This approach seeks to follow the principles of the energy hierarchy by reducing energy demand in the first instance, then maximising the efficiency of the technology using energy within the building, and then seeking to add renewables in order to offset the energy used by the building. To reduce energy demand in the first instance, the energy metrics were used as limits to the amount of energy that could be used to heat a building and overall energy use (for a house with average usage). An example of a policy that takes this approach and has been adopted by Cornwall Council is displayed below:

2b) **New Development – Residential**

Residential development proposals will be required to achieve Net Zero Carbon and submit an 'Energy Statement' that demonstrates how the proposal will achieve:

- Space heating demand less than 30kWh/m2/annum;
- Total energy consumption less than 40kWh/m2/annum; and
- On-site renewable generation to match the total energy consumption, with a preference for roof-mounted solar PV.

Figure 2: Exemplar use of energy metrics in operational net-zero planning policy

[2] Local Planning Authorities with operational NZ policies and embodied carbon policies (at time of evidence review): Bath and North East Somerset, Central Lincolnshire, Lake District National Park. Local Planning Authorities with just operational NZ policies: Cornwall, Glasgow

4.8 The approaches being taken in relation to embodied carbon were simply to set an upper limit for embodied carbon that was permitted to be emitted during the buildings life cycle (WLCA Modules A-C). Whilst this is novel policy its methodology is more aligned to common approaches. Of the reviewed policies there were a range of targets, from a limit of 450 $kgCO_2$ e/m^2 to 900 $kgCO_2$ e/m^2.

4.9 Following the review of exemplar planning policies, the project team met with Council Officers to determine an approach. It was determined that an approach mirroring the best practice emerging in England was desirable. We set out to develop an evidence base to this end, and the following scenarios were identified for review:

Operational emission scenarios		
Reference	Space heating demand	Energy use intensity (EUI)
AD: L (Wales) 2025	N/A	N/A
AECB CarbonLite	40 $kWh/m^2/yr$	75 $kWh/m^2/yr$
B&NES	30 $kWh/m^2/yr$	40 $kWh/m^2/yr$ res. 50 $kWh/m^2/yr$ non.
LETI	15 $kWh/m^2/yr$	40 $kWh/m^2/yr$ res. 50 $kWh/m^2/yr$ non.

Embodied emission scenarios		
Reference	Residential	Non-Residential
Masonry	Masonry with PIR	
Framed	140mm Stud with Mineral Wool & PIR	Steel Frame with PIR Panels
Timber	140mm Stud with Woodfibre	
Timber Optimised	Twin Stud Cellulose	

Figure 3: Scenarios identified for testing in development of evidence base

4.11 In the operational scenarios the AD: L (Wales) 2025 refers to anticipated Building Regulation standards that are expected as a minimum to come into effect in 2025. This information has previously been published by the Welsh Government and effectively means that as a minimum the changes expected in 2025 will introduce a requirement for heat pumps. The Association for Environment Conscious Building (AECB) Carbonlite and Low Energy Transformation Initiative (LETI) scenarios align with recommendations suggested by these organisations for best practice in achieving net-zero buildings. The B&NES scenario seeks to mirror the targets being employed in Bath and North East Somerset, who were one of the first LPAs to progress with this form of intervention. The intention with the embodied emissions scenarios was to achieve a figure under 600 $kgCO_2$ e/m^2.

Stage 2: Establishing a Net-Zero Methodology and Technical Feasibility

Stage 2 set out to test the technical feasibility of the above scenarios. The methodology for achieving operational net-zero was fundamentally established in Stage 1 as balancing annual energy consumption (EUI x GIA) with on-site renewable energy production.

4.12 Three house types (detached, semi-detached and flats) and two non-residential buildings, (a single storey office and a 2-storey school building) were modelled to establish whether it was feasible to achieve the targets set out in the above scenarios. Four operational scenarios were modelled in PHPP applying identical external envelope u-values to achieve increasing levels of building performance. Four embodied scenarios were then taken through PHribbon to achieve the LETI operational performance standard using a range of different constructions. In all scenarios, heat pumps were deployed as these are a prerequisite to achieving compliance with the LETI equivalent targets and are likely to be heavily favoured in the other identified operational scenarios, including the incoming AD: L 2025 (Wales).

4.13 These models were produced in 'worst-case scenarios' for obtaining compliance with the policy. This meant that all models were produced facing east west and sited at 50m A.O.D as explained within Section 3 of the Paper. All dwellings were also modelled to be occupied to maximum intended occupancy, as opposed to average occupancy levels, to maximise both regulated and unregulated demand and so stress-test EUI. The Stage 2 Report goes into significant details, however, the headline findings are identified below.

Residential Typologies – Operational Scenarios

4.14 For the residential typologies the key findings were that performance of identical buildings is significantly improved by air tightness, thermal bridging and ventilation. Through these improvements alone an 80% reduction in space heating demand was viewed on average across the three typologies between the AD: L (Wales) 2025 scenario and the LETI scenario. There were also significant improvements for energy use intensity and carbon emissions, with average reductions of 35% for between two aforementioned scenarios. Standardised fabric specifications were used across the house types, and this resulted in over performance in some instances and underperformance in others. Therefore, there is a need to ensure that the right fabric approach is taken and the policy approaches reviewed permit this flexibility.

4.15 An important point to note in this context is that a lower energy use intensity requires the deployment of less renewable energy, usually solar photovoltaics (Solar PV) to meet demand and achieve net-zero. **So, a lower EUI means less solar PV is required to meet net-zero.** The use of less PV panels also results in reduced embodied carbon and costs, as less panels need to be purchased and made. It was also found that improved form factor and higher density of developments result in reduced space heating demand. Form Factor expresses the relationship between the treated floor area and the area of the thermal envelope. A better i.e. lower - form factor signifies a more efficiently designed building.

4.16 The targets were all met aside from the detached dwelling narrowly missing the energy use intensity target to comply with the LETI standard. Despite this, significant reductions were viewed across all metrics when trying to achieve the LETI standard. The detached dwelling exceeding the LETI target for EUI is not considered to undermine this or suggest that the LETI target is unattainable for detached dwellings. As set out above, the models were set to 'worst-case scenarios' and this meant all dwellings have been stress-tested at maximum intended occupancy and with a standard specification for household appliances. Using more energy efficient appliances and/ or modelling the dwellings below capacity, reflective of the more typical occupancy patterns of privately owned homes, results in significant EUI reductions. The detached dwelling was modelled originally for 6 persons, which is the maximum intended occupancy, however, if this is reduced to 5 then re-modelling has established that the EUI drops to 39.89 kwh/m^2/year, which is compliant with the proposed LETI scenario. If the occupancy is dropped to an average dwelling occupancy figure of 3.4 then the EUI drops to 27.6 kwh/m^2/year. Evidence that shows compliance with a policy introducing the EUI standard would have to conform to the Royal Institution of Chartered Surveyors (RICS) Whole Life Carbon Assessment (WLCA) Guidance and this would involve following their recommendations of modelling occupancy levels.

Residential Typologies – Embodied Carbon Scenarios

4.17 Modelling of the embodied carbon scenarios identified that significant reductions in embodied carbon can be made through varying the material types. Notwithstanding this, the materials all allow for the same fabric standard to be achieved, thus ensuring that the operational targets are still met.

4.18 The key findings were: that higher density developments inherently achieve lower levels of embodied carbon (which is well known already); changing from masonry to a wooden framed structure reduced embodied carbon by 20-30%; timber frame with biogenic insulants can sequester 3-5 times as much CO_2e as masonry; and lower fabric specifications could be applied for larger buildings, such as apartment blocks, because an inherently better form factor requires less insulation and results in lower embodied carbon whilst still achieving the operational energy targets.

Non-Residential Typologies

4.19 The findings for the non-residential scenarios are broadly similar to the residential for both operational and embodied carbon. In the operational scenarios significant reductions were achieved for heat demand but similar to residential, there were less reductions for energy use intensity, albeit these were still notable. Embodied carbon figures are higher, however, the same trends are viewed as residential, with lower embodied carbon figures achieved by changing construction materials.

Summary

4.20 Stage 2 of the work established that it is technically feasible to implement a policy requiring the net-zero operational targets and embodied carbon target. Whilst the detached dwelling fails to reach the applied LETI Standard, this is explained by the use of ‘worst-case scenarios’ as inputs into the model, and the fact that this building was identified as having 6 occupiers, which is significantly beyond average occupancy.

Stage 3: Cost Analysis

4.21 The third stage in preparing the evidence base was to understand the cost implications of the proposed approaches, using the modelled dwellings as a basis. Following the completion of Stage 2, the LETI Standard was identified as the preferred approach for focussing the cost assessment, using AD:L (Wales) 2025 as a benchmark. This was because the LETI Standard was the most ambitious target, and thus desirable for policy implementation. Therefore, a cost comparison between AD:L (Wales) 2025 and the LETI Standard was conducted.

4.22 The cost analysis can be found in the Stage 3 and its conclusions and implications for the RLDP are summarised in the Affordable Housing Policy Review: High Level Viability Appraisal.

4.23 The Viability Appraisal provides the strongest summary of the work and sets out how we are employing Stage 3 of the work. To summarise the key outcomes, it was found that for dwellings it would cost less to construct a home that achieves Net Zero operational energy to the applied LETI Standard than anticipated AD:L (Wales) 2025 standards. The reason for this was that the thermal efficiency of a home under LETI would require a smaller air source heat pump (ASHP) and less solar PV in dwellings. This offsets the additional cost of an mechanical ventilation with heat recovery (MVHR) unit in buildings built to LETI Standard. There were, however, more additional costs for flats delivered to the LETI Standard when compared to AD:L (Wales) 2025 because the generic solutions applied to all house types across the operational scenarios were not able to be flexible enough to address the exceptionally low heating demand of LETI apartments. The comparison is shown in Figure 4:

AD L (Wales) 2025 upgrade to LETI (ex. preliminaries)					
Building Element			HT 211	HT 421	HT 641
Fabric	Double glazing to triple glazing	additional cost	+ £3,374.96	+ £991.76	+ £623.63
	ASHP reducing in size	cost saving	N/A	- £8,000.00	- £6,000.00
	MVHR addition	additional cost	+ £27,000.00	+ £7,000.00	+ £4,000.00
	MEV omission	cost saving	- £5,400.00	- £1,800.00	- £1,200.00
Generation	PV array decreasing in size	cost saving	- £11,250.00	- £1,600.00	- £1,200.00
TOTAL			**+ £13,724.96**	**- £3,408.24**	**- £3,776.37**
Cost per unit			+ £1,525.00	- £1,704.12	- £3,776.37
Cost per m² of GIA			+ £25.49	- £20.48	- £34.21

Figure 4: AD:L (Wales) 2025 upgrade to LETI costs (excluding preliminaries)

4.24 In this context, the Viability Appraisal goes on to estimate costings for achieving the LETI Standard. Whilst this will vary by unit type, for the purposes of high-level viability testing, it is desirable to use a single cost figure across all units types. This has been calculated to be £9,000 per dwelling, which reflects the estimated additional costs of meeting the LETI Standard when compared to AD:L (Wales) 2014, which have been used to inform baseline costs in wider viability work.

4.25 A point not raised in the Viability Appraisal as it is not strictly relevant, but is important to identify in this work, is that the Cost Analysis shows significant operational life cycle cost savings can be made by seeking to reduce energy usage. For example, achieving the LETI Standard in the semi-detached dwelling would result in 44% cheaper energy bills when compared to AD:L (Wales) 2025.

4.26 Following the completion of the Cost Analysis it was possible to produce our own planning policy.

Stage 4: Practical Implications

4.27 Stage 4 sought to understand the practical implications of the proposed interventions, in terms of what evidence was required from developers and the scrutiny that this required from the Development Management process. The practical implications of the proposed policies are discussed in Section 11, following the identification of the RLDP policy interventions.

5. Tai Ar Y Cyd

5.1 The Tai ar y Cyd project is a collaboration between 23 social landlords in Wales, alongside industry experts and Welsh Government, with a shared vision of delivering affordable, high-quality homes designed to meet the highest standards of low carbon performance, guided by a standardised pattern book. The Vale of Glamorgan Council is a member organisation, alongside a number of developing LAs and Registered Social Landlords.

5.2 In January 2025, Tai ar y Cyd published a design guide and technical guide comprising a standardised pattern book of a range of housing typologies that would be delivered through timber based off-site manufacturing. The units would be built to a performance specification to achieve net zero operational carbon and make a step change in reducing embodied carbon emissions. The pattern book will be used by the member social landlords to help build out their pipeline of new affordable homes.

Figure 5: Elements of Tai ar y Cyd Pattern book

5.3 Tai ar y Cyd uses the same metrics and definitions as the Spring Design work. Modelling has been undertaken of 19 different house types, which reflect the types of units being constructed by the social landlord members. This has informed the development of two standards. The first baseline standard matches closely with the performance of the AECB CarbonLite standard – one of the standards modelled as part of the Spring Design work. The second standard, the Enhanced Standard, is broadly similar to the LETI standard that has been discussed above and is the most stringent of the standards modelled by Spring Design. The key metrics are set out in Figure 6.

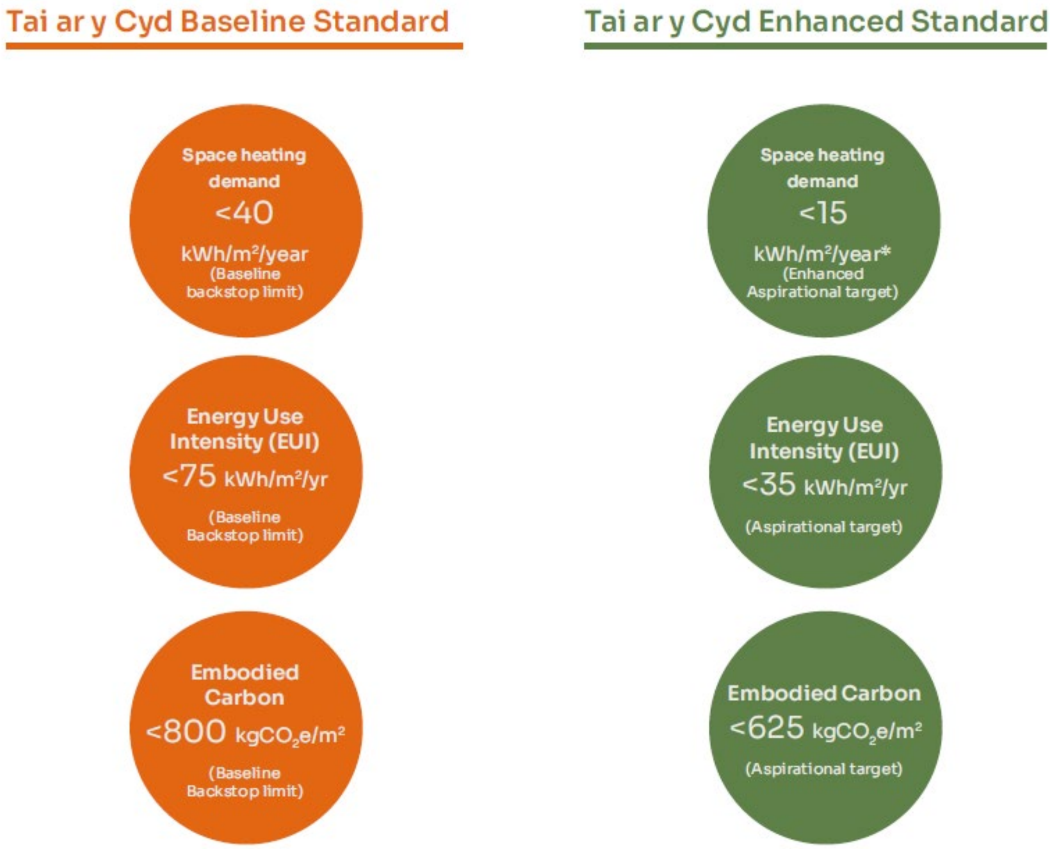

Figure 6: Tai ar y Cyd baseline and enhanced standards

5.4 The modelling undertaken indicates that all of the 19 tested affordable house types will be able to achieve the baseline standard (AECB) in terms of space heating demand, although in a small number of unit types this was dependent on orientation. All of the units were also below the target baseline EUI.

5.5 With the enhanced specification, most of the standard house types were modelled to be below the space heating demand targets, albeit in some cases this was affected by orientation. The enhanced standard EUI is slightly more stringent than tested in the Spring Design work at 35 kWh/m2/year rather than the 40 kWh/m2/year model by Spring Design, but all units built to the enhanced standard were lower than this.

5.6 The Tai ar y Cyd evidence base helps support the evidence from Spring Design that it is feasibly possible to achieve the proposed standards based on standardised house types.

5.7 No cost analysis has been published as part of the Tai ar y Cyd work, but discussions with partners involved in the scheme have indicated that the cost of achieving the enhanced standard is considered to be higher. For example, the baseline standard would require double glazing whereas the enhanced standard would require triple glazing. A further specific cost will be around contingency as the higher standards of air tightness required to meet the enhanced standard in particular require higher levels of workmanship. There is a need to upskill the labour force in these building methods and whilst this is happening there is a risk of work needing to be repeated at a cost if the higher airtightness is not achieved. As these practices become more commonplace, the risk and cost associated with this will inevitably reduce.

Implementation of Tai ar y Cyd

5.8 The Council is anticipating that the affordable units built as part of its own housebuilding programme will at least over the medium-term pipeline be built to the net zero baseline standard of Tai ar y Cyd. Given the significant need for affordable housing in the Vale, as demonstrated by the Local Housing Market Assessment, it is important that seeking to achieve net zero ambitions that are too ambitious do not adversely impact on the ability to deliver affordable housing.

5.9 Welsh Government grant is necessary for the delivery of the pipeline of affordable homes. At this point in time, it has also not been confirmed by Welsh Government that extra funding would be available to deliver affordable homes to the enhanced standard, although homes built to the baseline standard are expected to be supported. If planning policy were to introduce a higher standard than the Tai ar y Cyd baseline standard it may have financial implications for affordable housing delivery.

5.10 In the case of market housing, which is not reliant on grant, the Spring Design evidence indicates that there should broadly be cost parity with future Building Regulations. There may be the potential to add a ‘green premium’ to the sales value, albeit this is not something that has specifically been added to the proposed sales values of the properties in the viability assessment work. The Tai ar y Cyd pattern book has been prepared for use by social landlords, but there is no reason why a similar approach cannot be taken by market developers as they have their own pattern book of house types.

6. Policy Intervention – Operational Carbon

6.1 Following the completion of the work set out the previous sections, and a review of the latest Tai ar y Cyd evidence base, a policy that requires residential development to achieve net zero carbon in operation is proposed. As with the reviewed policies, the proposed approach seeks to reflect the energy hierarchy through maximising energy efficiency, utilising sustainable heating and cooling systems and incorporating onsite renewable energy generation.

6.2 It is proposed that the policy be phased to allow for the industry to upskill, supply chains to develop and to accord with the Tai ar y Cyd baseline standard in the first part of the plan period. As economies of scale and supply chain develop to support the policy, it is considered appropriate for the policy to become more stringent. The policy is presented below:

CC1: Residential Operational Net Zero Carbon Development

Proposals for one or more new dwellings will be required to achieve net-zero carbon operational emissions by:

A. Following the principles of the Energy Hierarchy for Planning, prioritising a reduction in energy demand and improved energy efficiency.

B. Achieving the following standards in individual dwellings as calculated using an identified energy performance model:

From RLDP adoption to 31st March 2030

i. Space heating demand less than or equal to 40kWh/m2/year;
ii. Energy use intensity less than or equal to 75kWh/m2/year; and

From 1st April 2030 onwards

i. Space heating demand less than or equal to 15kWh/m2/year;
ii. Energy use intensity less than or equal to 40kWh/m2/year; and

C. Providing on-site renewable electricity generation with an output equivalent to at least the annual energy consumption of the development, as calculated using an energy performance model.

Where the use of onsite renewable energy generation to match total energy consumption is demonstrated to not be technically feasible the following hierarchy should be followed:

- renewable energy generation should be maximised as much as possible; and/or
- connection made to an existing or proposed low carbon district energy network (in compliance with Policy CC5);
- or where this is not possible the residual energy (the amount by which total energy demand exceeds the renewable energy generation) is to be offset by a

contribution to the Council’s Project Zero fund as far as economic viability allows.

Compliance must be evidenced within an Energy Report.

Justification: Reflecting Best Practice

6.3 To address both the environmental and socio-economic issues, this policy has been developed with the energy hierarchy as its core organising principle. This means improving fabric standards, energy efficiency and minimising space heating requirements, before installing renewable energy and using this to offset residual energy demand. Not only is this the most sustainable approach, but it can also make an important contribution to addressing fuel poverty and improving social equity. **The policy would apply to all new build dwellings and not conversions.**

6.4 Realising zero carbon development in relation to regulated emissions (heating, hot water, cooling, lighting and auxiliary energy) and unregulated emissions (appliances and equipment, etc) also referred to as ‘operational’ carbon emissions, is a key part of tackling the climate emergency. The UK Green Building Council defines net zero carbon – operational energy as being ‘when the amount of carbon emissions associated with the building’s operational energy on an annual basis is zero or negative. A net zero carbon building is highly energy efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset.’

Energy Use Metrics

6.5 To reflect the latest best practice, as set out in Section 4, this policy uses energy use rather than CO_2 emissions as the metric for assessing compliance. This entails working towards the same overall goal (i.e. zero CO_2 emissions from operational energy use in new development). Energy use intensity is a measure of energy use per square metre of a given development. It is calculated by dividing the total energy consumed by a building in a single year by the gross internal area of the building.

6.6 As per the Energy Hierarchy, once space heating and EUI targets have been achieved through reducing demand and making buildings more efficient, renewable energy generation equal or greater than the average energy consumption should then be targeted. Where meeting renewable generation targets is unfeasible - due, for example, to the typology (i.e. apartments) - or unviable then renewable energy generation must be maximised. Once options have been exhausted, residual on-site renewable generation is to be either offset by a financial contribution to fund Council-approved renewable energy, low-carbon energy and energy efficiency schemes or agreeing acceptable directly linked or near-site provision.

6.7 The Climate Change Committee recommends a space heating demand of less than 15-20 kWh/ m2 /yr for new homes and this will be ultimately what the policy starts to deliver by 2030. This recommendation is also in line with the recommendations of the Royal Institute of British Architects (RIBA), LETI, UK Green Building Council (UKGBC) and the UK Net Zero Carbon Building Standard. As a dwelling with a low space heating demand loses heat very slowly, it will make it easier for the wider energy system to deliver energy in a flexible way, helping to maximise the contribution from renewable energy and reduce energy costs for residents.

6.8 The policy is proposed to be phased, starting with the AECB CarbonLite standard. By 2030, the policy requires that residential development achieves a maximum energy use intensity of 40 kWh/m²/year. This includes both regulated and unregulated energy consumption. The target is intended to be an energy efficiency target that is compatible with the building sector achieving net zero. This target is consistent with the recommendations in the UKGBC Net Zero Whole Life Carbon Roadmap which says that new homes should target an EUI of 35-40kWh/m²/year from 2025[3]. RIBA also recommend that homes being designed now should target 35kWh/m²/year, which is more stringent than the policy proposes.

6.9 A benefit of aligning the heat and EUI targets with these organisations is that it provides a consistent target for the development industry to aim for. The heat and EUI targets are underpinned by the Stage 2 work completed by Spring Design, which shows that this target is achievable, and modelling carried out in support of similar policies in several English LPAs. These studies demonstrate that targets are technically achievable for residential typologies, when modelling in line with the RICS WLCA methodology.

Renewable Energy Provision

6.10 New buildings should contribute to the significant increase in renewable energy generation required between now and 2050. The most robust way to deliver the overall objective to balance total energy use and total renewable energy generation is for new developments to seek to achieve this balance at the site level. This also has the advantage of generating 'free' electricity close to its point of use, helping to deliver significant energy cost savings for residents and building occupiers.

6.11 Solar PVs are one of the most effective means of generating onsite renewable energy. We acknowledge there are alternative uses for roof spaces in a dense urban environment, particularly in relation to building design and massing, but we are prioritising this use due to the importance of reaching net-zero. It is noted that roof space can have multi-functional benefits, with solar PVs installed in

[3] UKGBC, 2021. *Net Zero Whole Life Carbon Roadmap A Pathway to Net Zero for the UK Built Environment*. Online. Available at: UKGBC-Whole-Life-Carbon-Roadmap-A-Pathway-to-Net-Zero.pdf [Accessed 08/11/24].

combination with smaller elements of green or brown roofs, as well as wildlife habitats (insect hotel, bird boxes etc.). Evidence also shows how the installation of solar PVs can combat the urban heat island effect, by reducing the build-up of heat in the built environment. When combined with battery energy storage systems, solar PVs can also reduce peak demand on the electricity grid, by allowing energy to be stored and released when demand is highest.

Performance Gap

6.12 In order for the net zero carbon buildings policy to be effective, it is important that new buildings deliver their intended performance. Unfortunately, the actual energy performance of buildings often fails to meet the design standard. This difference is commonly referred to as 'the performance gap.' Reasons for the existence of this are explored further below. The Zero Carbon Hub concluded in their 2014 Evidence Review Report[4] that a compliance process focused on design, rather than as built performance is a key contributor to the 'performance gap'. Excellent design and detailing need to be matched by high quality construction and commissioning for the 'performance gap' between the design and actual in-use energy to be reduced.

6.13 Part L energy assessment methodologies (e.g. Standard Assessment Procedure (SAP) for domestic buildings and Simplified Building Energy Modelling (SBEM) for non-domestic buildings via the National Calculation Methodology are currently used to evidence the energy and carbon efforts for all planning applications and demonstrate their compliance with current Building Regulations requirements. However, it is important to note that these were developed only to check compliance with Building Regulations, not whether buildings comply with net zero carbon buildings policies, and or the prediction of future energy use.

6.14 Whilst not prescribing for the use of a particular energy performance model, in order to calculate operational energy use, suitable energy performance models would be those endorsed by RICS within the latest version of Whole Life Carbon Assessment for the Built Environment. Within the 2023 publication these are defined as CIBSE's TM54 Evaluating operational energy performance of buildings at the design stage, NABERS, ASHRAE Standard 90.1, the Passive House Planning Package (PHPP) or a local equivalent operational energy estimation method. Inputs should use realistic information on the intended use, occupancy and operation of the building to minimise the performance gap. SAP in its standard form cannot facilitate the calculations required to evidence compliance with CC2, however, it is acknowledged that conversion tools exist to allow SAP to provide energy metrics. Permitting that a strong conversion tool with associated methodology is provided, a modified SAP is also useable. The new Home Energy Model (HEM) will be forthcoming for use in respect of AD:L Building Regulations early in the plan period, it may

[4] Zero Carbon Hub, 2014. Written evidence submitted by the Zero Carbon Hub. Online. Available at: zero-carbon-hub.pdf [Accessed: 04/11/24].

be that this is suitable for use and if not a conversion tool would also be required.

Offsetting

6.15 As a last resort, where it is not possible to provide policy compliant renewable energy on site and this has been robustly demonstrated in an Energy Report, the Policy allows for the offsetting of any outstanding reduction in residual energy use. Fundamentally, this does not achieve net-zero on site, so is not a preferred option, but may be required in the case of some forms of flatted development, for example. The Council operate a Project Zero Fund, which contributes to the decarbonisation of the Council's activities. Funds received through offsetting should be used to fund this or any other subsequent scheme focussed on decarbonisation.

6.16 Evidence produced by the Centre for Sustainable Energy (CSE) for the West of England Authorities provides a baseline for offsetting where it is not possible to reach the renewable energy production on site[5]. CSE have produced this work as part of the evidence base to support policies that are identical in their implementation of the policy, and therefore, their findings are repeatable here.

6.17 The CSE recommend linking the price of roof mounted solar to the offset price. That is because in the vast majority of circumstances, roof mounted solar will be used to evidence compliance with criterion C of the Policy as it is almost universally deployable.

6.18 In calculating the shortfall to be offset, developers would be expected to demonstrate the proportion of annual energy demand that is to be met on-site and to quantify the shortfall in kWh per year. This figure could then be used to calculate the size of renewable installation (most likely solar PV) that would be required to generate equivalent power elsewhere. Further guidance on this will be provided as part of the Net Zero Building Supplementary Planning Guidance.

[5] Centre for Sustainable Energy, 2022. *Carbon offsetting report – Carbon offsetting within an energy intensity policy framing*. Online. Available at: Carbon offsetting within an energy intensity policy framing - CSE - June 2022 [Accessed: 08/11/24].

7. Justifying Higher Operational Targets than Building Regulations

7.1 At the time of preparing the evidence to justify a policy intervention, there was no clear direction in how far future Building Regulations requirements would go. As explained in Section 2, Welsh Government published a consultation on changes to Part L of Building Regulations (Conservation of Fuel and Power) as well as Part F (Ventilation) and Part O (Overheating). This consultation closed on 17th November 2025.

7.2 The consultation document indicates states "*The proposed 2025 standard aims to build on the 2022 uplift, keeping us in line with meeting our net zero target. Our intention is to implement a standard to ensure new buildings are fit for the future and will require no further work to produce zero carbon emissions as the electricity grid decarbonises*." This standard will ensure that homes are built to an energy efficient standard and are essentially 'net zero ready' but the standard does not go as far as is being proposed in the RLDP net zero policy, which requires the energy requirement to be offset on site through energy generation measures such as PV, rather than relying on the grid to decarbonise.

7.3 The consultation includes proposals to move to low carbon heating sources for heating and hot water in new dwellings.

7.4 It is proposed that the metric of measuring energy efficiency will be changed from the Dwelling Energy Efficiency Rate (DEER) to Energy Use Intensity (EUI), which is one of the metrics for the proposed RLDP policy.

7.5 The consultation focuses on two Options:

- Option 1 includes: Air source heat pumps; dMEV; Improved air tightness; increase in solar photovoltaic;
- Option 2 includes: Air source heat pumps; MVHR; Improved air tightness; increase in solar photovoltaic.

7.6 The Spring Design work made some assumptions on what the anticipated Part L 2025 would be. The table below provides an assessment of what the current 2022 Part L requirements are, what Spring Design assumed may be the 2025 Part L and what the requirements of Options 1 and 2 are. A comparison is also made with the RLDP proposed operational net zero policy, tested by Spring Design as the LETI standard.

Dwelling Requirement	Part L 2022	Anticipated Part L 2025 (Spring Design)	Actual Part L 2025 consultation Option 1	Actual Part L 2025 consultation Option 2	RLDP Proposed Policy
External wall U-Value	0.13	0.13	0.15[6]	0.15	0.13
Window U-Value (W/m2K)	1.3	1.12	1.2	1.2	0.19 moving to 0.550 from 2030
Airtightness (m3/m2.h @50Pa)	5	5	4	1.5	1.5 moving to 0.50 from 2030
Heat source	Main gas	Air Source Heat Pump	Air Source Heat Pump	Air Source Heat Pump	Air Source Heat Pump
Ventilation	Natural ventilation with intermittent extract fans	Mechanical Extract Ventilation	Mechanical Extract Ventilation (dMEV) [Specific Fan Power (SFP) of 0.15W/l/s]	Mechanical Ventilation with Heat Recovery (MVHR) [85% heat recovery efficiency and SFP of 0.50W/l/s]	Mechanical Ventilation with Heat Recovery (MVHR) [84% heat Recovery]
Renewable Energy	40% of ground floor area including unheated spaces/6.5	Not specified – enough to offset the energy generation	40% of ground floor area including unheated spaces/6.5	40% of ground floor area including unheated spaces/6.5	Not specified – enough to offset the energy generation

7.7 Part L Option 1 is broadly similar to what Spring Design had assumed that the 2025 Part L, with the exception that Option 1 has a more stringent target for airtightness.

7.8 Option 2 is broadly similar to the AECB Carbonlite standard which will form the basis for the RLDP policy until 2030.

7.9 Welsh Government have identified in the consultation document that Option 1 is the Preferred Option. If this is taken forward, then the proposed RLDP policy intervention will still be warranted in delivering operational net zero homes. If Option 2 is ultimately taken forward, then consideration should be given to whether it remains appropriate to have a planning policy that is broadly similar as it would be more desirable to deal with the relevant assessments through the Building Control process rather than the planning system. A review will be undertaken at such time as the WG publishes the outcome of the consultation.

[6] This figure is higher in the latest building regs consultation as analysis indicated that relaxing the external wall U-value but improving other fabric elements offered a more optimised specification.

Reducing Demand

7.10 As set out in national policy, demand reduction is imperative. Current standard approaches do not prioritise a reduction in demand as well as they could, as evidenced in Figure 5, which shows the heat demand performance of the UK dwelling stock[7]*. However, as per the Energy Hierarchy for Planning this is the first step that should be taken when considering energy in development. The benefit of reducing demand is reducing the strain on the grid and the amount of renewable energy that needs to be produced to balance out consumption.

7.11 In relation to heat demand, LETI's review identifies that new builds built to AD:L 2014 standards (pre 2021 in England and pre 2022 in Wales) had space heating demands of approximately 85 kwh/m2/year. Alternatively, standards such as the AECB and LETI, as targeted in our evidence base, deliver homes with significantly less energy demand. As found in the evidence base, these buildings do not have to be bespoke.

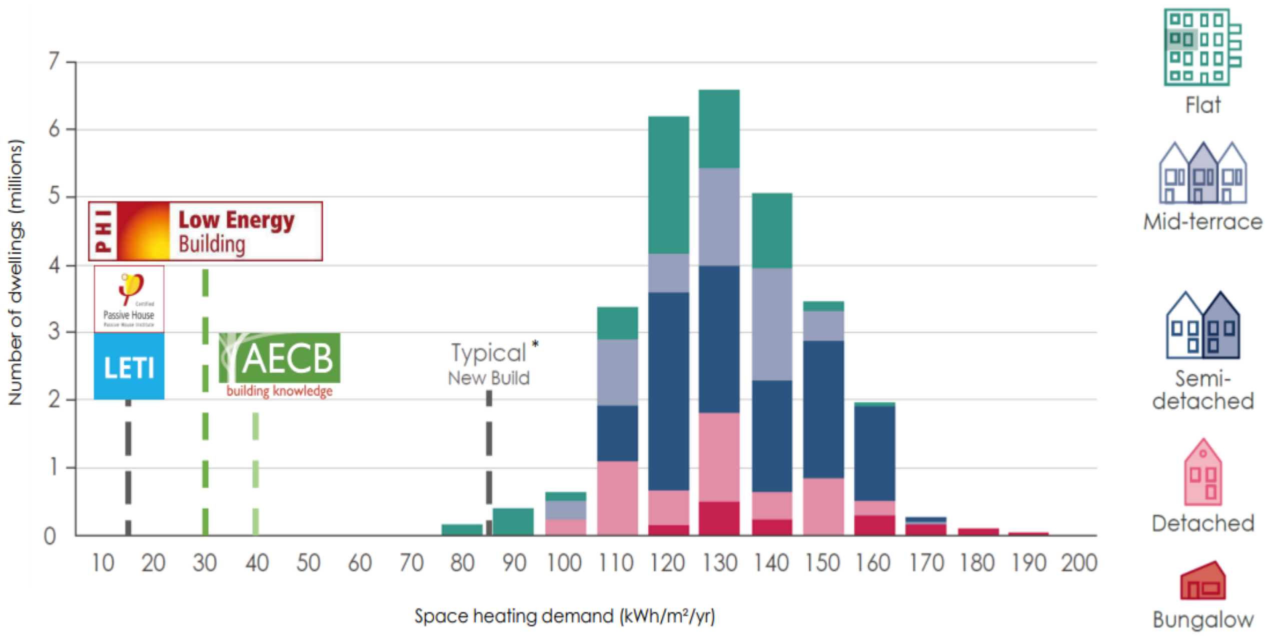

Figure 5: Energy Performance of UK Housing Stock

7.12 As progress continues toward net-zero, with increasing electrification of heating, hot water and private transport, electricity demand and overall energy demand is going to increase. This will inevitably place pressure on the grid. Reducing the demand of new dwellings by 30-40% (as suggested by the evidence base) is a significant reduction. When scaled up to consider all residential development included within the RLDP, the outcomes of this reduction in demand are meaningful.

7.13 This does not take into account these buildings being net-zero and having an even greater take off the grid. A reduction in demand makes net-zero more attainable as it directly reduces the amount of on-site renewable energy

[7] Leti, 2021. *Climate Emergency Retrofit Guide.* Online. Available at: 252d09_c71428bafc3d42fbac34f9ad0cd6262b.pdf [Accessed: 31/10/24].
*Note that the proposed policy intervention also relates to energy use intensity.

generation required to cancel out a building's energy demand. Thus, reducing energy demand in the first instance is integral to making net-zero achievable. The delivery of housing to meet need without the normal anticipated energy offtake from the grid may create capacity headroom which may produce other benefits.

Reduced energy bills

7.14 In 2022, following the increase of energy prices, it was estimated that up to 45% of households in Wales could be in fuel poverty[8]. Like many other places in Wales this causes significant issue in the Vale of Glamorgan, where three LSOAs are within the top 10% most deprived in Wales and a further seven are in the 10-20% most deprived. The whole of the Vale has been impacted by energy price rises and the general cost of living crisis, with impacts particularly acute in areas of the greatest deprivation. Through reducing energy demand, fundamentally, energy bills are also reduced as found in the evidence base and explained in paragraph 4.25. This means that as well as achieving net-zero, buildings constructed to higher standards would have lower energy bills, with associated socio-economic wellbeing benefits for future residents.

[8] Welsh Government, 2022. *Fuel poverty modelled estimates for Wales (headline results): as at October 2021*. Online. Available at: Fuel poverty modelled estimates for Wales (headline results): as at October 2021 [HTML] | GOV.WALES [Accessed: 31/10/24].

8. Policy Intervention – Embodied Carbon

8.1 As set out, the evidence base also investigated the feasibility of introducing a policy on embodied carbon. A significant proportion of a building's lifetime carbon is locked into its fabric and systems. Embodied carbon means all the carbon dioxide (and other greenhouse gases) emitted in producing materials. In the case of buildings, this means all the emissions from the sourcing and construction of building materials, the construction of the building itself, all the fixtures and fittings inside and, arguably, the deconstruction and disposal at the end of a building's lifetime.

8.2 The Welsh Construction Forum Buildings Sectoral Working Group, headed by Welsh Government Ministers, recommended that new residential buildings should have had an embodied carbon content of 600 kg CO_2 e/m^2 from 2020 onwards, with 450 kg CO_2 e/m^2 from 2025 . These targets align with those identified by LETI and RIBA, which set out the standards that need to be achieved to reach net-zero by 2050. Despite these standards, these organisations identified that buildings coming forward in 2020/2021 were achieving 800-1200 kg CO_2 e/m^2 . Whilst it is understood that homes currently coming forward have improved and are being delivered the lower end of that spectrum and beyond, it is apparent that improvement must be made to even reach the 2020 targets.

8.3 The review of the policy approach taken by other local authorities in the UK indicates that only some of the LAs that have sought to implement operational net zero targets have also introduced embodied carbon targets. These targets for residential units have varied significantly, with some authorities adopting a phased approach that becomes increasingly more stringent over a plan period.

8.4 Tai ar y Cyd adopts a baseline standard maximum target of <800kgCO_2e/m^2 and an enhanced standard target of <625kgCO_2e/m^2.

8.5 In this context, it is relevant to consider the evidence identified in Stage 2 and 3 of the work completed by Spring Design. The embodied carbon results, as derived from the Stage 2 Report are as follows:

Option	RIBA/RIAI	Option	RIBA/RIAI
Masonry		Timber	
HT211	486 kgCO_2e/m^2	HT211	405 kgCO_2e/m^2
HT421	602 kgCO_2e/m^2	HT421	480 kgCO_2e/m^2
HT641	748 kgCO_2e/m^2	HT641	593 kgCO_2e/m^2
Framed		Timber Optimised	
HT211	389 kgCO_2e/m^2	HT211	373 kgCO_2e/m^2
HT421	460 kgCO_2e/m^2	HT421	429 kgCO_2e/m^2
HT641	580 kgCO_2e/m^2	HT641	560 kgCO_2e/m^2

Figure 6: Embodied Carbon in typologies modelled by Spring (cradle to grave)

8.6 Figure 6 displays that despite no specific intervention to reduce upfront carbon, the embodied carbon of the modelled buildings are all under 600 kg CO2 e/m² for all options apart from masonry. The timber framed option is significantly under for all building typologies Masonry is under for the flatted scheme (HT211) but above for the dwellings. Essentially, if a cradle to grave embodied carbon target was set at the 600 kg CO2 e/m² recommended by the Welsh Construction Forum Buildings Sectoral Working Group, this could only be achieved through the use of timber construction techniques. The Spring evidence indicates that this would be a more expensive option, which is a concern raised by stakeholders. Whilst it is acknowledged that some major housebuilders already construct timber framed houses as standard, the additional costs for developers that use masonry techniques may significantly impact on development viability.

8.7 It is important to note that significantly lower levels of embodied carbon will be delivered simply by the introduction of the operational net zero target and therefore substantial improvements will be made without specifying a target. On this basis, it is proposed not to set targets for embodied carbon at this stage. However, if developers do wish to aim for lower embodied carbon, for example by following the Tai ar y Cyd standards, then this will be supported.

Demolition and rebuild

8.8 To avoid the wastage of embodied carbon in existing buildings and avoid the creation of new embodied carbon in replacement buildings, there is a presumption in favour of repairing, refurbishing, re-using and re-purposing existing buildings over their demolition. The proposed policy wording is set out below.

Presumption Against Demolition

Proposals for the demolition and replacement of a standalone building will only be acceptable where it is demonstrated that:

A. the building proposed for demolition is structurally unsound to the extent that it is not practical or viable to be repaired, refurbished, re-used, or re-purposed; or
B. there are significant public benefits which could not be delivered through repairing, refurbishing, re-using, or re-purposing; or
C. repairing, refurbishing, re-using, or re-purposing the building would likely result in equal or higher newly generated embodied carbon than if the building is demolished and a new building is constructed; or
D. repairing, refurbishing, re-using, or re-purposing the building would create a building with such poor thermal efficiency that on a whole life cycle basis would mean a lower net carbon solution would arise from demolition and re-build.

Compliance with Criteria A and B should be justified within a Demolition Statement. Compliance with Criteria C and D should be justified within the site's Energy Report**.**

Where demolition is justified replacement development should recover and reuse waste material from the demolition on sites wherever possible.

8.9 Proposals that result in the demolition of a building (in whole or a significant part) should be accompanied by a full justification for the demolition. These developments will also have higher embodied carbon targets than regular new builds. This policy would apply to standalone buildings in their own right, for example a new dwellinghouse, and not ancillary buildings within the curtilage of larger buildings, such as a detached garage.

8.10 The policy takes a sequential approach to considering whether a demolition is justifiable. In the first instance, it considers whether there is any merit in seeking to retain the building and considers whether it is structurally unsound. Evidence in support of this would need to be provided by a professional with industry knowledge, such as a structural engineer. Evidence would need to be submitted in a report accompanying any relevant planning application. It would not be possible to comply with Criterion A through simply stating a building is in disrepair, this must be evidenced.

8.11 Next, the policy provides the opportunity for compliance if benefits in the public interest can be identified. This may include a consideration against the Vision and Objectives of the RLDP and its Strategic Policies, and whether demolition and replacement with a new development would assist in delivering against one of these. For example, if a small disused building was sited in a highly sustainable location that if demolished would provide the opportunity for the delivery of high numbers of affordable homes in a flatted development. Alignment with objectives within the Council's Corporate Plan, the Vale of Glamorgan Wellbeing Plan, national policy, and/or other relevant documents may also assist in justifying development in compliance with criterion B.

8.12 In evidencing compliance with Criterion C and D Whole Life Carbon Assessments that are calculated through nationally recognised WLCA methodologies should be submitted. These should compare the anticipated lifecycle carbon of the building to be replaced and the replacement building. Inherently, the replacement building should be low carbon. The policy applies when demolition is proposed for buildings of any proposed or existing usage. However, when residential development is proposed, and to ensure that highly inefficient buildings are not replaced with unnecessarily poorly performing buildings. This target is synchronous with where all buildings should be in order to meet net-zero targets. In order to limit carbon in sourcing materials, and follow circular economy principles, replacement buildings should reuse materials recovered from any demolition that is permitted.

9. Stakeholder Engagement

9.1 On the 12th of July 2024 the Council conducted a stakeholder engagement session which sought to raise awareness of the work that Spring Design had completed in relation to operational net-zero and embodied carbon. The session was well attended, with 43 attendees including the project team.

9.2 A briefing note was provided ahead of the session and this and the slides from the session are included in Appendix 1 and 2 respectively. The presentation highlighted the key findings of the work, as broadly set out in Section 4 of this Paper, and indicated that the Council would be considering a policy intervention based off the completed work.

9.3 Detailed minutes have been prepared setting out the key discussions from the engagement session. These, along with the slides, were shared with attendees and are identified in Appendix 3. A lot of the issues raised in the session have been addressed elsewhere within this Paper, in particular, why standards beyond Building Regulations were chosen and the policy basis for this intervention. The minutes cover the majority of discussion and the Project Team's responses, however, key points from these are summarised below. Correspondence received after the session is also identified both here and within the Viability Appraisal.

9.4 A key point raised was that this was an intervention in the Vale alone, which wasn't reflective of approaches elsewhere in Wales, and that would result in developers having to take bespoke approaches here. In response, it was identified that other Local Authorities in Wales are considering such an approach and many in the South West of England already have such an approach in place or are actively progressing them. Therefore, it isn't considered that the Vale is making this intervention alone and that others are already progressing such an approach or have it in place. Furthermore, given that standard dwelling types have been modelled, it is not suggested that significant changes are required to the buildings being put forward when compared to existing stock. There are just some key interventions required, as discussed in the Stage 2 Report. Ultimately, when weighing the changes required to build **net zero** dwellings and the implications of that against the positives of taking this intervention, the need for a policy intervention prevails. That decision is more straightforward when the build costs have been modelled as similar to expected AD:L (Wales) 2025 **costs**.

9.5 The skills required to ensure that dwellings are built to higher standards were also queried. It was suggested by another participant that potential skill issues could be dealt with through appropriate training once the standards were known, it just takes time to get courses and learners on board. The skills issue was also framed as an opportunity for improving standards in the wider region. The Council consider that sufficient time is available between the policy being made public and when dwellings are required to be built to this standard **for upskilling to take place**. Furthermore, improved skillsets will be a positive outcome of this intervention, which may create a competitive advantage for businesses that work within the Vale, if other Authorities are to follow suit in the wider region.

9.6 The Written Ministerial Statement published by Lee Rawley, the former Minister of State for Housing and Planning, on the 13/12/23 was noted by respondents. This statement sought to clarify that national Building Regulations should be the main point of reference and that the U.K. Government did not expect LPAs to go beyond these. It then sets out the following criteria where this may be justifiable:

- That development remains viable, and the impact on housing supply and affordability is considered in accordance with the National Planning Policy Framework.
- The additional requirement is expressed as a percentage uplift of a dwelling's Target Emissions Rate (TER) calculated using a specified version of the Standard Assessment Procedure (SAP).

9.7 This Statement does not apply to Wales and this was communicated to participants. The position set out in the Welsh Government letter to Chief Planning Officers dated 05/06/14 sets out a position from the Welsh Government that has been considered, as set out in paragraph 3.6.

10. Non-Residential Buildings

10.1 An evidence base has been prepared to investigate operational net zero and embodied carbon on non-residential buildings. However, the decision has been made to not pursue such an intervention on non-residential buildings at this time.

10.2 There is a significant range in building typologies for non-residential buildings, which makes it more difficult to test the technical feasibility and financial viability of such an intervention. Whilst evidence has been collected to make this intervention, and indeed it has been pursued in England, the level of investigation considered in a Welsh context is not considered to have been met to pursue this at this time.

10.3 Residential buildings are the majority of those constructed currently and this will likely extend to 2036. However, non-residential buildings have significant footprints and can consume significantly more energy. This does mean the opportunity to decarbonise the future building stock will not be fully taken. However, proprietors of non-residential buildings are already taking significant steps to decarbonise their buildings and reach net-zero, notably:

- the Council are already delivering and have committed to continue delivering, net-zero schools[9], using an approach that relies upon energy use metrics;
- industries sited in the Vale, namely Aston Martin[10] and Renishaw[11], are seeking to construct or retrofit existing buildings to reduce their carbon intensity
- Cardiff and the Vale College are constructing the first net-zero further education campus in Wales[12].

[9] Vale of Glamorgan Council, 2024. *Sustainable Communities for Learning Decarbonisation.* Online. Available at: Sustainable Communities for Learning Decarbonisation [Accessed: 05/11/24].

[10] Aston Martin, 2023. *Aston Martin intensifies Racing. Green. sustainability strategy, achieving carbon neutral manufacturing*. Online. Available at: Aston Martin intensifies Racing. Green. sustainability strategy, achieving carbon neutral manufacturing – Aston Martin | Pressroom [Accessed: 05/11/24].

[11] Renishaw, 2022. Renishaw announces investment of over £50 million for UK manufacturing site. Online. Available at: Renishaw announces investment of over £50 million for UK manufacturing site [Accessed: 05/11/24].

[12] CAVC, 2024. Cardiff and Vale College's plans for Advanced Technology Centre at Cardiff Airport approved. Online. Available at: Cardiff and Vale College's plans for Advanced Technology Centre at Cardiff Airport approved - Cardiff and Vale College. Accessed: 05/11/24.

11. Practical Implications of Proposed Intervention

11.1 The final stage of the Spring Design Commission was to consider the cost implications and skill sets and cost implications of introducing a policy of this nature. Implementing net-zero building policies in the Vale of Glamorgan through the proposed interventions carries several practical implications, which can be categorised as affecting developers, the council, and residents.

11.2 The implications for housing developers primarily relate to the costs of the Operational Energy Assessment and the Embodied Carbon Assessment necessary to meet the proposed policy requirements. The Vale of Glamorgan Council will primarily be affected by the resource demands of scrutinising the aforementioned assessments.

Developer Implications

<u>Operational Energy Assessment Costs</u>

11.3 More consultancies, including architectural practices, can now perform RICS-aligned operational energy calculations for residential projects, with some offering in-house energy consultancy. Where designers don't offer energy assessments or developers want cost comparisons, external consultants can be hired. While this will usually cost more, it can be offset if the consultant isn't VAT registered.

11.4 The cost of energy assessments for developments of 10 to 50 homes typically ranges from £100 to £500 per unit (excluding VAT), influenced by procurement methods, design complexity, and the application of standard house types. For larger projects of 50 or more dwellings with uniform specifications and standard designs, developers may be able to negotiate lower per-unit rates. In contrast, smaller developments (under 10 homes) and single-family homes, lacking the replicability of larger assessments, are likely to see increased per-unit consultancy costs. For these smaller projects, engaging qualified designers who can integrate the assessment into their services is often the most cost-effective approach.

11.5 Regarding social housing in the Vale of Glamorgan delivered under the RLDP, meeting the Tai ar y Cyd standard (equivalent to CC1, assessed via PHPP) is a minimum requirement for partner organisations. This approach negates the need for additional modelling, resulting in minimal extra cost. Mixed-tenure developments can leverage economies of scale, with additional modelling costs primarily associated with the market housing component.

11.6 While the focus here has been on the initial cost of commissioning these assessments, it's important to note their potential for long-term cost benefits for developers. Integrating this analysis early in the design process can inform valuable optimisations, allowing for strategic investment in energy efficiency measures that can reduce upfront capital expenditure. Furthermore, energy-efficient homes tend to command higher market values and may qualify for more favourable interest rates (as seen with lenders like Ecology Building Society), ultimately presenting a more lucrative investment opportunity for developers.

11.7 **CC2: Presumption Against Demolition** necessitates a WLCA comparing both a retrofit scenario of the existing building(s) and new build proposals. Given the significant contribution of operational carbon to life cycle emissions, typological assessments will need to incorporate the operational energy performance for each residential block. While this involves slightly more work than a purely embodied carbon assessment, the calculations done for CC1 should minimise additional costs beyond what has already been identified. Assessing the existing building will be a separate, site-specific task.

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Council implications

11.8 Validating Energy Reports should be straightforward if they clearly present the outputs required for policy compliance, primarily involving comparing the reported figures against the policy targets. However, a more detailed scrutiny of these figures requires advanced knowledge of building physics and life cycle assessment, potentially requiring additional training for Council staff or the engagement of external consultants. To mitigate this, a guidance document outlining general principles could enable officers to identify potentially incorrect reports, thereby reducing the number of cases needing referral to specialists. Furthermore, as members of recognised professional associations adhere to a code of conduct and ethics, reports prepared by them should be expected to uphold these professional standards, with any deliberate infractions being reported to the relevant professional body.

11.9 The Vale of Glamorgan Council could build in-house expertise in building physics and life cycle assessment. There are two options for this: training current staff or hiring specialists.

11.10 Developing skills internally necessitates identifying willing team members and offers the advantages of broader skillsets and greater officer autonomy in applying the new policy. However, this approach demands a significant commitment from at least one employee (ideally more for workload management and cover) to undertake substantial initial and ongoing Continuous Professional Development (CPD) to remain current with industry and regulatory changes, presenting a considerable learning curve and sustained investment for the Council. CPD encompasses both structured learning (e.g. taught courses) and unstructured learning, (e.g. self-directed study).

11.11 Alternatively, hiring specialists would avoid the need for the Council to fund primary training and would embed expertise within the team, enabling the specialist to educate other officers. Nevertheless, at least initially, unless multiple positions are created, all queries on this subject would likely be directed to this single individual. It's important to acknowledge that current departmental budgets likely do not include funds for recruitment in this field. Regardless of the chosen approach, the Council would be responsible for the ongoing CPD and training requirements.

11.12 Finally, the Council could also explore the possibility of collaborating with qualified consultancies or course providers to design bespoke training programs. This approach would ensure that the training is specifically tailored to the current knowledge levels within the Council and comprehensively addresses all aspects of policy compliance.

11.13 As an alternative to in-house verification, the Council could engage external consultants to verify the accuracy of both operational and embodied carbon reports. Increasingly more consultancies, including architectural practices, are equipped to perform these RICS-aligned assessments for residential developments, with some offering these services internally. While utilising external consultants may involve a higher cost per application compared to relying on in-house resources, it would alleviate the Council of the responsibilities and costs associated with ongoing training and the need to reallocate resources within already stretched planning teams.

Residents Implications

11.14 The focus on energy efficiency and on-site renewable energy generation will result in significantly reduced energy costs for residents. Measures aimed at energy efficiency, such as improved insulation and minimising heat loss, reduce the amount of energy needed to heat and power homes. Furthermore, the integration of on-site renewable energy generation enables residents to benefit from "free" electricity. In addition, the policy will significantly contribute to addressing fuel poverty and improving social equity through the promotion of more energy-efficient homes with lower energy costs.

12. Conclusion

12.1 In conclusion, tackling climate change is a key priority both for the Welsh Government and for the Vale of Glamorgan Council. The Vale of Glamorgan has declared a climate emergency and adopted the Climate Change Challenge Plan, supporting the strategic objectives of the Welsh Government. This highlights the reasoning for a policy intervention in the RLDP, and a need to investigate the feasibility of achieving net-zero buildings and creating more energy efficient buildings through planning policy.

12.2 The proposed policies are supported by a comprehensive evidence base, primarily through the work conducted by Spring Design and reinforced by the Tai ar y Cyd project. The evidence prepared by Spring Design was split into four key stages:

- Stage 1: Research and Policy Formulation;
- Stage 2: Establishing a Net-Zero Methodology and Technical Feasibility;
- Stage 3: Cost Analysis; and
- Stage 4: Practical Implications.

12.3 Stage 1 aimed to create a decarbonisation approach for the Vale of Glamorgan by reviewing existing policies and evidence in late 2023 to early 2024. This included looking at national/local contexts and net-zero policies from other UK councils.

12.4 Stage 2 tested the technical feasibility of the net-zero scenarios. Operational net-zero was assessed by balancing energy use with on-site renewables using models of different house types and non-residential buildings. These models used "worst-case scenarios" to stress-test performance, with heat pumps used in all. Stage 2 concluded that implementing policies requiring the tested net-zero operational and embodied carbon targets is technically feasible.

12.5 Stage 3 focused on the cost of the proposed approaches, using the modelled dwellings. The LETI Standard was chosen for detailed cost assessment against the AD:L (Wales) 2025 benchmark because it was considered the most ambitious and allowed for greater reductions in energy usage in houses. This cost analysis enabled our ability to create our own planning policy.

12.6 Stage 4 aimed to determine the practical aspects of implementing the proposed changes, specifically what evidence developers would need to provide and how this would be reviewed during the planning application process. The full set of works is available for review in the referenced background documents.

12.7 Finally, Tai ar y Cyd, a Welsh project aiming to build affordable, low-carbon homes using a standard design book, released guidelines in January 2025 for timber-frame homes targeting net-zero operation and lower embodied carbon. Using similar metrics to other studies, they modelled house types and created baseline (like AECB CarbonLite) and enhanced (like LETI) standards. Modelling shows these standards are achievable for their designs. While enhanced standards likely cost more, the Council expects its affordable homes to meet at least the baseline.

12.8 The RLDP proposes a phased approach to Net Zero buildings. For operational carbon, new residential developments will be required to achieve a space heating demand of less than or equal to 40 kWh/m²/year and an energy use intensity of less than or equal to 75 kWh/m²/year from RLDP adoption until March 31, 2030. From April 1, 2030, these standards will be raised, requiring a space heating demand of less than or equal to 15 kWh/m²/year and an energy use intensity of less than or equal to 40 kWh/m²/year. On-site renewable electricity generation equivalent to at least the annual energy consumption will also be required.

12.9 Consideration has been given to the introduction of an embodied carbon policy. However, embodied carbon in new buildings will inherently decrease as a result of the operational net zero carbon policy. It is recognised that there may be a cost uplift in achieving operational net zero, and further policy requirements on embodied carbon may result in additional costs in respect of a more limited choice of building materials. As a consequence, it is not proposed to specifically introduce an embodied carbon target at this stage.

12.10 In summary, the Spring Design project, reinforced by Tai ar y Cyd, offer strong evidence for the RLDP's planned phased introduction of Net Zero building standards. The Operational Net Zero planning policy provides a strong opportunity for the Council to achieve its climate change goals and create a more sustainable built environment.

12.11 However, the Council note the recent publication of amended Part L Regulations 2025 and will review any implications of this at such time as the outcome of the consultation is published.

Appendices

Appendix 1: Minutes from Net Zero Buildings Stakeholder Engagement Session

Net zero buildings workshop

Attended by

Jaime Moya	Spring Design
Jonathan Davies	Spring Design
John Butler	John Butler - Sustainable Building Consultancy
Paul Griffiths	RPA
Lucy Butler	Vale of Glamorgan - Planning
Marcus Bayona-Martinez	Vale of Glamorgan - Planning
Andrew Wallace	Vale of Glamorgan - Planning
Liam Jones	Vale of Glamorgan - Planning
Owain Dolan-Gray	Vale of Glamorgan - Planning
Victoria Morgan	Vale of Glamorgan - Planning
Andrew Burrows	Burrows-Hutchinson
Peter Ballantyne	Barratt Homes
Abigail Kinsey	Barratt Homes
Richard Vine	Edenstone
Katie Peters	Edenstone
Chris Monk	Hafod
Sara Brock	Hafod
Mike Simmonite	Hammond
Eliot Hopkins	Hammond
Paul Collins	Hammond
Paul Hammond	Hammond
Mark Harris	HBF
Rhodri Williams	HBF
Shauna Blake	Llanmoor
Jonathan Davies	Lovell
Mark Harris	Lovell
Darrel Powell	Newydd
Morgan Williams	Persimmon
Luke Davies	Persimmon
Andrew Crompton	PMG
Philippa Cole	PMG
Jane Carpenter	Redrow
Wayne Rees	Redrow
Sam Thomas	Redrow
Andrew Weeks	Savills
Nick Heard	Savills
Lorna Cross	Vale of Glamorgan - Estates
Nick Jones	Vale of Glamorgan - Housing
Jonathan Lewis	Vale of Glamorgan - Housing

Alys Pride	UWHA
Peter Seaborne	UWHA
Alys Thomas	Wales and West Housing Association
Gill (OtterPilot)	

Notes of meeting

<u>Questions raised on Teams Chat and responses given.</u>

Did you consider using The Future Homes Hub New Homes specific Whole Life Carbon Assessment tool?

This tool only became available in May this year, by which point most of the modelling for this project had happened. The tool is a welcome addition to available tools, though.

Why a 60 year life plan, no new home will be demolished after 60 years, A 120 yr period which be more appropriate.

This is a standard 'reference service life', used in the methodology to allow comparison. Crucially not an expected lifespan!

It is based on average lifespan in the UK across different typologies - the average for residential buildings is clearly usually longer than that, but using a reference service life just enables comparison of results on a like for like basis.

A judgement by the High court handed down on 2 July dismissing a challenge to Lee Rowley's WMS statement of 13 December advising local authorities to adhere to the Building Regs and not seek to go further through local plans. All three grounds were dismissed.

Definitely something we need to consider but also important to remember that the UK Gov Ministerial Statement doesn't apply to Wales and this position would be set out by the WG

You've referenced lots of LPA's who are using this policy none of which are in Wales, and a KC advice based on England.

Of course you're right, however, we need to acknowledge the wider context.

Why wasn't Part L Wales 2021 used as a starting point.

We took this decision because by the time the houses are being built / consents granted 2025 standards should be applicable.

We were originally going to model to existing Part L, so it could be a useful bit of narrative.

We are experiencing significant difficulty in locating ASHP's in higher density schemes ie. linked / flatted schemes. Potential impact on amenity due to noise and vibration.

This is indeed a challenge but there are alternatives. We can discuss later but Exhaust Air Heat Pumps can leverage the advantages of heat pump technology without the need for external units. We are currently employing this strategy on apartment projects.

I guess the apartment blocks you are referring too are affordable units. The E/O costs are therefore subsidised by SHG via WG ?

Yes, we are utilising EAHPs on affordable apartments but their applicability as a feasible alternative to ASHPs with external units is equally relevant to OMS apartments.

The baseline - (2025 B.Regs) build costs @ £1300/m2 is considered to be very low compared to current build costs.

PV panels cost £99 (I've just installed them on my house) each so where does such a large saving come form, you still need all the other equipment to run the panels regardless of the number of panels?

There are also savings on the framing system & time. Happy to discuss further after the meeting

In terms of house types modelled 3 bed new build data indicates detached are the most common built in Wales. Accept in the Vale data suggests 4 bed are a similar number to 3 bed why was this not modelled?

4 bed homes have been a more common house type than 3 beds in recent years, so most relevant based on our local evidence.

If we were to adopt this energy efficiency policy, it would mean that all developers would require a bespoke full suite of house type drawings just for VOGCBC ??

This policy intervention is something other LAs are actively considering elsewhere in Wales so it will likely not just be the Vale. The options presented are standard dwelling types so it doesn't need to be anything radically different.

We currently build circa 5000 new homes pa in Wales - all to the latest building regs. This represents only 0.0035% of total housing stock in Wales. I calculate that it would therefore, take more than 5150 years to achieve Net Zero Carbon in our housing stock. Are we therefore approaching this issue from the right direction ie. Cost / Benefits ????

The emissions reductions from improvements discussed here even on a development level are significant. e.g. Over the 60 yr reference lifespan in HT421 the total tonnes reduction in CO_2e emissions from AD-L to LETI is around 42 tonnes per building. (combined operational and embodied savings, including from PV)

We have been asked to investigate in light of the Council's declared climate emergency; we need to be doing things differently. So the approach comes from the position / point of view of ensuring houses added are not going to further exacerbate our emissions from housing stock. This approach also means lower bills & less electricity taken off an increasingly stressed grid.

It will also assist with the cost of living crisis and fuel poverty.

The closure of the 2 blast furnaces in Port Talbot will achieve a 20% CO_2 annual saving in Wales as a whole

The closure of the blast furnaces is currently the only reason Wales is on track to meet the current carbon budget. All development delivered within the lifetime of the LDP will fall within subsequent carbon budgets: there are currently no proposals that demonstrate how the necessary reductions will be achieved. Policy interventions such as these will be instrumental in reducing emissions.

In terms of the embodied carbon and the use of timber where is the timber presumed to be coming from? Does the fact most of it is currently imported allowed for / make a difference?

Yes, figures include the transport emissions of most timber being imported currently. Hopefully this could be reduced further if more locally-sourced timber becomes available, but the current modelling here assumes imported timber.

The difficulty is each LPA will probably take a different approach so different house type requirements again. This is exactly why we have always used Building Regulation, a standard that applies across Wales to control the way we build homes.

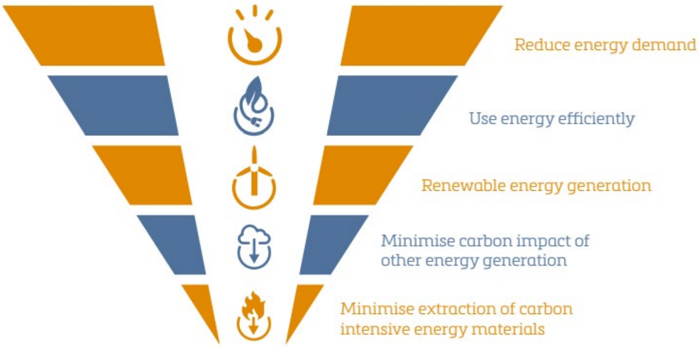
Whilst this is accepted, with little sign of centralised action - a point made by all the English LAs who have adopted or proposed such policy - individual authorities/ regions must seek appropriate interventions to meet their Net Zero targets. Alignment between regional LAs and/ or national policy is an aspiration of this work, however: it will not be used to dilute the aspiration of the Vale's policy.

There is a danger of Over Heating in the Summer

This also means careful management through design. As pointed out earlier, all typologies modelled here complied with Part O. And E/W is often the hardest to manage for over heating (as harder to shade). There is ample evidence of the green premium leveraging additional sales value in the current market (e.g. Octopus Zero Bills model) and in this instance there are multiple health benefits for the occupier due to the latent mitigation of overheating and improved IAQ.

Worth remembering that prioritising the reduction of heating demand is what is called for by the over-arching policy objectives and is reiterated in PPW12. This of course underpins the approach.

Figure 10: The Energy Hierarchy for Planning



In terms of meeting PPW12 current improvements in house building and those planned by Part L 2025 all meet this diagram, there is no requirement to be zero carbon.

Paragraph 5.8.5 of PPW states 'Planning authorities should assess strategic sites to identify opportunities to require higher sustainable building standards, including zero carbon, in their development plan. In bringing forward standards higher than the national minimum, which is set out in Building Regulations, planning authorities should ensure the proposed approach is based on robust evidence and has taken into account the economic viability of the scheme.'

In light of the climate emergency that has been declared by the Vale of Glamorgan Council, the Council's Project Zero programme has funded this work to provide the necessary robust evidence required to support such a policy intervention.

The quote above does specifically mentions strategic sites, does this mean the proposed policy will only apply on larger strategic sites?

The intention would be that it would apply to all new build.

Is the intention of the proposed policy to require all new buildings to be zero carbon not just homes?

Others can comment on the policy, but the modelling also included non-residential buildings, in this case a school and an office building.

Spring have tested some non-resi building types but this is a matter for further discussion as there is significant variance across the typologies.

There needs to be realism about the amount of a 'green premium' - if there is one. Even if you can demonstrate to a buyer they can save £1,000 a year on energy bills, if they expect to live in a house for say 10 years that is a max saving of £10k, the present value of that is obviously lower, and buyers will not wish to pay all that saving away in the premium on day 1 because they would be left with no actual saving. Suggest price resilience rather than premium.

Spring Designs notes that there is ample evidence of the green premium leveraging additional sales value in the current market (e.g. Octopus Zero Bills model) and in this instance there are multiple health benefits for the occupier due to the latent mitigation of overheating and improved IAQ.

Is there an issue around skills to achieve the requisite airtightness and other construction standards?

The view of one participant was that this can be dealt with once we know the requirements, through training, it just takes a while for colleges to change courses and then get learners through.

Another participant agreed and stated that the challenge of upskilling is applicable to us all. The skills challenge also represents an opportunity in terms of industry/training/education partnerships for those wishing to get ahead of the curve.

Questions raised prior to the meeting

Several questions were raised by participants who had received the briefing note but were unable to attend the session.

The embodied carbon in higher fabric standards can be more than the benefit, in some cases. There has been a fair bit of coverage on this and it may nullify the benefits around thicker walls and triple glazing, for example. It may be that "worse" u-values than suggested by AD L 2025 are optimum.

The modelling shows that we need to be achieving somewhere in the 15-30 kw hours per m2 per year in order to deliver really good and climate resilient buildings. If you choose to degrade the specifications, then there will be much higher heating demand then much bigger technology (i.e. larger heating systems, larger ASHPs, and larger photovoltaic arrays to balance the annual consumption) is needed.

It was clarified that PV is included in embodied carbon calculation. However, they are not included in the LETI rating because they want to encourage people to use PV.

Embodied carbon - The maths done now is a snapshot in time. The manufacturing sector is decarbonising, as we see at Port Talbot, there should be care to allow for policy made in 2024 to evolve so that in 2032, when much lower carbon materials are available, it still makes sense.

This is a good point. We either have to have a staggered or phased policy, improving ambitions of embodied carbon targets over time, or be ambitious from the start.

For the foreseeable future, we are going to be shipping steel from abroad. However, the decarbonisation of Port Talbot steel manufacturing will make it easier to justify the use of the material.

We can only work with the snapshot in time, rather than make assumptions about the future. The policy must be based on a sound evidence base.

Transport is excluded. Although this seems logical, almost all new homes will have an EV charger and an electric vehicle soon. In that case, a car will use around 2,500kWhs of home energy each year. That is more around a third of total electricity a new home will need and emphasises that a "net zero" house in a location that requires a lot of driving could be a lot worse than a low spec. heat pump home in a good location. Facilities, comprehensive car clubs and easy, safe cycling and walking are crucial and aren't making progress.

EV will increase energy demand, but it is important to reduce demand in one place to allow it for another. If we include EV in the definition of net zero, there will be a need for more PV – viability and grid implications. EV is not within the operation of the building and therefore not within the definition.

RLDP looks to allocate sites in locations that reduce the need for private vehicle ownership.

In an all-electric future, when we use energy will be as/more important than how much. Most people in new homes will soon have variable energy tariffs as they save so much money when you have an EV and heat pump. The policy analysis doesn't seem to be looking at this. The ability to move energy demand around must be promoted – bigger hot water tanks? Batteries? Different orientation of solar? The current net zero process relies on an annual balance, it is important to realise that an energy system doesn't work on an annual net basis, it has to be in balance in real-time. Solar value is likely to reduce in value over time as cheaper summer price electricity becomes normal.

It would be difficult to dictate energy storage for the next 15 years as any method identified now will be redundant in a couple of years. Energy storage is developing at pace.

Peak usage is normally between 5-7pm when people may be using many electrical devices at the same time, which may exceed the capacity of storage devices and rely on the grid.

From a heating demand perspective, a home with good heat recovery is going to require lower input. This is why the focus is on the building first and then the technology after.

Once you get to very big solar arrays on plots, such as 10kWp, you are likely to get issues with grid connections as there will need to be bigger allowance for export. This should be considered.

An energy efficient building would need less PV and less export to the grid.

Other comments

There was concern about the LA preparing a bespoke policy, as it could cause confusion, more work, more fees, and a delay in housing delivery. In response, the Vale noted that other LAs are currently considering this approach.

It was stated that Julie James had recently said that the zero carbon target implementation date is to be pushed back due to viability reasons. Whilst noted as recent commentary from the minister, this contradicts the legal requirement for UK/ Wales to decarbonise.

It was queried that the proposals are a massive step change, but the information presented does not show a massive step change in costs. The base build costs are lower than what were discussed at the recent viability workshop.

It was suggested that whilst developers realise they need to be on the journey towards zero carbon, it should be done in stages to allow the industry to absorb it.

It was pointed out that MVHR and heat pumps are not new technologies – they have been in place for decades. The sector, however, needs to get to grips with them more quickly in terms of design, installation and maintenance.

The HBF stated that homes currently being built are already cheaper to run than they were 10+ years ago. It was highlighted that energy (electric and gas) bills for a typical 3 bed new build were about £700 a year, which is considered to be reasonable. The energy hierarchy in PPW talks about reducing demand, not achieving net zero. Spring Designs note that these homes are still being built with gas boilers. This goes against the urgent need to decouple from gas as an unsustainable heating solution and establishes legacy issues for decarbonisation within the immediate life of the asset.

Spring Design highlighted that we have had the consultation documents for Part L but we don't know which option will be chosen. We do, however, know in the current context that the reduction of energy is not actually something that is prioritised. It prioritises adding renewables because renewables are perceived as having the most cost benefit, and SAP is effectively a cost benefit analysis tool, but one that is static and slow to change. Part L does not specifically regulate energy demand, but planning policy identifies energy reduction as the highest priority.

The point was made that from a planning perspective the floorplan won't change, but the technical designs will change and will require a bespoke set of drawings. There will be a cost to this. It is suggested that different plans would be needed for every orientation. Spring clarified that they had modelled the worst case scenario for orientation, and provided air tightness and thermal bridging were considered at the outset, standard house types could be easily applied.

The housebuilding industry relies on sub-contractors – there is a danger of mistakes and lack of consistency if the construction approaches in different LAs are different.

There was concern that orientation will affect placemaking if there is a need for rows and rows of housing with the same orientation. This may not be marketable. Spring clarified that whilst certain orientation certainly optimized the energy performance of buildings, it's not an obstacle to achieving the kind of standards that are being discussed. It just requires consultants to deliver appropriate solutions for the standards. The analysis is based on East West orientation as that is functionally the worst, so other options will improve the critical outputs (heating demand and EUI) and perhaps facilitating more flexibility in the architectural language or fabric of the dwelling. It will still be possible to respond to site characteristics and deliver brilliant placemaking. The modelling is as conservative as could reasonably be to make sure that there is confidence that whatever the orientation, it will be possible to get a really good energy performance out of it.

Developers noted that there is a presumption that people will pay more for net zero homes. However, there is a limit in how much people can afford to pay for a home and it is difficult in the current climate to ask for more. Homes also need to be valued to secure a mortgage and net zero credentials are not taken into account in the value. The mortgage system needs to catch up with this.

The impact on the affordability of homes was also reiterated by an RSL, who highlighted that this may be a problem for the 70% LCHO properties by increasing the cost further. This may mean that homes are not being provided for the people most in need.

Developers were not aware that customers have asked for energy efficiency credentials in sales offices, although Spring Design had anecdotal evidence that buyers are beginning to ask these questions in the Vale.

One developer was already including ASHP in their homes. They had found that customers were generally supportive of the technology, but it has not led to increased revenue.

Concern was raised about the ability to include PV on interesting roofscapes and the impact that having to change design would have from a placemaking perspective.

One developer has had a discussion with another Welsh LA about their emerging policy and there was concern that they would need to redesign some of their house types as a result.

It was noted that in England the starting point is different and therefore this was a bigger shift than it will be in Wales, where building regs are more advanced.

There was a view from the development industry that moving in the direction of zero carbon was the right thing to do in the future. One RSL felt that this needed to be done in small incremental steps with financial resources from WG.

The feedback that the HBF had had on costs is that to achieve current part L 2021, the cost is £4-5k and to achieve Future Homes Standards, it is £10k per dwelling on an average 3 bed. Construction to LETI standards significantly increases - £18-20k.

The HBF indicated that they would provide more information on this. It was clarified that these relate to uplifts above the English standards, rather than the Welsh so not a fair comparison.

It was noted that the last Part L consultation included costs on what 2025 would look like and assumptions on things such as sprinklers so costs are available. It was clarified that the 2025 regulations were originally due to be published at the end of the year, but this has been pushed back.

It was queried whether there would be any relaxation of the specification standards for ASHP, as these standards don't apply in England.

It was queried whether there have been any schemes of 50+ units that have delivered net zero or close to net zero as an example. Exeter Living was highlighted as an example of this. They had been delivering to Passivhaus standards and originally the uplift cost was 15% over building regs but in the latter stages of their development programme, there has been cost parity versus the requirements of AD: L 2014 .

It was agreed that there would be an opportunity for developers to consider further and come back with any further comments or points of clarification.

Appendix 2: Briefing Note for Net Zero Buildings Stakeholder Engagement Session

Vale of Glamorgan Council

Net Zero Carbon Buildings Feasibility Study and Cost Assessment

Work Stage 3F

Briefing Note

July 2024

Revision: A

Architecture
Low Energy Consultancy
Civil Engineering
Structural Engineering
Urban Design

Contents

Section 1: Introduction

1.1 Introduction

Spring Design Consultancy Limited is appointed to assist Vale of Glamorgan Council in developing suitably evidenced Net Zero policy to guide, assess and determine applications for new-build residential and non-residential development within the emerging Replacement Local Development Plan 2021-2036.

This process has been divided into distinct work stages:

Work Stage 1	A - Policy Review B - Policy Approach C - Evidence Base
Work Stage 2	D - Methodologies E - Technical Feasibility
Work Stage 3	F - Cost Analysis
Work Stage 4	G - Evidence H - Cost Implications I - Scrutiny Skillset
Work Stage 5	Examination

This Briefing Note summarises the reported outputs up to Work Stage 3F - Cost Analysis with a focus on the on residential typologies to inform attendees of the Developer Engagement Workshop.

1.2 Emission Targets

1.2.1 Operational Targets

Operational energy relates to the amount of energy required to operate a building. For this exercise, two measures of operational energy were quantified: Space Heating Demand and Energy Use Intensity (EUI) which both use the metric of kWh/m²/yr.

Space heating demand refers to the amount of energy required to maintain an internal temperature of 20°C or above annually based on Treated Floor Area (TFA). This does not factor in the in-/ efficiencies of the heating system but quantifies the necessary input of heat.

Energy use intensity (EUI) relates to the sum of all energy use by a building on an annual basis based on Gross Internal Area (GIA). This can be delivered via the grid or by on-site renewables and accounts for space heating, hot water, lighting and all unregulated usage in occupation (e.g. all appliance usage) - factoring in system in/ efficiencies - but excludes EV charging.

Four operational scenarios were agreed with VoGC using identical fabric specifications derived from Approved Document L (Wales) 2022 Appendix E.

Operational emission scenarios		
Reference	Space heating demand	Energy use intensity (EUI)
AD: L (Wales) 2025	N/A	N/A
AECB CarbonLite	40 kWh/m²/yr	75 kWh/m²/yr
B&NES	30 kWh/m²/yr	40 kWh/m²/yr res. 50 kWh/m²/yr non.
LETI	15 kWh/m²/yr	40 kWh/m²/yr res. 50 kWh/m²/yr non.

These generally follow the standards for which they are named, however: in recognition of modelling the worst-case scenarios, EUI targets are slightly relaxed from LETI recommendations. No cooling load has been modelled as passive techniques are integrated.

1.2.2 Embodied Targets

Embodied energy (also embodied carbon or life cycle embodied carbon) refers to the total greenhouse gas emissions and removals associated with materials and construction processes throughout the whole life cycle of an asset including its disposal.

Embodied energy is measured in kg CO_2e/m².

As it has historically received less attention than operational energy, no specific targets were set for embodied energy. Instead, it was considered more appropriate to establish what current practice achieves and use this as a baseline to leverage improvements.

Identical u-values were targeted for all operational scenarios with changes concentrated in the quality of the design and construction (improved airtightness and thermal bridge mitigation), quality of external door and window specification and the optimisation of heating and ventilation technologies.

Four scenarios were agreed with VoGC to represent the residential and non-residential typologies.

Embodied emission scenarios		
Reference	Residential	Non-Residential
Masonry	Masonry with PIR	
Framed	140mm Stud with Mineral Wool & PIR	Steel Frame with PIR Panels
Timber	140mm Stud with Woodfibre	
Timber Optimised	Twin Stud Cellulose	

Inclusions and exclusions for embodied outputs vary slightly between different assessment methodologies (e.g. upfront, WLCA, LETI, RIBA, etc.).

1.3 Calculation Methodology

1.3.1 Whole Life Carbon Assessment

Whole Life Carbon Assessment (WLCA) is in accordance with the internationally recognised RICS methodology which is based on EN 15978 and used by RIBA, LETI, CIBSE and IStructE. This WLCA standard provides a detailed methodology to enable consistent measurement and quantification of whole life carbon emissions, inclusive of all embodied and operational carbon throughout the whole life cycle of a building.

Whole life carbon assessment for the built environment 2nd edition (2023) requires operational energy use predictions to be completed by a suitably qualified professional using the guidance outlined either in CIBSE's TM54, NABERS, ASHRAE Standard 90.1 or the Passivhaus Planning Package (PHPP). Approved Document L 2021/ 2022 calculations using the SAP methodology are explicitly forbidden: these are not considered to be either an appropriate or accurate prediction of energy consumption.

All modelling has been undertaken in the Passivhaus Planning Package (PHPP), an Excel-based design tool introduced in 1998 and subjected to continual refinement since. PHPP is produced by the Passivhaus Institute and aimed for use by architects, engineers and other building designers to determine compliance with the spectrum of low energy building standards.

Net Zero in Operation

For the purposes of this policy development exercise, Net Zero in operation requires the EUI of a building to be balanced by on-site renewable generation. This translates into balancing annual consumption with annual on-site generation for each dwelling.

Section 2: Technical Feasibility

2.1 Summary

Achieving Net Zero Carbon in the built environment is critical to mitigating anthropogenic climate change and meeting climate commitments.

Substantial operational carbon savings are achievable with only minor changes to building specifications and embodied carbon can be cut without compromising building performance.

This summary presents the operational and embodied carbon of three residential new-build typologies to establish the technical feasibility of Net Zero:

- **HT 211** - 3 storey block of nine flats;
- **HT 421** - two semi-detached dwellings;
- **HT 641** - detached single family dwelling.

Four operational scenarios were modelled in PHPP applying identical external envelope u-values to achieve increasing levels of building performance:

- **AD: L (Wales) 2025** - future Building Regulations;
- **AECB CarbonLite** - 40 kWh/m²/yr threshold;
- **B&NES** - 30 kWh/m²/yr threshold;
- **LETI** - 15 kWh/m²/yr threshold.

Four embodied scenarios were then taken through PHribbon to achieve the LETI performance standard using a range of different constructions:

- **Masonry** - masonry + PIR;
- **Framed** - mineral wool & PIR;
- **Timber** - timber + woodfibre;
- **Timber Optimised** - twin stud timber + cellulose.

In all scenarios heat pumps were applied to supply hot water and space heating. If these were substituted for any alternative heating and/ or hot water systems the associated energy use and operational emissions would be likely to increase approximately fourfold.

Headlines for operational analysis

- Heating demand reductions > 80% achievable between identical buildings by improving airtightness & thermal bridging complemented by MVHR
- EUI & CO_2e reductions of 30-40% available applying these improvements
- Reduced EUI requires 30-40% fewer PV panels to achieve Net Zero balance
- Heat pumps reduce energy required for heating & hot water demand to < 25% of the direct electric equivalent

Heating demand reductions of more than 80% were achieved for the assessed typologies while applying identical fabric u-values. This illustrates the benefit of well-considered airtightness and thermal bridge detailing with MVHR as the ventilation strategy and how this efficiently deliver low carbon buildings.

Hot water, auxiliary and household electricity loads remain constant throughout each operational scenario as no changes were made to appliances or lighting. This is to allow direct comparison of the impact of the interventions on the energy use intensity (EUI) and potential CO2e emissions: these reduce by 30-40% progressing through the operational scenarios and so require 30-40% fewer photovoltaics to meet Net Zero.

Beyond fewer photovoltaic panels, reductions in space heating demand would also translate into smaller heat pumps and heating infrastructure. This provides further opportunities for cutting embodied carbon.

Headlines for embodied analysis

- Higher-density building typologies can facilitate material efficiencies that result in lower embodied carbon
- Changing from masonry construction to timber frame reduces CO_2e 20-30%
- Timber frame with biogenic insulants can sequester 3-5x CO_2e as equivalent built in masonry with PIR insulation
- Improved form factor can achieve high performance standards with less insulation, saving embodied carbon

While the fabric specifications were developed to ensure compliance by the typologies with the worst form factor, **HT 211** illustrates how application of the same fabric standards is not the most materially efficient way of achieving high performance buildings. Improved form factor can use less depth of insulation and still achieve the same high performance building standards. Terracing dwellings or apartments are therefore a cost-effective way of reducing operational energy demand.

Before considering materiality or potential reductions to insulation thickness, significant embodied carbon savings are also possible by improving the form factor of buildings and delivering greater density. Such an approach must be balanced against placemaking and urban design aspirations but the same principle of terracing dwellings or building apartments to reduce operational carbon applies to reducing embodied carbon versus building detached, low-rise buildings.

Material and specification choices significantly impact embodied carbon. In the context of the assessed typologies, replacing masonry with timber frame reduced embodied emissions 20-30% and facilitated greater CO_2e sequestration. Further improvements are available by substituting conventional petrochemical and mineral insulants with short-rotation biogenic or recycled insulations such as hemp and cellulose.

In addition to the operational cost and carbon savings available by reducing heating demand, capital cost and embodied carbon savings can also be realised. While there are costs associated with installing MVHR units these are quickly offset by the savings available from installing smaller heating systems and requiring fewer photovoltaics to achieve the Net Zero energy demand.

Material efficiency goes beyond reducing embodied carbon: it also contributes to alleviating the complex issues of social justice and ethics. Particularly in the context of extracting and refining rare earth minerals, there are well-publicised transgressions of human rights and environmental protections. Technologies reliant upon these materials, chiefly renewables such as batteries and photovoltaics, must therefore be used as efficiently as possible in the pursuit of Net Zero and only sourced from those manufacturers who can offer visibility of their supply chains.

It is acknowledged that decarbonisation of existing buildings is critical to combatting climate change. New buildings must not contribute to this retrofit workload and so must be climate resilient, achieving the lowest embodied and operational carbon practicable. Due to the range of typologies, construction methodologies and heritage constraints present within the Vale it was considered impractical to accommodate analysis of the stock within the current scope and timeframes.

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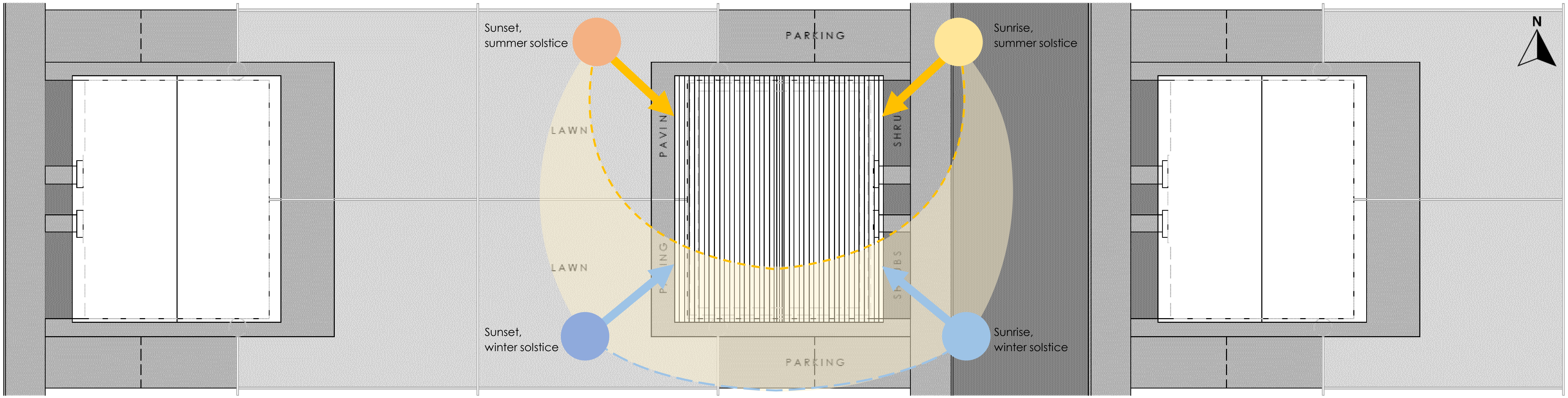

Fig. 01: Excerpt from **2740-421(02)100 - Notional Site Layout**
Not to scale.

All typologies were modelled facing East-West as the least favourable orientation for solar gains. In winter this orientation excludes the majority of sunlight, limiting heat gains that could offset space heating demand; in summer it is exposed to low angle sun that can exacerbate issues with overheating.

Residential typologies were modelled to account for units of the same scale 15.0m from the front elevation and 21.0m from the rear.

Distances between buildings are derived from the principles established by Manual for streets (2007). Similar units are positioned to the East and West to establish horizon shading objects and ensure the assessment remains conservative: unshaded building models would overestimate the potential of solar gains to offset space heating demand.

Operational fabric specification

- Identical ground floor, external wall and roof u-values used across the four operational scenarios
- Improved: airtightness, thermal bridging, door & window specification
- Ventilation strategy improved from MEV as AD: L (Wales) 2025 base to increasingly efficient MVHR
- ASHP used for hot water & heating: unit with improved SCOP used for AECB, B&NES + LETI scenarios

Operational	AD: L (Wales) 2025	AECB CarbonLite	B&NES	LETI
Building Fabric				
Ground floor	0.110 W/m²K	0.110 W/m²K	0.110 W/m²K	0.110 W/m²K
External wall	0.130 W/m²K	0.130 W/m²K	0.130 W/m²K	0.130 W/m²K
Roof	0.110 W/m²K	0.110 W/m²K	0.110 W/m²K	0.110 W/m²K
Air permeability	5.00 m³/m²/hr	1.50 m³/m²/hr	1.05 m³/m²/hr	0.50 m³/m²/hr
Thermal bridges	0.200 W/mK	0.100 W/mK	0.050 W/mK	-0.050 W/mK
Doors & Windows				
Frames U_f	1.400 W/m²K	0.850 W/m²K	0.810 W/m²K	0.810 W/m²K
Installation TB	0.040 W/mK	0.040 W/mK	0.040 W/mK	0.023 W/mK
Glazing U_g	1.120 W/m²K DG	1.190 W/m²K DG	0.550 W/m²K TG	0.550 W/m²K TG
Glazing g-value	0.64	0.64	0.63	0.63
Glazing edge	0.040 W/mK	0.025 W/mK	0.025 W/mK	0.025 W/mK
Ventilation Strategy				
Ventilation rate	30m³ per person/ hr	30m³ per person/ hr	30m³ per person/ hr	30m³ per person/ hr
Ventilation unit	MEV	MVHR energiSava 300	MVHR energiSava 400	Zehnder ComfoAir 225
HR efficiency	N/A (extract only)	84%	84%	92%
Heating				
ASHP	Generic	Vaillant aroTHERM	Vaillant aroTHERM	Vaillant aroTHERM
SCOP	3.30	4.10	4.10	4.10

Above is a summary of the fabric standards applied to the operational scenarios.

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2.2 Residential

2.2.1 Operational

Modelling of the typologies clearly illustrates that application of standardised fabric specifications is not the most efficient way of delivering buildings that meet space heating demand and EUI targets. The specification, derived to ensure the compliance of heating demand for **HT 641**, results in **HT 211** overperforming by a significant margin. Discussion of the potential impact of standard specifications on the embodied carbon of buildings is continued within 3.2.2 Embodied.

In the context of this feasibility study, aligning with the analysed adopted policy by other Local Authorities, Net Zero is achieved by generating as much electricity on-site per annum as the building consumes. The reality is more complex as there are still emissions generated by buildings where photovoltaics meet the annual on-site energy demand. This is a product of the electricity generated by the photovoltaics being imported and exported to and from the grid as not all on-site generation will be immediately utilised.

Operational results are broken down into five separate metrics, tabulated individually for each typology. These were selected to evidence the correlation between thermal performance, operational emissions and the number of photovoltaics required to achieve Net Zero.

The applied metrics are:

- space heating demand;
- energy use intensity (EUI);
- annual energy use per dwelling;
- CO_2e emissions excluding photovoltaics;
- kWp of photovoltaics required to achieve Net Zero.

CO_2e emissions excluding photovoltaics describes the potential emissions if all electricity were imported from the grid. These are the cumulative emissions within a 60 year building lifecycle, applying the 'Falling Short' grid decarbonisation scenario. Work Stage 2E – Technical Feasibility explores how this is applied and explains grid decarbonisation scenarios in more detail.

Headlines for residential typologies

- Performance of identical buildings is significantly impacted by airtightness, thermal bridging & ventilation > 80% reduction of heating demand possible
- EUI & CO_2e reductions of 35% in upgrading **AD: L (Wales) 2025** to **LETI**
- Lower EUI requires 35% fewer PV panels to achieve Net Zero balance
- Fewer PV panels reduces embodied carbon & capital cost of buildings
- Better form factor/ higher density significantly reduces heating demand

As demonstrated within the result tables, minor improvements to build quality can significantly reduce operational emissions. Upgrading from the build quality of **AD: L (Wales) 2025** to **LETI** lowers energy use and associated emissions by 32-37% across the assessed typologies. As building performance improves, space heating reduces from c. 35% of total dwelling energy consumption to c. 6-10%.

Diminishing energy demand also requires less on-site generation to achieve Net Zero, reducing the size of photovoltaic arrays. Reducing photovoltaic panels lowers embodied energy and capital cost of the works. Such cost implications are explored in 4: Cost Analysis.

Operational outputs - HT 211

Operational scenarios	Space heating demand	Energy use intensity (EUI)	Annual energy use per dwelling	CO_2e emissions ex. PV (60 yrs)	kWp of PV to Net Zero per dwelling
1 AD: L (Wales) 2025	60.7 kWh/m²/yr	44.9 kWh/m²/yr	2,686 kWh/yr	10.10 tonnes	4.0 kWp
2 AECB CarbonLite	19.7 kWh/m²/yr	37.5 kWh/m²/yr	2,244 kWh/yr	8.53 tonnes	2.9 kWp
3 B&NES	13.4 kWh/m²/yr	33.0 kWh/m²/yr	1,974 kWh/yr	7.49 tonnes	2.5 kWp
4 LETI	3.9 kWh/m²/yr	28.5 kWh/m²/yr	1,705 kWh	6.44 tonnes	2.4 kWp

Operational outputs - HT 421

Operational scenarios	Space heating demand	Energy use intensity (EUI)	Annual energy use per dwelling	CO_2e emissions ex. PV (60 yrs)	kWp of PV to Net Zero per dwelling
1 AD: L (Wales) 2025	87.1 kWh/m²/yr	62.5 kWh/m²/yr	5,200 kWh	19.75 tonnes	7.6 kWp
2 AECB CarbonLite	36.7 kWh/m²/yr	43.8 kWh/m²/yr	3.644 kWh	13.95 tonnes	5.4 kWp
3 B&NES	28.3 kWh/m²/yr	41.8 kWh/m²/yr	3,478 kWh	13.30 tonnes	5.0 kWp
4 LETI	14.3 kWh/m²/yr	40.0 kWh/m²/yr	3,328 kWh	12.75 tonnes	4.8 kWp

Operational outputs - HT 641

Operational scenarios	Space heating demand	Energy use intensity (EUI)	Annual energy use per dwelling	CO_2e emissions ex. PV (60 yrs)	kWp of PV to Net Zero per dwelling
1 AD: L (Wales) 2025	79.5 kWh/m²/yr	65.6 kWh/m²/yr	7,242 kWh	27.20 tonnes	10.0 kWp
2 AECB CarbonLite	35.8 kWh/m²/yr	48.4 kWh/m²/yr	5,343 kWh	20.10 tonnes	7.4 kWp
3 B&NES	27.3 kWh/m²/yr	46.3 kWh/m²/yr	5,112 kWh	19.20 tonnes	7.0 kWp
4 LETI	15.1 kWh/m²/yr	44.5 kWh/m²/yr	4,913 kWh	18.50 tonnes	6.8 kWp

EUI and operational emissions must be contextualised with the use of highly efficient ASHPs. As modelled, the specified units deliver heating and hot water at an effective rate of 4.1 kWh of heat for every 1 kWh input of electricity: if heating and hot water were delivered by any other system, associated energy use and resulting emissions would increase c. 400%.

2.2.2 Embodied

Modelling of the construction scenarios demonstrates how significant embodied carbon reductions can be achieved by changing what we use to build. Despite the use of different materials, all four scenarios are capable of achieving identical fabric performance and therefore identical operational emissions.

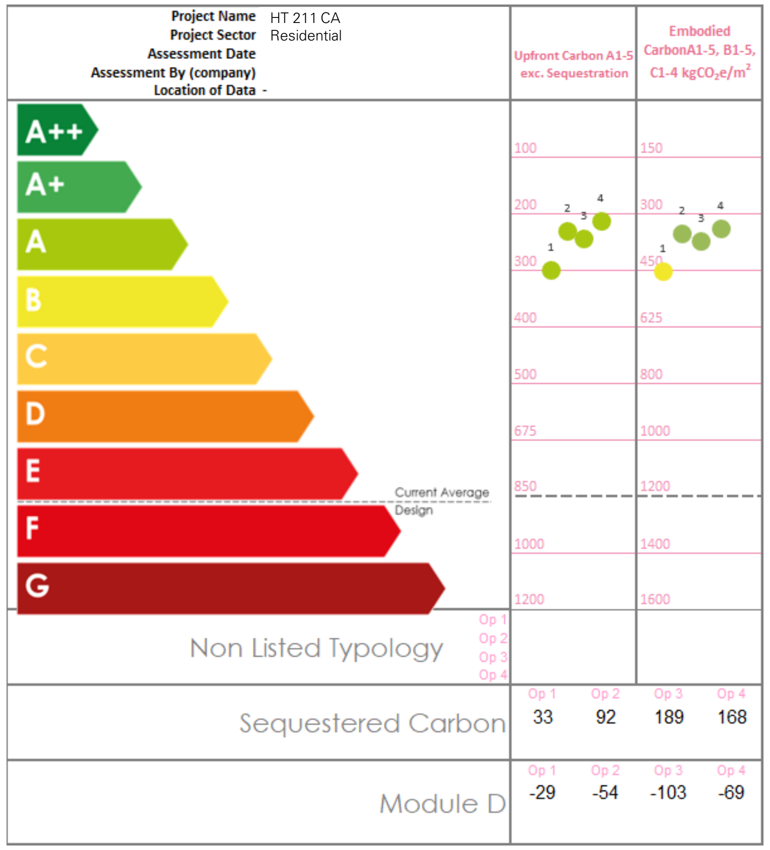
Embodied results to **LETI** standards are represented graphically by individual building typology with results to **RIBA/ RIAI** standards in the far table. **LETI** metrics:

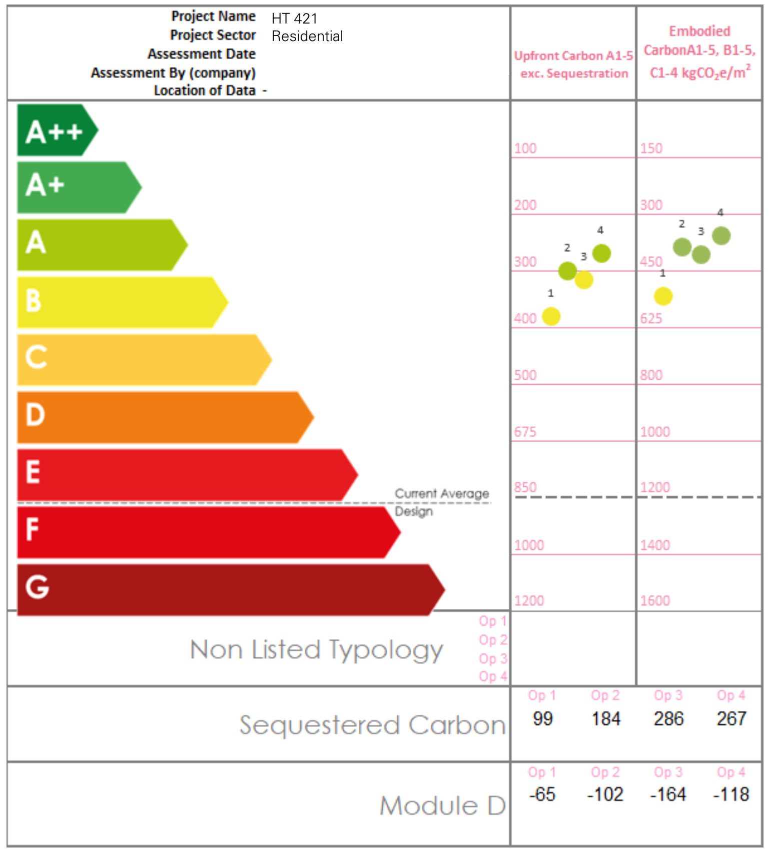
- upfront carbon (A1-5);
- embodied carbon (A1-5, B1-5, C1-4);
- sequestered (biogenic) carbon;
- module D (potential off-site benefits).

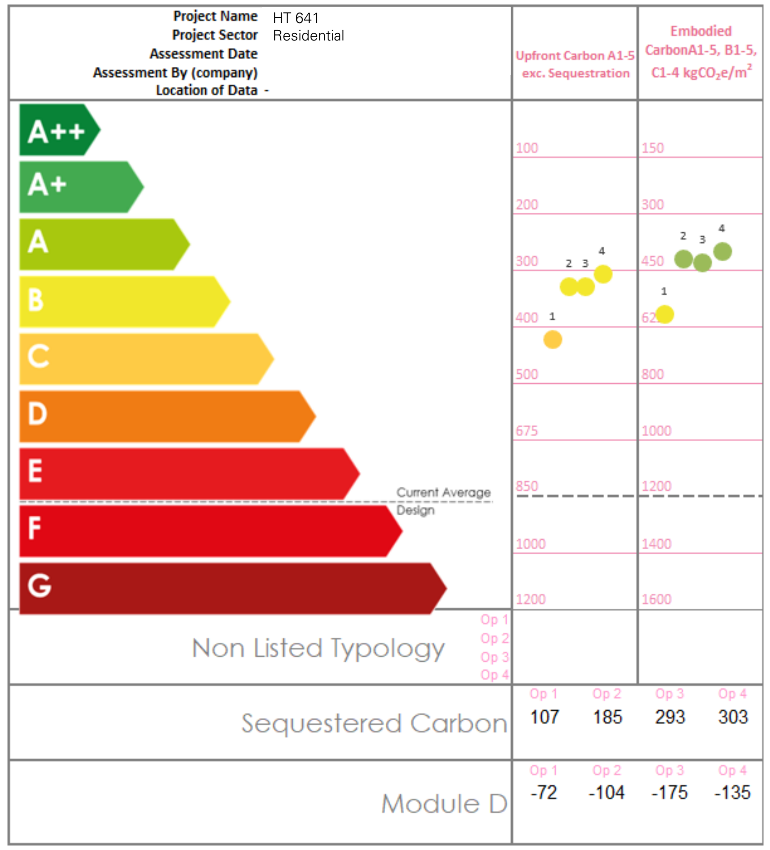
Within the assessment, masonry always results in higher embodied emissions than timber frame options. Reductions of 20-30% are achievable by changing from masonry with PIR to timber frame with mineral wool and PIR. Substituting conventional insulants with biogenic ones can further reduce embodied emissions while sequestering CO_2e within the material.

HT 211 demonstrates at least a 20% reduction in embodied emissions compared to **HT 421** by the **RIBA/ RIAI** lifecycle and **LETI** upfront carbon metrics. The detached **HT 641** increases carbon emissions by 5-50% above **HT 421** and 40-50% above **HT 211**.

Further efficiencies are possible: as demonstrated by the disparity in heating demand between **HT 211** and **HT 421** / **HT 641** a standard specification across typologies is not the most material efficient way of achieving low energy building standards. Apartments and other buildings with good form factor can use a lower fabric specification and still achieve high levels of energy performance. The material efficiencies associated with using less insulation immediately reduces embodied energy.







Headlines for residential typologies

- Higher-density residential buildings deliver lower embodied emissions
- Changing from masonry to timber frame reduces CO_2e by 20-30%
- Timber frame with biogenic insulants can sequester 3-5x as much CO_2e as masonry construction with PIR
- Lower fabric specification for larger buildings/ buildings with better form factor requires less insulation and results in lower embodied emissions

While **LETI** excludes on-roof photovoltaic panels to focus on emissions associated with the building, the impact of on-site generation is a material consideration when assessing embodied energy. This assessment considered identical levels of energy performance for each scenario and therefore requires an identical number of panels to achieve Net Zero: however, as discussed in 3.2.1 Operational, buildings with a higher energy demand will require more on-site renewables to achieve Net Zero. Improved performance also requires less heating infrastructure (smaller heat pumps, fewer/ smaller radiators) which can further reduce embodied emissions and capital cost.

The embodied energy of photovoltaics varies widely but the average for monocrystalline panels is currently 2,560 $kgCO_2e$ per kWp. With a useful lifespan of 25 years, these are renewed twice within the modelled 60 year reference period with additional embodied emissions each time. Fewer panels produce carbon, energy and cost savings for the project life cycle.

Embodied emissions (cradle to grave)		
Option		RIBA/ RIAI
1 Masonry	HT 211	486 $kgCO_2e/m^2$
	HT 421	602 $kgCO_2e/m^2$
	HT 641	748 $kgCO_2e/m^2$
2 Framed	HT 211	389 $kgCO_2e/m^2$
	HT 421	460 $kgCO_2e/m^2$
	HT 641	580 $kgCO_2e/m^2$
3 Timber	HT 211	405 $kgCO_2e/m^2$
	HT 421	480 $kgCO_2e/m^2$
	HT 641	593 $kgCO_2e/m^2$
4 Timber Optimised	HT 211	373 $kgCO_2e/m^2$
	HT 421	429 $kgCO_2e/m^2$
	HT 641	560 $kgCO_2e/m^2$

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Section 3: Cost Analysis

3.1 Summary

As evidenced in Work Stage 2E Technical Feasibility, substantial operational carbon savings are achievable with minor revisions to specifications and embodied carbon reduced without compromising performance.

This report assesses the relative costs associated with constructing buildings to operational Net Zero. Three residential new-build typologies were costed to establish the cost at various scales of development:

- **HT 211** - 3 storey block of nine flats;
- **HT 421** - two semi-detached dwellings;
- **HT 641** - detached single family dwelling.

Four operational scenarios were modelled in PHPP applying identical external envelope u-values to achieve increasing levels of building performance:

- **AD: L (Wales) 2025** - future Building Regulations;
- **AECB CarbonLite** - 40 kWh/m²/yr threshold;
- **B&NES** - 30 kWh/m²/yr threshold;
- **LETI** - 15 kWh/m²/yr threshold.

Cost analysis focused on **AD: L (Wales) 2025**, applying the necessary specification upgrades to achieve **LETI** as the exemplar operational scenario.

Four embodied scenarios were modelled in PHribbon to achieve the **LETI** operational scenario with a range of different constructions:

- **Masonry** - masonry + PIR;
- **Framed** - timber + mineral wool & PIR;
- **Timber** - timber + woodfibre;
- **Timber Optimised** - twin stud timber + cellulose.

All costs associated with land purchase, professional consultancy and statutory fees, utility connections, enabling works, civil engineering, landscaping and so forth are excluded from this exercise as beyond its scope: this analysis focuses purely on the construction of the buildings.

Headlines for embodied cost analysis

- Reducing embodied carbon 20-30% attracts a 6-18% uplift in capital cost
- Masonry construction costs least but is the most carbon intensive option, failing to achieve RIBA/ RIAI 2030 and LETI 2030 targets for most typologies
- External finishes can have significant impact on project costs, sales values and embodied carbon - but do not directly impact building performance

Cost analyses for the embodied specifications are summarised in the adjacent tables.

Scenario 1: Masonry is the cheapest approach across the typologies. While this may make it attractive to developers, this approach must be acknowledged as the most carbon intensive, failing to achieve RIBA/ RIAI 2030 and LETI 2030 targets for all but **HT 211**.

Scenario 1: Masonry sets a baseline to assess capital cost associated with reducing embodied carbon. Maintaining a constant performance specification **Scenario 2: Framed** attracts an 8% uplift; **Scenario 3: Timber** 13% and **Scenario 4: Timber Optimised** 17%.

However, much of this additional expense is not generated by the thermal envelope but in parts of the building that do not impact contribute little - if anything - to building performance. If just roof finishes are standardised to concrete tiles across the scenarios the uplift reduces to 7%, 11% and 8% respectively.

HT 211 to AD L (Wales) 2025				
Construction	Scenario 1: Masonry	Scenario 2: Framed	Scenario 3: Timber	Scenario 4: Timber Opt.
Foundations	£22,750.00	£22,750.00	£75,600.00	£22,750.00
Ground floor	£57,420.00	£49,680.00		£23,760.00
External walls	£148,203.00	£166,263.00	£163,788.00	£166,428.00
Party walls	£29,057.50	£59,100.00	£81,755.00	£81,755.00
Internal walls	£35,190.00	£43,470.00	£51,750.00	£60,030.00
Intermediate floor	N/A			
Separating floor	£95,400.00	£97,200.00	£97,200.00	£97,200.00
Roof	£47,736.00	£54,216.00	£69,336.00	£101,736.00
Doors & windows	£19,736.00	£19,736.00	£19,736.00	£19,736.00
M&E	£156,150.00	£156,150.00	£156,150.00	£156,150.00
TOTAL	**£611,642.50**	**£668,565.00**	**£715,315.00**	**£729,545.00**
Cost per unit	£67,960.28	£74,285.00	£79,479.44	£81,060.56
Cost per m²	£1,135.83	£1,241.53	£1,328.35	£1,354.77

HT 421 to AD L (Wales) 2025				
Construction	Scenario 1: Masonry	Scenario 2: Framed	Scenario 3: Timber	Scenario 4: Timber Opt.
Foundations	£13,000.00	£13,000.00	£38,500.00	£13,000.00
Ground floor	£29,150.00	£25,300.00		£12,100.00
External walls	£67,298.00	£73,258.00	£74,408.00	£75,648.00
Party walls	£5,752.50	£11,700.00	£16,185.00	£16,185.00
Internal walls	£15,300.00	£22,500.00	£22,500.00	£26,100.00
Intermediate floor	£8,360.00	£9,240.00	£9,240.00	£10,560.00
Separating floor	N/A			
Roof	£24,200.00	£27,500.00	£35,200.00	£51,700.00
Doors & windows	£10,822.40	£10,822.40	£10,822.40	£10,822.40
M&E	£49,800.00	£49,800.00	£49,800.00	£49,800.00
TOTAL	**£223,682.90**	**£243,120.40**	**£256,655.40**	**£265,915.40**
Cost per unit	£111,841.45	£121,560.20	£128,327.70	£132,957.70
Cost per m²	£1,344.25	£1,461.06	£1,542.40	£1,598.05

HT 641 to AD L (Wales) 2025				
Construction	Scenario 1: Masonry	Scenario 2: Framed	Scenario 3: Timber	Scenario 4: Timber Opt.
Foundations	£8,750.00	£8,750.00	£25,550.00	£8,750.00
Ground floor	£19,345.00	£16,790.00		£8,030.00
External walls	£54,230.00	£58,990.00	£59,960.00	£60,960.00
Party walls	N/A			
Internal walls	£9,435.00	£13,875.00	£13,875.00	£16,095.00
Intermediate floor	£5,225.00	£5,775.00	£5,775.00	£6,600.00
Separating floor	N/A			
Roof	£15,958.00	£18,148.00	£23,258.00	£34,208.00
Doors & windows	£7,018.76	£7,018.76	£7,018.76	£7,018.76
M&E	£31,200.00	£31,200.00	£31,200.00	£31,200.00
TOTAL	**£151,161.76**	**£160,546.76**	**£166,636.76**	**£172,861.76**
Cost per unit	£151,161.76	£160,546.76	£166,536.76	£172,861.76
Cost per m²	£1,369.22	£1,454.23	£1,509.39	£1,565.78

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This reduction is a direct outcome of the increased cost of natural roof finishes with Welsh slate 6.25x the price of concrete tiles (+525% uplift). What material is specified for the finish does not impact the operational performance - it exists outside of the thermal envelope - but the effect on embodied carbon can be significant.

Considering the embodied carbon of the roof finishes in isolation for WLCA stages A-C:

Concrete tiles	41.38 $kgCO_2e/m^2$
Clay tiles	14.12 $kgCO_2e/m^2$
Spanish slate	8.64 $kgCO_2e/m^2$
Welsh slate	2.83 $kgCO_2e/m^2$

While costing 6.25x as much as concrete tiles, Welsh slate is 14.64x less carbon intensive. This could be extended to all external elements - stone cladding instead of brick in the external walls or timber frame windows in place of uPVC - and demonstrates how aesthetic choices can significantly impact project costs and embodied carbon while having no bearing on building performance and operational Net Zero.

High quality, locally sourced materials can be relatively expensive versus alternatives but have benefits for placemaking and can yield potential reductions in embodied carbon. Considered use of such materials often leverages higher sale values for properties with RICS Placemaking and value (2016) identifying 5-50% premium to sales values from successful placemaking.

Locally sourced materials have the added advantage of more transparent and more readily traceable supply chains. Additional scrutiny contributes to reducing social justice issues, ethical transgressions and the environmental degradation associated with material extraction, refinement and transportation.

Within the context of the declared Climate Emergency and the Wellbeing of Future Generations (Wales) Act 2015 it seems proportionate to accept a capital cost uplift to reduce embodied carbon.

Headlines for operational cost analysis

- Less efficient operational scenarios that omit MVHR (and/ or ASHP) can cost more to achieve Net Zero due to larger PV arrays and heating systems
- Building to LETI demonstrates cost parity with AD: L (Wales) 2025 when achieving Net Zero operational carbon
- Energy efficiency is recognised as contributing to desirability, increased and market-resilient property prices

While immediate cost uplift is perceived with replacing MEV with MVHR, heat recovery reduces the heating demand and EUI. If targeting operational Net Zero, the capital cost of MVHR is quickly justified by the savings it can leverage from smaller heating systems (ASHPs) and photovoltaic arrays. Operational cost savings would also be available for the life of the building(s).

Remaining variations are within window specifications, levels of airtightness and mitigation of thermal bridges. The first has negligible impact on cost; the others can be delivered without additional cost by appropriate specification, detailing and workforce skills.

Across all scenarios, if ASHPs were substituted with other less efficient heating and hot water systems this would also make it more difficult to achieve Net Zero and require more investment in photovoltaics and other technologies to balance the increased EUI. This would have the added disadvantage of increasing the operational costs for the life of the building(s).

AD L (Wales) 2025 upgrade to LETI					
Building Element			HT 211	HT 421	HT 641
Fabric	Double glazing to triple glazing	additional cost	+ £3,374.96	+ £991.76	+ £623.63
	ASHP reducing in size	cost saving	N/A	- £8,000.00	- £6,000.00
	MVHR addition	additional cost	+ £27,000.00	+ £7,000.00	+ £4,000.00
	MEV omission	cost saving	- £5,400.00	- £1,800.00	- £1,200.00
Generation	PV array decreasing in size	cost saving	- £11,250.00	- £1,600.00	- £1,200.00
TOTAL			+ £13,724.96	- £3,408.24	- £3,776.37
Cost per unit			+ £1,525.00	- £1,704.12	- £3,776.37
Cost per m² of GIA			+ £25.49	- £20.48	- £34.21

Upgrading **AD: L (Wales) 2025** to **LETI** requires changing only the doors, windows, ventilation and heating units.

The cost implications of these adjustments are explored in the table above. Presented as the cost difference changing from **AD: L (Wales) 2025** to **LETI**, this shows total capital cost decreases for achieving the higher operational standard for **HT 421** and **HT 641**. Despite additional cost installing MVHR, savings are derived from reduced ASHP unit sizes and photovoltaic arrays. **HT 211** is slightly more expensive to uplift as the ASHP remains the same size in both scenarios.

Generally, as the above discussion of MVHR, lower specifications have increased heating demand and EUI. If the aspiration is to deliver operational Net Zero buildings this, as the above, results in additional cost elsewhere as larger heating systems are required to meet higher peak heating loads and larger arrays of photovoltaic panels are needed to balance higher annual energy consumption.

Lower performance specifications also deliver higher operational costs for building occupants in perpetuity, explored for each typology later in this section.

Furthermore, use of dwellings post-pandemic has changed with many now providing home offices and more flexible energy profiles through the day: in this context, it is critical to reduce EUI.

This commentary and exercise do not consider the additional capital cost savings available to typologies that, due to favourable scale and form factor, significantly exceed targets for heating demand and EUI. Simplistically, levels of insulation for **HT 211** - and therefore the associated cost of the insulation - could half and still meet **LETI** operational targets.

Before declaration of the Climate Emergency, outbreak of the COVID pandemic or the Russian invasion of Ukraine, RICS Insights into energy efficiency and residential values (2019) identified that increased energy efficiency was beginning to positively impact property values. Referred to as the ‘green premium,’ recent turmoil in the domestic energy market has seen this translate into energy efficient properties being more desirable for purchasers, commanding higher sales values and more successfully retaining value during periods of market instability.

Some specification decisions are driven by logistics rather than capital cost or carbon intensity. For example, concrete decks are typically favoured over suspended timber floors because they establish a level working platform and can withstand longer exposure to wet weather and generally inclement conditions.

Similarly, timber frame is becoming increasingly common for new-build housing due to its efficiency and flexibility versus conventional masonry. An added advantage is the compatibility of timber with Modern Methods of Construction (MMC) and delivery of prefabricated panellised or 3D volumetric units to site to expedite construction programmes.

Section 4: Conclusions

4.1 Conclusions

High performance buildings are achievable without significantly altering the anticipated fabric specification of Building Regulations Wales 2025. Uplifts beyond basic compliance are limited to improved airtightness, mitigation of thermal bridges, improved quality of windows and provision of MVHR for ventilation.

Improved levels of building performance result in an inherently lower need for heat generation and on-site renewables, reducing the number of photovoltaics required to balance EUI and heating infrastructure size. These cost savings may mean the most economical way to achieve Net Zero is by leveraging the highest feasible level of performance and marketing this as a positive sales feature to realise higher property values and improve loan affordability, expanding the market.

In the case of larger or otherwise optimised buildings targeting heating demand or EUI based performance metrics could justify potential reductions in insulation thicknesses with the resulting material efficiencies benefitting embodied emissions and project costs.

Choice of construction methodology can significantly impact embodied emissions. The principle of replacing mineral and petrochemical-based materials with short-rotation biogenic alternatives lowers embodied emissions while increasing sequestration potential. Cost increases associated with lower carbon materials might be justified by leveraging additional value from the green credentials of the development; widespread adoption would reduce current premiums and offer an opportunity to re-establish a local resource market.

This assessment has focused on a range of residential typologies modelled on a nominal site at 50m altitude, applying typical design responses in an East-West orientation to demonstrate the technical feasibility of Net Zero. Further optimisations - including but not limited to improved form factor, orientation and fenestration design - could reach Net Zero more efficiently, driving further reductions in embodied carbon and realising cost savings for the construction.

Headlines for operational analysis

- Heating demand reductions > 80% achievable between identical buildings by improving airtightness & thermal bridging complemented by MVHR
- EUI & CO_2e reductions of 30-40% available applying these improvements
- Reduced EUI requires 30-40% fewer PV panels to achieve Net Zero balance
- Heat pumps reduce energy required for heating & hot water demand to < 25% of the direct electric equivalent

Headlines for embodied analysis

- Higher-density building typologies can facilitate material efficiencies that result in lower embodied carbon
- Changing from masonry construction to timber frame reduces CO_2e 20-30%
- Timber frame with biogenic insulants can sequester 3-5x CO_2e as equivalent built in masonry with PIR insulation
- Improved form factor can achieve high performance standards with less insulation, saving embodied carbon

Headlines for cost analysis

- Reducing embodied carbon 20-30% attracts a 6-18% uplift in capital cost
- Masonry construction costs least but is the most carbon intensive option, failing to achieve RIBA/ RIAI 2030 and LETI 2030 targets for most typologies
- Less efficient operational scenarios that omit MVHR (and/ or ASHP) can cost more to achieve Net Zero due to larger PV arrays and heating systems
- External finishes can have significant impact on project costs and embodied carbon - but do not contribute directly to building performance
- Using high quality local materials for external finishes can leverage higher value and increased property prices
- Energy efficiency is recognised as contributing to desirability, increased and market-resilient property prices

HT 211 to AD L	Scenario 1: Masonry	Scenario 2: Framed	Scenario 3: Timber	Scenario 4: Timber Opt.
TOTAL	**£611,642.50**	**£668,565.00**	**£713,315.00**	**£729,545.00**
Cost per unit	£67,960.28	£74,285.00	£79,257.22	£81,060.56
Cost per m²	£1,135.62	£1,241.30	£1,324.39	£1,354.52

HT 421 to AD L	Scenario 1: Masonry	Scenario 2: Framed	Scenario 3: Timber	Scenario 4: Timber Opt.
TOTAL	**£223,982.90**	**£243,120.40**	**£256,655.40**	**£265,915.40**
Cost per unit	£111,991.45	£121,560.20	£128,327.70	£132,957.70
Cost per m²	£1,346.05	£1,461.06	£1,542.40	£1,598.05

HT 641 to AD L	Scenario 1: Masonry	Scenario 2: Framed	Scenario 3: Timber	Scenario 4: Timber Opt.
TOTAL	**£151,161.76**	**£160,546.76**	**£166,636.76**	**£172,861.76**
Cost per unit	£151,161.76	£160,546.76	£166,636.76	£172,861.76
Cost per m²	£1,369.22	£1,454.23	£1,509.39	£1,565.78

AD L (Wales) 2025 cost difference from LETI	HT 211	HT 421	HT 641
TOTAL	**+ £13,724.96**	**- £3,408.24**	**- £3,776.37**
Cost per unit	+ £1,525.00	- £1,704.12	- £3,776.37
Cost per m² of GIA	+ £25.49	- £20.48	- £34.21

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Section 5: Appendices

5.1 Glossary

5.1.1 Carbon Definitions

Clarity and consistency in the basic terminology used to discuss carbon and Net Zero is key to ensuring meaningful outcomes.

Carbon Definitions for the Built Environment, Buildings and Infrastructure: Improving Consistency in Whole Life Carbon Assessment and Reporting (2023) is a collaboration between professions throughout the construction industry including the Chartered Institute of Building Service Engineers (CIBSE), Institution of Civil Engineers (ICE), Institution of Structural Engineers (IStructE), Low Energy Transformation Initiative (LETI), Royal Institute of British Architects (RIBA), Royal Institute of Chartered Surveyors (RICS), UK Green Building Council and the Whole Life Carbon Network (WLCN) and applies the following.

Greenhouse Gases (GHG)
often 'carbon emissions' in general usage
'Greenhouse Gases' are constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of infrared radiation emitted by the Earth's surface, the atmosphere, and clouds.

Whole Life Carbon
'Whole Life Carbon' emissions are the sum total of all asset related GHG emissions and removals, both operational and embodied over the life cycle of an asset including its disposal (Modules: A0-A5; B1-B7; B8 optional; C1-C4, all including biogenic carbon, with A0 assumed to be zero for buildings). Overall Whole Life Carbon asset performance includes separately reporting the potential benefits or loads from future energy or material recovery, reuse, and recycling and from exported utilities (Modules D1, D2).

Embodied Carbon *or* Life Cycle Embodied Carbon
'Embodied Carbon' emissions of an asset are the total GHG emissions and removals associated with materials and construction processes throughout the whole life cycle of an asset (Modules A0-A5, B1-B5, C1-C4, with A0 assumed to be zero for buildings).

Upfront Carbon - Buildings
'Upfront Carbon' emissions are the GHG emissions associated with materials and construction processes up to practical completion (Modules A0-A5). Upfront carbon excludes the biogenic carbon sequestered in the installed products at practical completion.

Operational Carbon - Energy, Buildings
'Operational Carbon - Energy' (Module B6) are the GHG emissions arising from all energy consumed by an asset in-use, over its life cycle.

Carbon Sequestration
'Carbon Sequestration' is the process by which carbon dioxide is removed from the atmosphere and stored within a material - e.g. stored as 'Biogenic Carbon' in 'Biomass' by plants/ trees through photosynthesis and other processes.

Biogenic Carbon
'Biogenic Carbon' refers to the carbon removals associated with carbon sequestration into biomass as well as any emissions associated with this sequestered carbon. Biogenic carbon must be reported separately if reporting only upfront carbon but should be included in the total if reporting embodied carbon or whole life carbon.

These definitions only address the GHGs with Global Warming Potential assigned by the Intergovernmental Panel on Climate Change (IPCC). A0 is generally assumed to be zero for buildings.

5.1.2 Net Zero Definitions

Net Zero (whole life) Carbon
A 'Net Zero (whole life) Carbon' Asset is one where the sum total of all asset related GHG emissions, both operational and embodied, over an asset's life cycle (Modules A0-A5, B1--B8, C1-C4) are minimized, which meets local carbon, energy and water targets or limits, and with residual 'offsets', equals zero.

To meet the requirements of 'Net Zero (whole life) Carbon' the definitions for 'Net Zero Upfront Carbon', Net Zero Embodied Carbon', 'Net Zero Capital Carbon', Net Zero operational Carbon - Energy', 'Net Zero Operational Carbon - Infrastructure', 'Net Zero In-Use Carbon Asset' and 'Net Zero Operational Carbon - Water' must also be individually met as applicable.

Net Zero Carbon Embodied Carbon *or* Net Zero Life Cycle Embodied Carbon
A 'Net Zero Embodied Carbon' asset is one where the sum total of GHG emissions and removals over an asset's life cycle (Modules A0-A5, B1-B5 and C1-C4) are minimized, which meets local carbon targets or limits (e.g. $kgCO_2e/m^2$), and with additional 'offsets', equals zero.

Net Zero Upfront Carbon
A 'Net Zero Upfront Carbon' asset is where the sum of GHG emissions, excluding 'biogenic carbon', from Modules A0-A5 is minimized, which meets local carbon targets or limits (e.g. $kgCO_2e/m^2$), and with additional 'offsets', equals zero.

Net Zero Operational Carbon - Energy
A 'Net Zero Operational Carbon - Energy' asset is one where no fossil fuels are used, all energy use Module B6) has been minimized, meets the local energy use target or limit (e.g. $kWh/m^2/a$) and all energy use is generated on- or off- site using renewables that demonstrate additionality. Direct emissions from renewables and any upstream emissions are 'offset'.

Direct emissions must include CH_4 and N_2O emissions from the combustion of biomass and biodiesel fuels. Upstream emissions include: direct and indirect emissions from energy generation and distribution, WTT emissions for energy consumed in the building and from energy generation and distribution.

Net Zero Operational Carbon - Water
A 'Net Zero Operational Carbon - Water' asset is one where water use (Module B7) is minimized, meets local water targets or limits (e.g. litres/person/year) and where those GHG emissions arising from water supply and wastewater treatment are 'offset'.

Net Zero In-Use Asset
A 'Net Zero In-Use Carbon Asset' is one where on an annual basis the sum total of all asset related GHG emissions, both operational and embodied, (Modules B1-B8) are minimized, which meets local carbon, energy and water targets or limits, and with residual 'offsets', equals zero.

Additionality
Procurement of renewable energy for the asset's use which results in new installed renewable energy capacity that otherwise would not have occurred had the intervention not taken place.

Carbon Neutral
All carbon emissions are balanced with offsets based on carbon removals or avoided emissions.

Absolute Zero Carbon
Eliminating all carbon emissions without the use of credits.

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5.1.3 Reference Terms

ASHP
Air source heat pump: heating and hot water from electrical source. Efficiency described by COP/ SCOP.

COP/ SCOP
(Seasonal) coefficient of performance: rate of conversion of electricity to useful heat energy.

MEV
Mechanical extract ventilation: constant mechanical extraction from 'wet' rooms (bathroom, kitchen, utility, WC, etc.) with fresh air from trickle vents circulated through the building by depressurisation.

MVHR
Mechanical ventilation with heat recovery: ventilation systems that ensure a constant throughput of fresh, filtered air. 'Waste' heat is transferred from outgoing exhaust air to incoming fresh air to pre-warm it and reduce heating demand.

CO_2e Emissions
Equivalent carbon dioxide emissions calculated using the global warming potential (GWP) of exhaust gases.

Form Factor
Expresses the relationship between the treated floor area and area of the thermal envelope. A better form factor signifies a more efficiently designed building.

Thermal Envelope
The insulated components (floors, walls, ceilings) that separate internal and external volumes. Note this often excludes features such as porches and balconies.

Treated Floor Area (TFA)
The floor area of the rooms within the building that are heated. It excludes areas of internal partitions, doors, stairs and unusable spaces.

5.2 Net Zero Policy

5.2.1 UK

The UK is required to achieve Net Zero by 2050 (Climate Change Act as amended 2019), and 78% reductions by 2035 (Climate Change Act as amended 2021) with 68% reductions by 2030 (COP26 Nationally declared contribution).The core Climate Change Act 2008 established an interim emissions reduction target of 34% by 2020: by 2019, before the complexities associated with assessing progress during COVID, UK attributed CO_2e emissions were estimated to have fallen by 40%.

While significant, emission reductions to date have been primarily driven by increased rates of efficiency and a relatively rapid decarbonisation of the electricity generation. To achieve Net Zero by 2050 the built environment - representing approximately 25% of UK emissions - requires the same principles of efficiency and decarbonisation to be urgently implemented.

Emissions in the built environment are primarily targeted by Building Regulations in England and Wales and the Building Warrant process in Scotland.

5.2.2 Wales

Well-being of Future Generations (Wales) Act 2015 recognises that, in order to prevent persistent issues such as poverty, health inequalities and climate change, it is essential to consider the long-term implications of decisions. By planning for future generations it is possible to create a cohesive, prosperous and resilient Wales that is more equitable and healthier, enjoys a vibrant culture in which the Welsh language can thrive and is recognised as globally responsible.

The Environment (Wales) Act 2016 enshrines in law the requirement to reduce net Welsh emissions by 80%of the baseline by 2050 and the requirement to determine interim emissions targets to reflect the success of implemented measures.

In response to the IPCC Special Report on Global Warming of 1.5°C - October 2018, Wales became the first nation to declare a Climate Emergency in April 2019. Accordingly, 2020-2030 is identified as the decade of action with more progress required in these ten years than has been achieved in the last thirty. Estimates show that from 2020, greenhouse gas emissions need to decline by 7.6% every year to 2030 to limit global warming to 1.5°C. Overall, emissions in Wales have fallen by 25% since 1990; however, dramatic reductions are needed this decade with Welsh Government targeting 45% reduction by 2030.

Future Wales: The National Plan 2040 (2021) positions the planning system to deliver a prosperous and fairer Wales by normalising efficient use of resources to achieve sustainable lifestyles. It identifies the need for urgent action on carbon emissions with planning mechanisms geared toward helping Wales lead the way in delivering a competitive, sustainable decarbonised society. Decarbonisation commitments and renewable energy targets are promoted as opportunities to build a more resilient and equitable

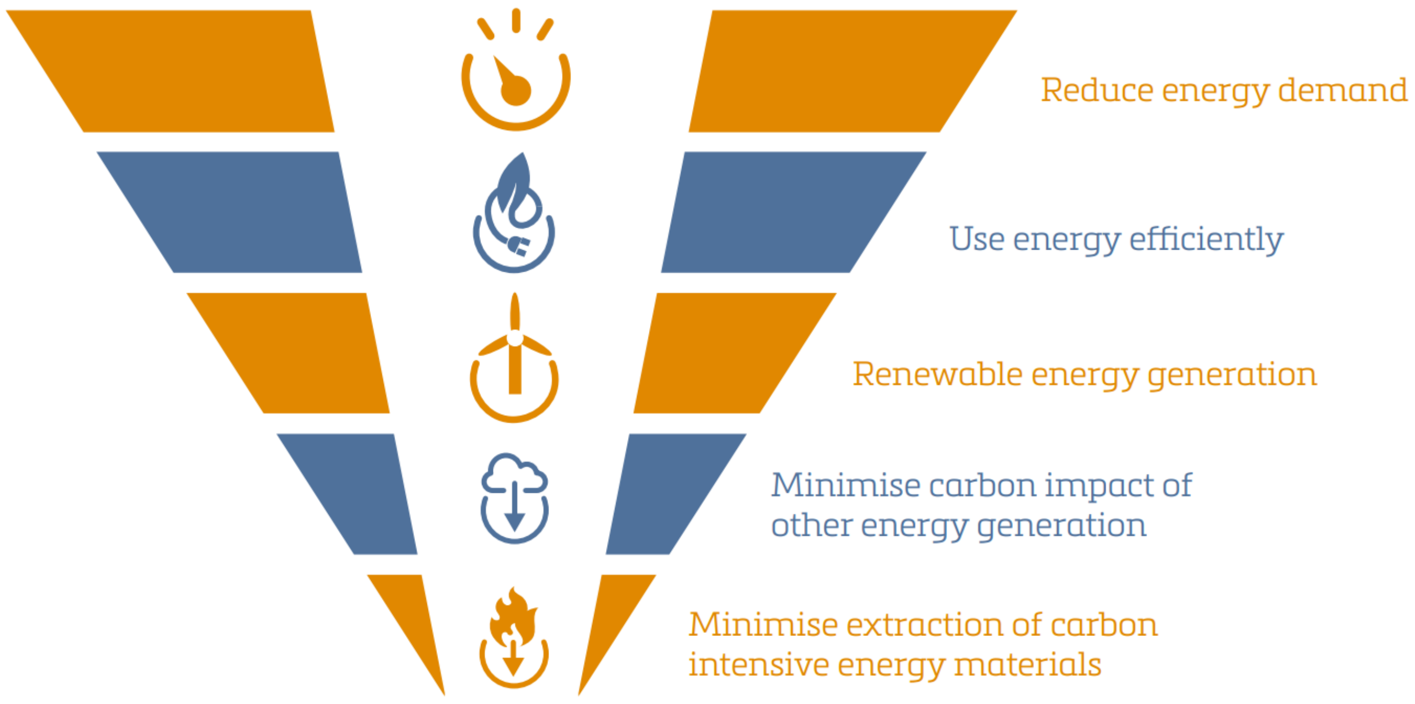

Fig. 02: Energy hierarchy for planning, PPW12 (2024)

low-carbon economy: however, Net Zero targets are not enshrined in any of the 36 policies.

Most national carbon emission reduction strategies and plans, such as Welsh Government's Net Zero Wales Carbon Budget 2 (2021-2025), recognise that new build homes need to be energy efficient with non-fossil fuelled energy sources and systems of operation. Buildings are responsible for almost half of the UK's carbon emissions, half of water consumption and about a quarter of all raw materials used in the economy, therefore reducing the impact of new development through planning policy can contribute towards considerable carbon reductions.

Planning Policy Wales Edition 12 (2024) incorporates 'The Energy Hierarchy for Planning' (above) as a direct response to this analysis, mandating the reduction of energy demand as the highest priority. This clearly outlines Welsh Government's target of securing zero carbon buildings and the responsibility of the planning system to support development with high energy performance that supports decarbonisation, tackles the causes of the climate emergency and adapts to current and future effects of climate change.

For local and regional authorities, PPW12 suggests adopting an active leadership role with established visions for decarbonisation. It also suggests Major Developments require an Energy Report to outline how policy objectives could be successfully achieved. While recommending the impacts of operational and embodied carbon emissions are considered, policy currently leaves the assessment metrics and methodologies at the discretion of local authorities.

Approved Document L (Wales) Volume 1 - Dwellings and 2 - Buildings other than dwellings - Conservation of fuel and power 2022 align with policy objectives of reducing emissions, mandating reductions of 31% for dwellings and 27% for non-domestic builds. Consultation documents for the 2025 Building Regulations suggest a 75% reduction in operational carbon emissions beyond 2014 standards: at present there are no details on whether embodied carbon will be assessed or regulated.

5.2.3 Local - Adopted

Since the IPCC Special Report on Global Warming of 1.5°C - October 2018, over 300 local authorities throughout England and Wales have declared a climate emergency. Many are in the process of developing new policies to reduce carbon emissions, mitigate the impacts of anthropogenic climate change and build resilience into their communities.

While carbon reduction targets have been in place for years at a national level - primarily applied through Building Regulations and assessed via SAP methodology - it is only very recently that local authorities have adopted policies to explicitly target decarbonisation. This reflects an evolving understanding of the severity and urgency of the climate crisis and perceived inaction by government and uncertainty in satisfactorily addressing the issue.

Despite the clear wording of the Planning and Energy Act 2008, local authorities had previously been reluctant to implement energy performance targets with the perceived cause being a Written Ministerial Statement dating from 2015 that thwarted West Oxfordshire's attempt to mandate performance standards at Salt Cross Garden Village.

A Ministerial letter of confirmation in 2021 clarified:

" Local planning authorities have the power to set local energy efficiency standards through the Planning and Energy Act 2008. In January 2021, [the government] clarified in the Future Homes Standard consultation response that in the immediate term [the government] will not amend the Planning and Energy Act 2008, which means that local authorities still retain these powers."

The National Model Design Code (2021) now requires local authorities to outline Net Zero targets within emerging design code and design guides.

A December 2023 Ministerial statement declared:

" The improvement in standards already in force, alongside the ones which are due in 2025, demonstrates the Government's commitment to ensuring new properties have a much lower impact on the environment in the future. In this context, the Government does not expect plan-makers to set local energy efficiency standards for buildings that go beyond current or planned buildings regulations. The proliferation of multiple, local standards by local authority area can add further costs to building new homes by adding complexity and undermining economies of scale. Any planning policies that propose local energy efficiency standards for buildings that go beyond current or planned buildings regulation should be rejected at examination if they do not have a well-reasoned and robustly costed rationale that ensures:

- *That development remains viable, and the impact on housing supply and affordability is considered in accordance with the National Planning Policy Framework.*
- *The additional requirement is expressed as a percentage uplift of a dwelling's Target Emissions Rate (TER) calculated using a specified version of the Standard Assessment Procedure (SAP).*

Where plan policies go beyond current or planned building regulations, those polices should be applied flexibly to decisions on planning applications and appeals where the applicant can demonstrate that meeting the higher standards is not technically feasible, in relation to the availability of appropriate local energy infrastructure (for example adequate existing and planned grid connections) and access to adequate supply chains."

This is being challenged in court by the local authorities who have adopted and progressed policies.

Local authorities have taken different approaches to implementing Net Zero policies. The following have, within their adopted Local Development Plans or Supplementary Planning Documents/ Guidance, been identified as incorporating Net Zero emission targets and/ or mandated targets for operational and embodied energy/ emissions substantially beyond basic levels of compliance with building control.

Local Authority	Policy Document	Date
Bath and North East Somerset	Core Strategy and Placemaking Plan incorporating the Local Plan Partial Update	2023 (Jan.)
Central Lincolnshire	Local Plan	2023 (Apr.)
Cornwall Council	Climate Emergency Development Plan Document	2023 (Feb.)
Lake District National Park	Design Code: Sustainable Design SPD	2023 (Sep.)

The table below summarises the adopted policies.

Local Authority	Operational Emissions	Embodied Emissions
Bath and North East Somerset	SCR6: Sustainable Construction Policy for New Build Residential Development	SCR8: Embodied Carbon
	SCR7: Sustainable Construction Policy for New Build Non-Residential Buildings	
Central Lincolnshire	S7: Reducing Energy Consumption – Residential Development	S11: Embodied Carbon
	S8: Reducing Energy Consumption – Non-Residential Development	
Cornwall Council	SEC1: Sustainable Energy and Construction	N/A
Lake District National Park	Code 2.99: Sustainable Design, Embodied Energy and Construction	

5.2.4 Local - Emerging

The following tabulates the proposed policies by local authorities within emerging plans that incorporate Net Zero emission targets or mandated operational and embodied energy/ emissions thresholds substantially beyond nationally mandated standards.

Local Authority	Operational Emissions	Embodied Emissions
Bristol	NZC1: Climate Change, Sustainable Design and Construction	
	NZC2: Net Zero Carbon Development – Operational Carbon	NZC3: Embodied Carbon, Materials and Waste
Enfield	SE4: Reducing Energy Demand	SE3: Whole-life Carbon and Circular Economy
	SE5: Greenhouse Gas Emissions and Low Carbon Energy Supply	
Essex*	NZ1: Net Zero Carbon Development (in Operation)	NZ2: Net Zero Carbon Development – Embodied Carbon
Merton	CC2.2 Minimising Greenhouse Gas Emissions	CC2.5 Minimising Waste and Promoting a Circular Economy
	CC2.3 Minimising Energy Use	
Newham	CE2: Zero Carbon Development	CE3: Embodied Carbon
North Somerset	DP6: Net zero construction	
Oxford	R1: Net Zero Buildings in Operation	R2: Embodied Carbon in the Construction Process
Warwick	NZC1: Achieving Net Zero Carbon Development	NZC3: Embodied Carbon
	NZC2(A): Making Buildings Energy Efficient	
	NZC2(B): Zero or low Carbon Energy Sources and Zero Carbon Ready Technology	
	NZC2(3): Carbon Offsetting	
Wiltshire	Policy 85: Sustainable Construction and Low Carbon Energy	Policy 87: Embodied Carbon

Essex County Council are centrally developing policy for adoption by the individual district, borough and city councils to ensure consistency throughout the county.

5.3 Building Typologies

5.3.1 Residential

Refer to drawings:

2740-211(02)100 - HT 211 Notional Site Layout
2740-211(02)101 - HT 211 Notional Street Elevation
2740-211(02)200 - HT 211 GF Plan
2740-211(02)201 - HT 211 1F Plan
2740-211(02)202 - HT 211 2F Plan
2740-211(02)300 - HT 211 Elevations
2740-211(02)301 - HT 211 Elevations

2740-421(02)100 - HT 421 Notional Site Layout
2740-421(02)200 - HT 421 Floor Plans
2740-421(02)300 - HT 421 Elevations

2740-621(02)100 - HT 641 Notional Site Layout
2740-621(02)200 - HT 641 Floor Plans
2740-621(02)300 - HT 641 Elevations

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Urban Design

Appendix 3: Presentation to Net Zero Buildings Stakeholder Engagement Session

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Vale of Glamorgan Council

Net Zero Carbon Buildings
Feasibility Study & Cost Assessment

Developer Engagement Workshop

JB Sustainable Building Consultancy

RPA

VALE of GLAMORGAN
BRO MORGANNWG

Architecture
Low Energy Consultancy
Civil Engineering
Structural Engineering
Urban Design

1

1. Introduction

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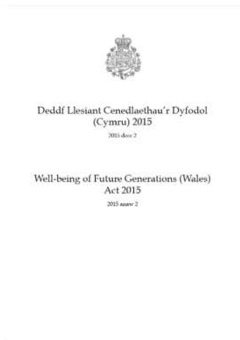
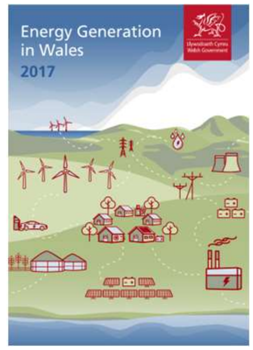
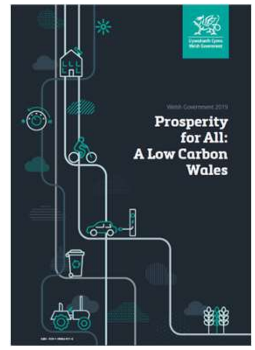
2







"A society in which people's **physical and mental well-being is maximised** and in which choices and behaviours that benefit future health are understood."

29 The 2050 emissions target

"**(1)** The Welsh Ministers must ensure that the net Welsh emissions account for the year 2050 is at least 100% lower than the baseline."

"The Welsh Government has set a target of generating 70% of Wales' electricity consumption from renewable sources by 2030."

"Our **highest priority is to reduce demand** wherever possible and affordable"

"Opportunities include: Buildings - new products and **delivery models** for **low carbon new-builds** and retrofitting"

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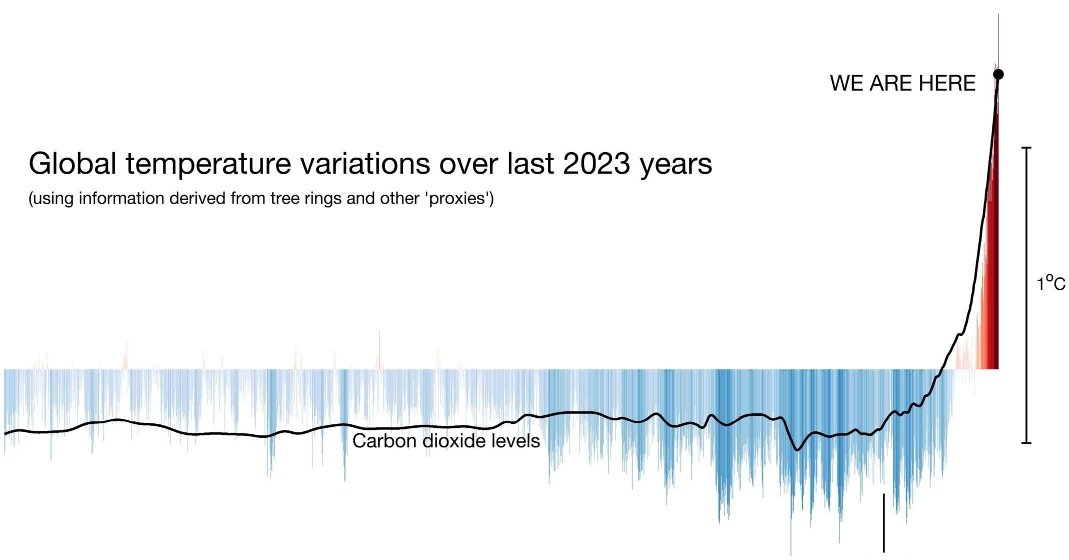
3

Global temperature variations over last 2023 years

(using information derived from tree rings and other 'proxies')



Graphic: @ed_hawkins
Data: PAGES2k (years 1-2000) and HadCRUT5.0 (2001-2023)
Reference period: 1901-2000

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Global temperature variations & CO_2 levels over last 2023 years
Diagram property of Professor Ed Hawkins, University of Reading

4

Llywodraeth Cymru Welsh Government

Cymraeg

Home > Announcements > All announcements > Written statement: Welsh Government declares Climate Emergency

CABINET STATEMENT

Written statement: Welsh Government declares Climate Emergency

Lesley Griffiths, Minister for Environment, Energy and Rural Affairs

First published: 30 April 2019

Last updated: 30 April 2019

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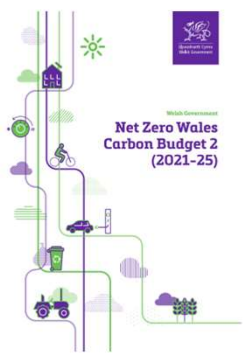
5

A Wales where people live in places which are decarbonised and climate resilient

"The challenges of the climate emergency demand urgent action on carbon emissions and the planning system must help Wales lead the way in promoting and delivering a competitive, sustainable decarbonised society. **Decarbonisation commitments and renewable energy targets will be treated as opportunities to build a more resilient and equitable low-carbon economy,** develop clean and efficient transport infrastructure, improve public health and **generate skilled jobs in new sectors**."



Building sector ambition statement

"By 2025 **all new affordable homes in Wales will be built to net zero carbon**, and our ambition is that our **net zero standards are adopted by developers of all new homes regardless of tenure** by this date."

"Ensure our **planning policies** […] work to adapt to and mitigate the effects of climate change […]

- **Work with developers to develop zero carbon buildings.**
- **Create more energy efficient buildings through planning policy.**"

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6

2. Net Zero Carbon Buildings

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7

Project Team

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Passivhaus Designer

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Tudor Butler
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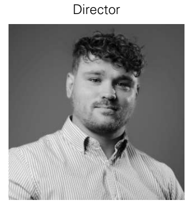
Christopher Lewis
Project Architect

Bethan Griffiths
Architectural Assistant

JB Sustainable Building Consultancy



Thomas Griffiths
Graduate Surveyor

RPA

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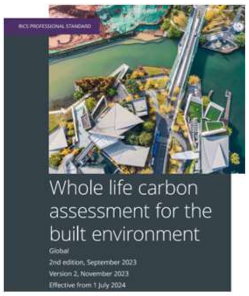
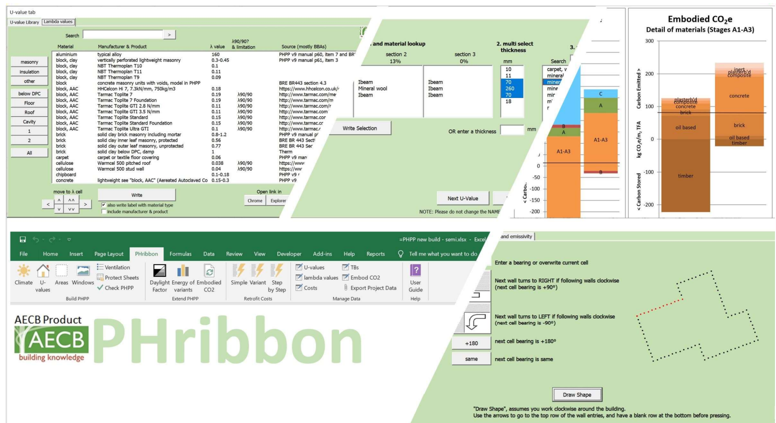
8

Methodology



5.3.1 Energy modelling for buildings

"In the UK, the **results of Part L 2021 calculations must not be used under any circumstances**, as they are not a prediction of energy consumption."



Net greenhouse gas emissions including carbon budgets, National Grid Future Energy Scenarios 2023

Building life cycle stages and information modules with additions to illustrate sequestered biogenic carbon, RICS Whole life carbon assessment for the built environment 2nd edition 2023

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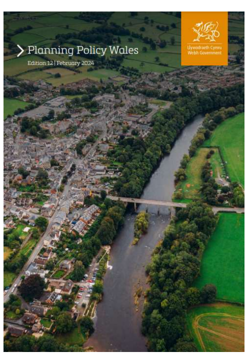
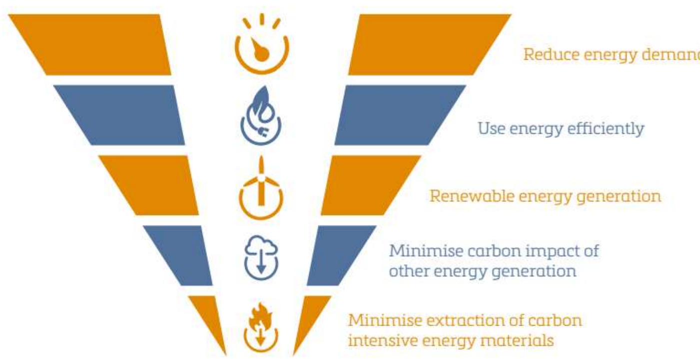
Energy Hierarchy for Planning





"The Welsh Government's **highest priority is to reduce demand** wherever possible and affordable."

"**Reducing energy demand** and increasing energy efficiency, through the location and design of new development, will assist in meeting energy demand with renewable and low carbon sources"

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10

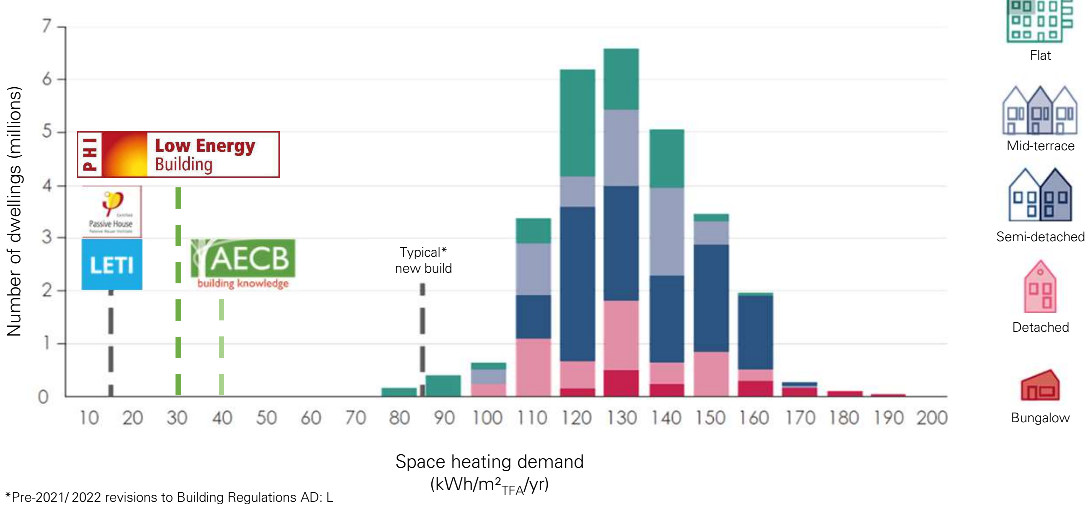
Heating demand = Amount of energy required to heat a space annually

energy / area (TFA) / annum

kWh / m^2_{TFA} / yr

11

Energy Performance of UK Housing Stock



*Pre-2021/ 2022 revisions to Building Regulations AD: L

Diagram demonstrating heating demand of UK's housing stock by typology
LETI, Climate Emergency Retrofit Guide (2021)

12

Energy use intensity (EUI) = All energy consumed by a building annually*

energy / area (GIA) / annum

kWh / m^2_{GIA} / yr

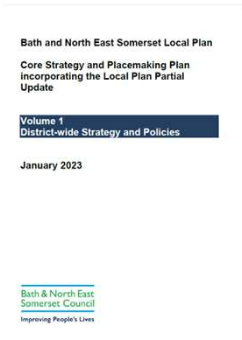
* *excludes EV charging*

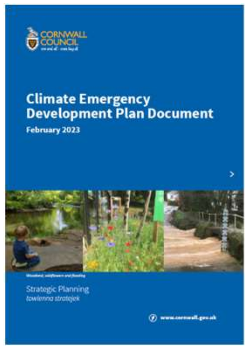
13

Net Zero (operational) = Balancing annual consumption with on-site generation

14

Local Policy - Adopted





SCR6: Sustainable Construction Policy for New Build Residential Development

SCR7: Sustainable Construction Policy for New Build Non-Residential Buildings

SCR8: Embodied Carbon

S7: Reducing Energy Consumption - Residential Development

S8: Reducing Energy Consumption - Non-Residential Development

S11: Embodied Carbon

SEC1: Sustainable Energy and Construction

Code 2.99: Sustainable Design, Embodied Energy and Construction

15

Local Policy - Emerging

16

3. Residential Typologies

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Residential Typologies

Operational emission scenarios		
Reference	Space heating demand	Energy use intensity
AD: L (Wales) 2025	N/A	N/A
AECB CarbonLite	40 kWh/m²/yr	75 kWh/m²/yr
B&NES	30 kWh/m²/yr	40 kWh/m²/yr
LETI	15 kWh/m²/yr	40 kWh/m²/yr

Embodied emission scenarios	
Reference	Construction
Masonry	Masonry with PIR
Framed	140mm Stud with Mineral Wool & PIR
Timber	140mm Stud with Woodfibre
Timber Optimised	Twin Stud with Cellulose

HT 641
1 unit

HT 421
2 units

HT 211
9 units

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Residential Typologies - Operational Specifications

Operational	AD: L (Wales) 2025	AECB CarbonLite	B&NES	LETI
Building Fabric				
Ground floor	0.110 W/m²K	0.110 W/m²K	0.110 W/m²K	0.110 W/m²K
External wall	0.130 W/m²K	0.130 W/m²K	0.130 W/m²K	0.130 W/m²K
Roof	0.110 W/m²K	0.110 W/m²K	0.110 W/m²K	0.110 W/m²K
Air permeability	5.00 m³/m²/hr	1.50 m³/m²/hr	1.05 m³/m²/hr	0.50 m³/m²/hr
Thermal bridges	0.200 W/mK	0.100 W/mK	0.050 W/mK	-0.050 W/mK
Doors & Windows				
Frames U_f	1.400 W/m²K	0.850 W/m²K	0.810 W/m²K	0.810 W/m²K
Installation TB	0.040 W/mK	0.040 W/mK	0.040 W/mK	0.023 W/mK
Glazing U_g	1.120 W/m²K DG	1.120 W/m²K DG	0.550 W/m²K TG	0.550 W/m²K TG
Glazing g-value	0.64	0.64	0.63	0.63
Glazing edge	0.040 W/mK	0.025 W/mK	0.025 W/mK	0.025 W/mK
Ventilation Strategy				
Ventilation rate	30m³ per person/ hr	30m³ per person/ hr	30m³ per person/ hr	30m³ per person/ hr
Ventilation unit	MEV	MVHR energiSava 300	MVHR energiSava 300	Zehnder ComfoAir 225
HR efficiency	N/A (extract only)	84%	84%	92%
Heating				
ASHP	Generic	Vaillant aroTHERM	Vaillant aroTHERM	Vaillant aroTHERM
SCOP	3.30	4.10	4.10	4.10
Refrigerant / GWP	R290 / 3.3	R290 / 3.3	R290 / 3.3	R290 / 3.3

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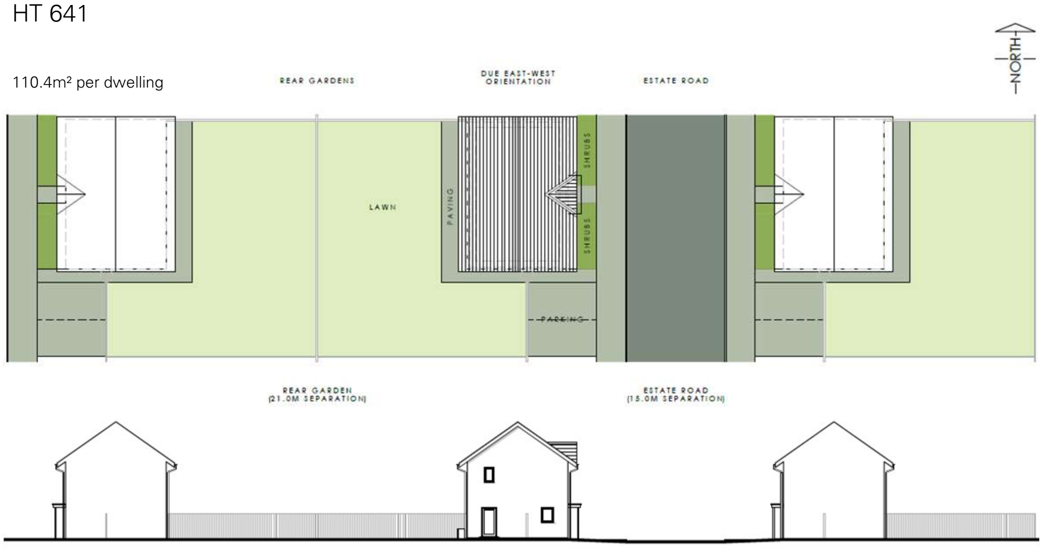
Residential Typologies - Embodied Specifications

Embodied	Masonry	Framed	Timber	Timber Optimised
Foundations				
	Trench fill	Trench fill	N/A	Trench fill
Ground Floor				
	Screed, PIR, slab on grade	Screed, XPS, beam & block	Raft on Jackon XPS formwork	Steico joist w/ Warmcel
External Walls				
Brickwork finish externally	Plasterboard on dabs, masonry cavity w/ PIR	Plasterboard w/ service zone, PIR, SMARTPLY OSB, 140mm timber stud w/ ISOVER	Plasterboard w/ service zone, SMARTPLY OSB, 140mm stud w/ woodfibre	Plasterboard w/ service zone, SMARTPLY OSB, 292mm twin stud w/ Warmcel
Party Walls				
All to Robust Details	Wet plaster, blockwork, ROCKWOOL filled cavity, blockwork, wet plaster	Plasterboard, stud w/ ISOVER, SMARTPLY OSB, cavity w/ ISOVER, stud w/ ISOVER, plasterboard	Plasterboard, SMARTPLY OSB, stud w/ Warmcel, cavity w/ Warmcel, stud w/ Warmcel, SMARTPLY OSB, plasterboard	Plasterboard, SMARTPLY OSB, timber w/ Warmcel, cavity w/ Warmcel, timber w/ Warmcel, SMARTPLY OSB, plasterboard
Internal Walls				
	Wet plaster, blockwork, wet plaster	Plasterboard, stud w/ ISOVER, plasterboard	Plasterboard, stud w/ woodfibre, plasterboard	Plasterboard, stud w/ Warmcel, plasterboard
Intermediate Floor				
	Chipboard, Posi-joist w/ ROCKWOOL, plasterboard	Chipboard, Posi-joist w/ ROCKWOOL, plasterboard	Chipboard, Posi-joist w/ woodfibre, plasterboard	Chipboard, Posi-joist w/ Warmcel, plasterboard
Separating Floor				
All to Robust Details	Screed, resilient layer, beam & block, suspended ceiling w/ ROCKWOOL & plasterboard	Screedboard, OSB deck, resilient layer, Posi-joist w/ ROCKWOOL, resilient bar w/ plasterboard, suspended ceiling w/ plasterboard	Screedboard, OSB deck, resilient layer, Posi-joist w/ ROCKWOOL, resilient bar w/ plasterboard, suspended ceiling w/ plasterboard	Screedboard, OSB deck, resilient layer, Posi-joist w/ ROCKWOOL, resilient bar w/ plasterboard, suspended ceiling w/ plasterboard
Roof				
	Plasterboard, polythene VCL, ROCKWOOL, concrete tiles	Plasterboard, polythene VCL, EARTHWOOL, clay tiles	Plasterboard, SMARTPLY OSB, hemp insulation, Spanish slate	Plasterboard, SMARTPLY OSB, Warmcel, Welsh slate

20

HT 641

110.4m² per dwelling



Notional Site Layout & Street Scene

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21

HT 641

Ground & First Floor Plans

Elevations

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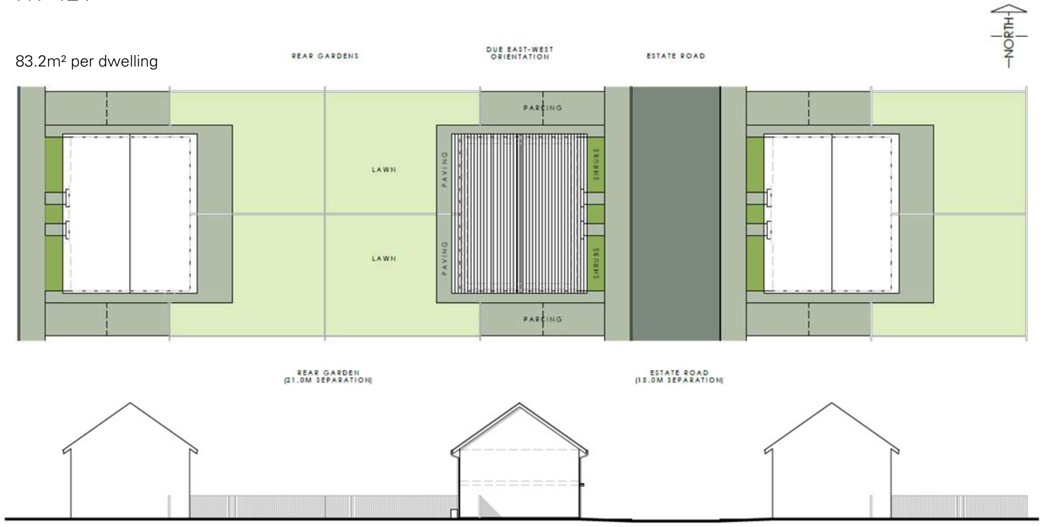
22

HT 421

83.2m² per dwelling



Notional Site Layout & Street Scene

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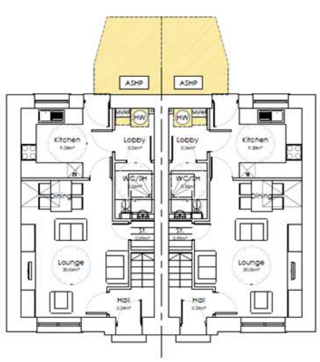
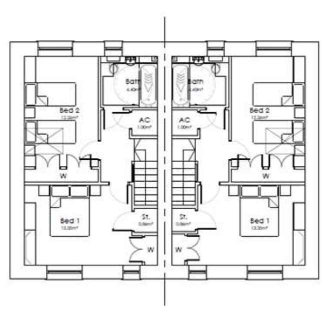
HT 421



Ground Floor Plan



First Floor Plan

Front & Rear Elevations

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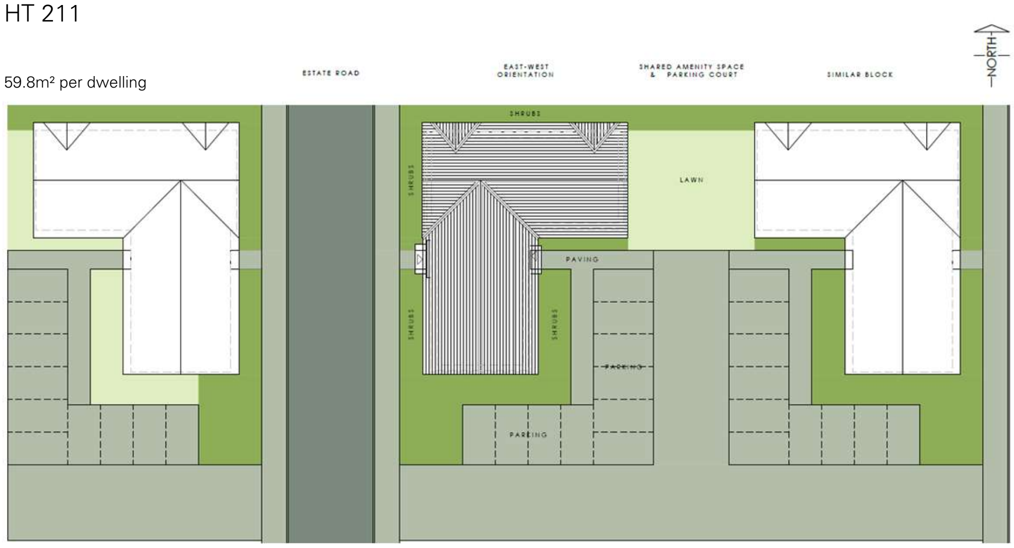
24

HT 211

59.8m² per dwelling



Notional Site Layout

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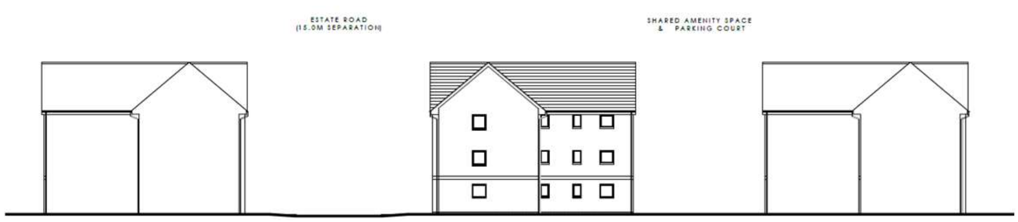
HT 211



Notional Street Scene

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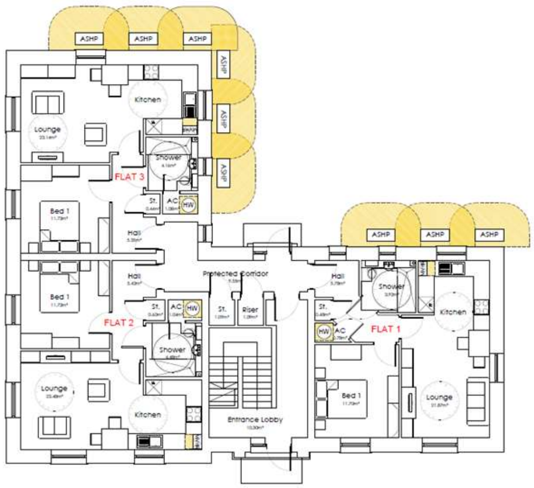
26

HT 211



Ground Floor Plan

First & Second Floor Plans

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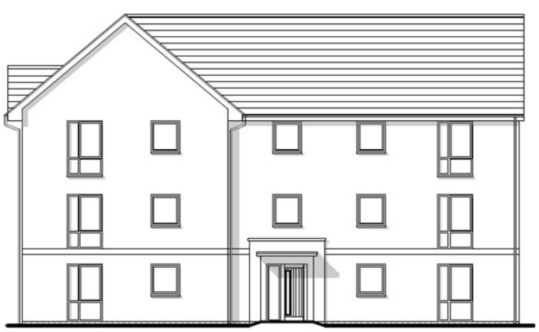
HT 211



West Elevation

North Elevation

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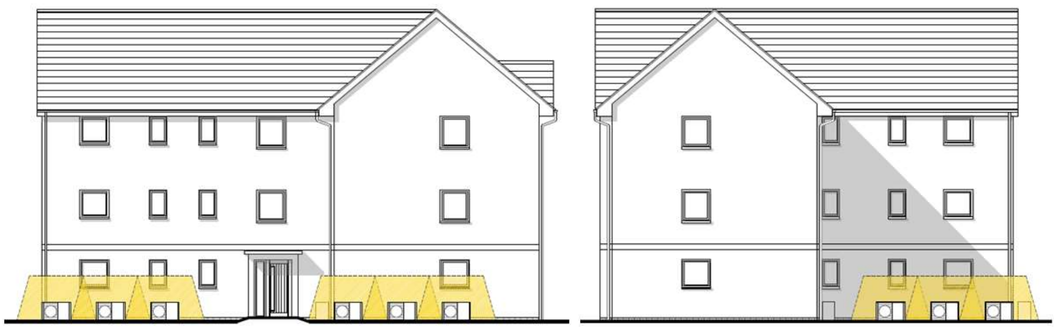
HT 211



East Elevation

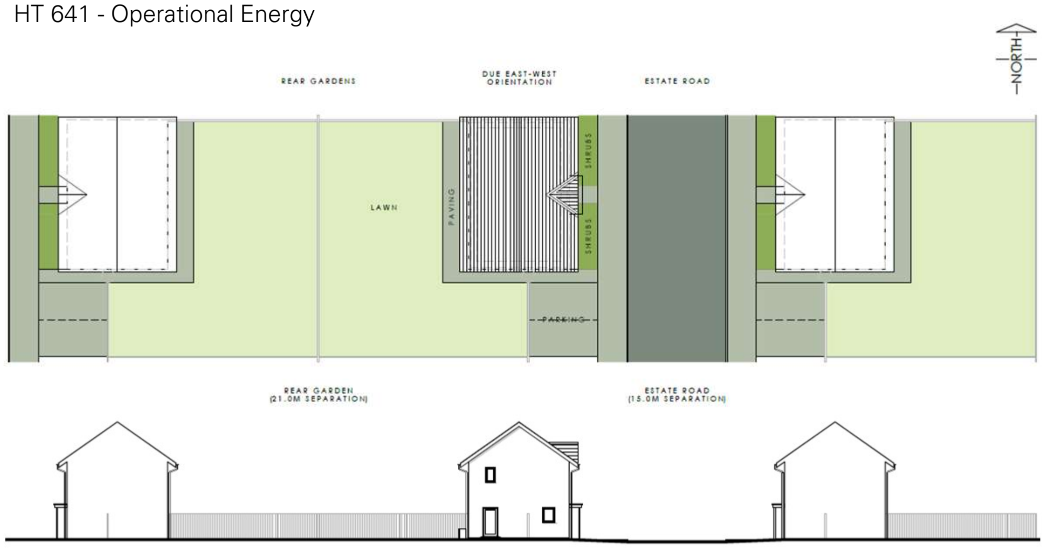
South Elevation

29

4. Operational Energy

30

HT 641 - Operational Energy



Notional Site Layout & Street Scene

spring design

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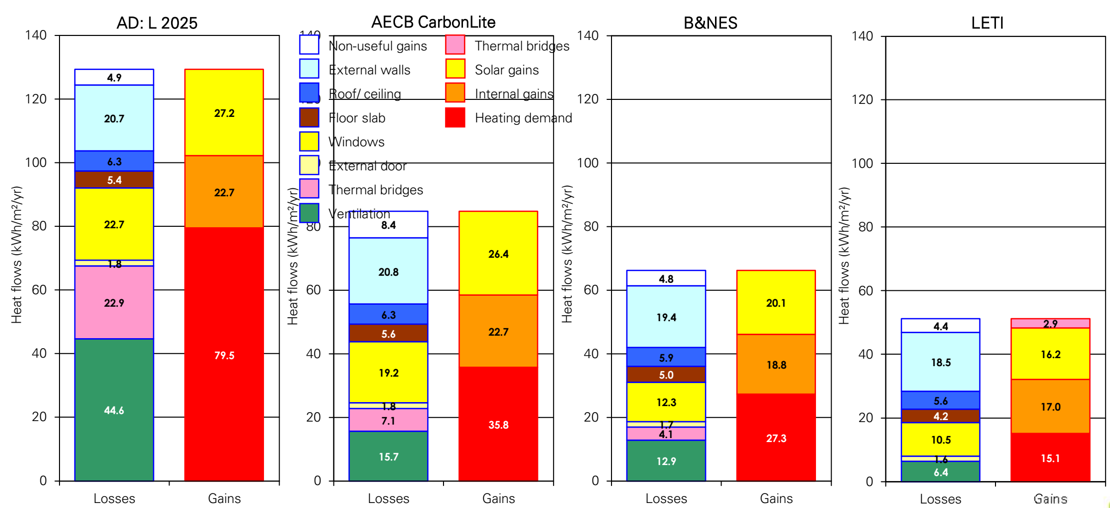
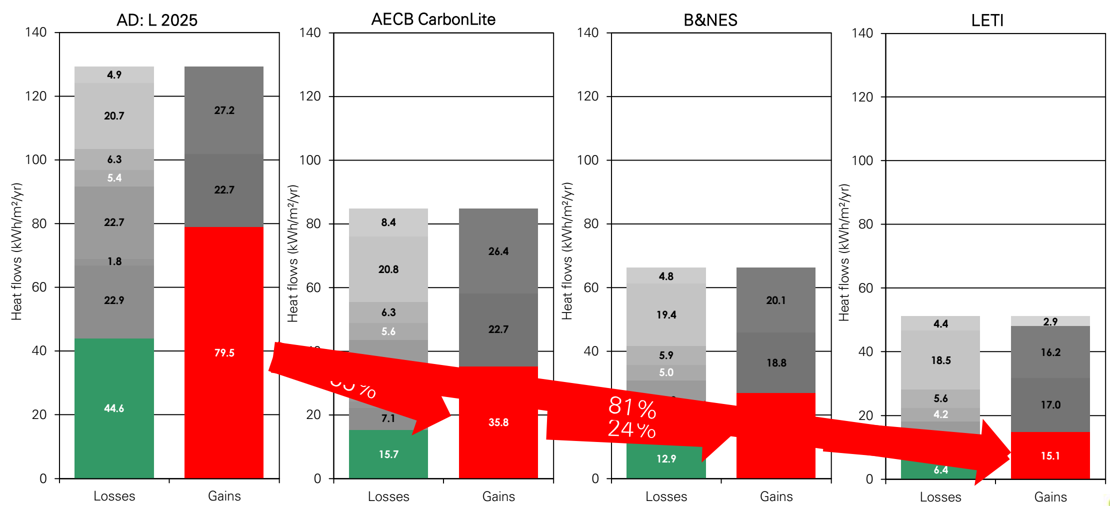
HT 641 - Operational Energy



spring design

32

HT 641 - Operational Energy



33

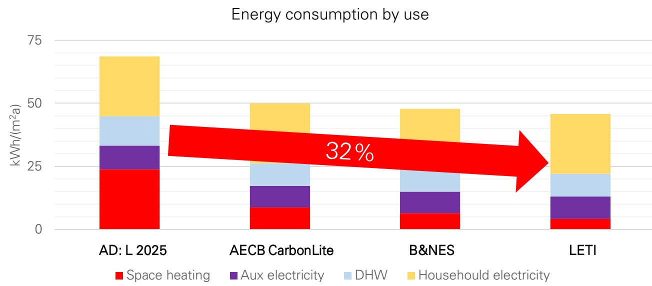
HT 641 - Operational Energy

Operational outputs					
Operational scenarios	Space heating demand	Energy use intensity (EUI)	Annual energy use per dwelling	CO_2e emissions ex. PV (60 yrs)	kWp of PV to Net Zero per dwelling
1 AD: L (Wales) 2025	79.5 kWh/m²/yr	65.6 kWh/m²/yr	7,242 kWh	27.20 tonnes	10.0 kWp
2 AECB CarbonLite	35.8 kWh/m²/yr	48.4 kWh/m²/yr	5,343 kWh	20.10 tonnes	7.4 kWp
3 B&NES	27.3 kWh/m²/yr	46.3 kWh/m²/yr	5,112 kWh	19.20 tonnes	7.0 kWp
4 LETI	15.1 kWh/m²/yr	44.5 kWh/m²/yr	4,913 kWh	18.50 tonnes	6.8 kWp

32%

34

HT 641 - Operational Energy



AD L (Wales) 2025 upgrade to LETI						
Building Element			B&NES		LETI	
Fabric	Double glazing to triple glazing	additional cost	+	£623.63	+	£623.63
	ASHP reducing in size	cost saving	-	£6,000.00	-	£6,000.00
	MVHR addition	additional cost	+	£4,000.00	+	£4,000.00
	MEV omission	cost saving	-	£900.00	-	£900.00
Generation	PV array decreasing in size	cost saving	-	£1,200.00	-	£1,200.00
TOTAL			-	**£3,476.37**	-	**£3,476.37**
Cost per unit			-	£3,476.37	-	£3,476.37
Cost per m² of GIA			-	£31.49	-	£31.49

Projected annual electricity bills

- AD:L (Wales) 2025 £1,774.29
- AECB CarbonLite £1,309.04
- B&NES £1,252.44
- LETI £1,203.69

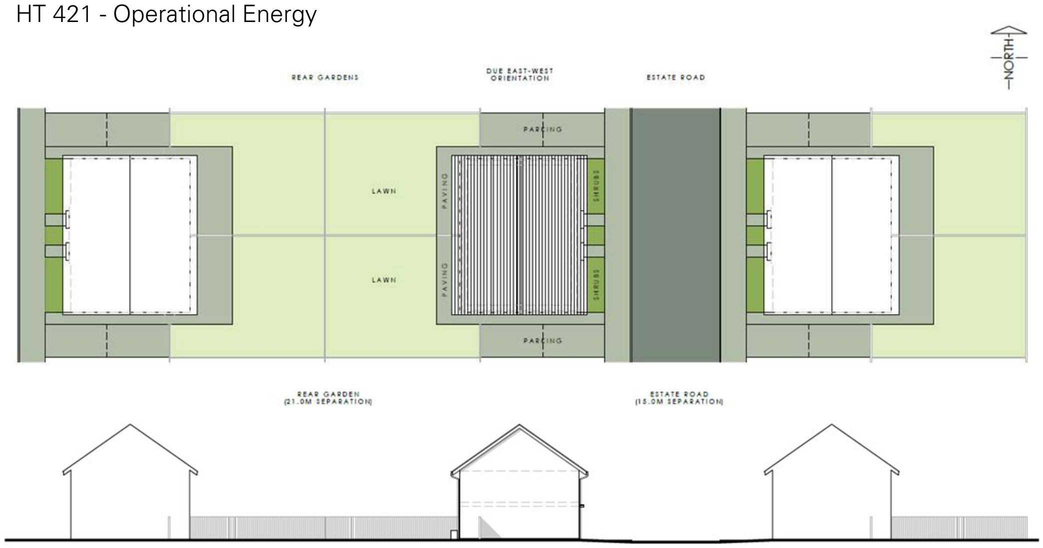
excludes standing charge & PV offsets

Headlines

- EUI & CO_2e reductions of 32% in upgrading **AD: L (Wales) 2025** to **LETI**
- ASHP reduce from 7 kW to 3.5 kW due to reduced space heating demand
- PV provision reduces 32%to achieve Net Zero with reduced EUI
- PV provisions for **AD: L (Wales) 2025** do not fit on a single roof slope

35

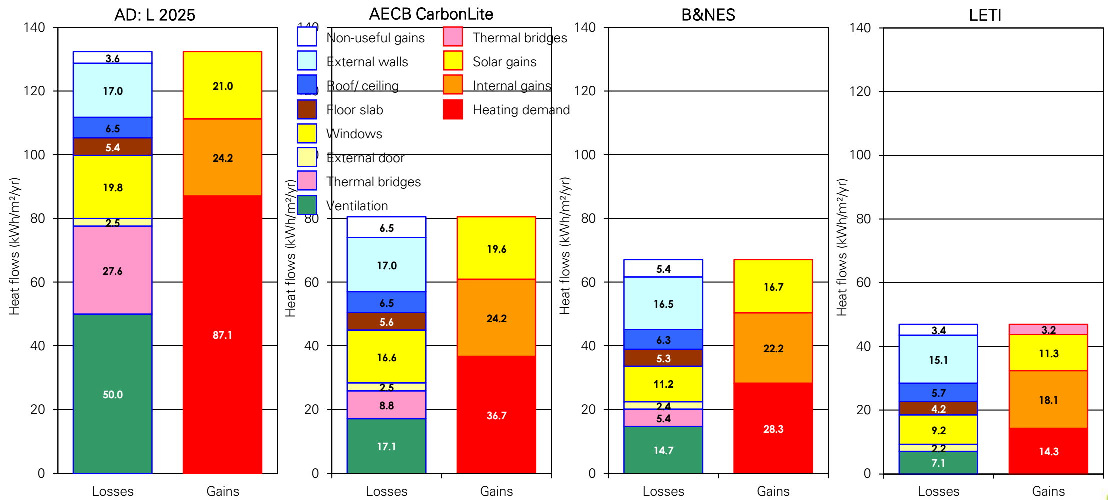
HT 421 - Operational Energy



Notional Site Layout & Street Scene

36

HT 421 - Operational Energy



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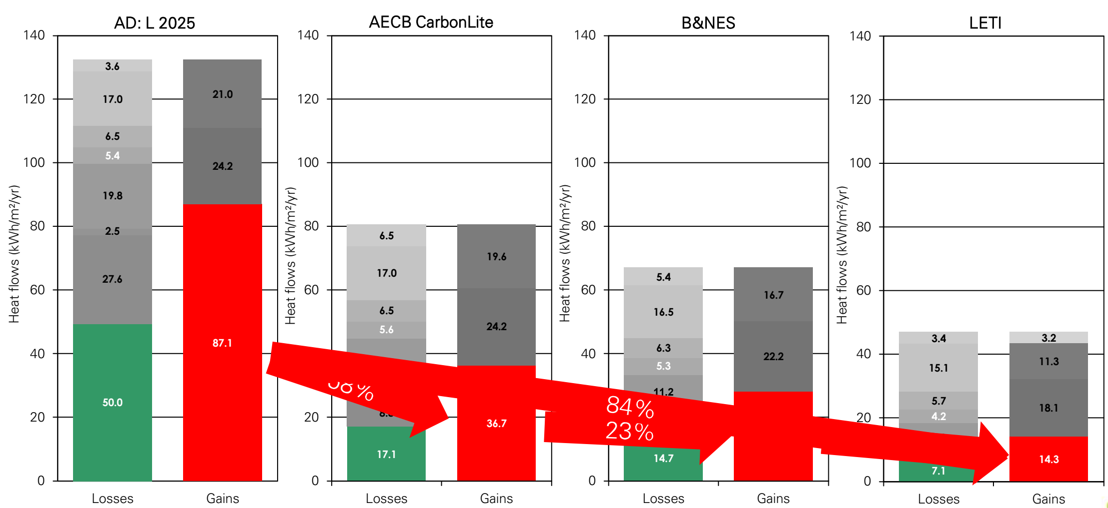
HT 421 - Operational Energy



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HT 421 - Operational Energy

Operational outputs					
Operational scenarios	Space heating demand	Energy use intensity (EUI)	Annual energy use per dwelling	CO_2e emissions ex. PV (60 yrs)	kWp of PV to Net Zero per dwelling
1 AD: L (Wales) 2025	87.1 kWh/m²/yr	62.5 kWh/m²/yr	5,200 kWh	19.75 tonnes	7.6 kWp
2 AECB CarbonLite	36.7 kWh/m²/yr	43.8 kWh/m²/yr	3.644 kWh	13.95 tonnes	5.4 kWp
3 B&NES	28.3 kWh/m²/yr	41.8 kWh/m²/yr	3,478 kWh	13.30 tonnes	5.0 kWp
4 LETI	14.3 kWh/m²/yr	40.0 kWh/m²/yr	3,328 kWh	12.75 tonnes	4.8 kWp

37%

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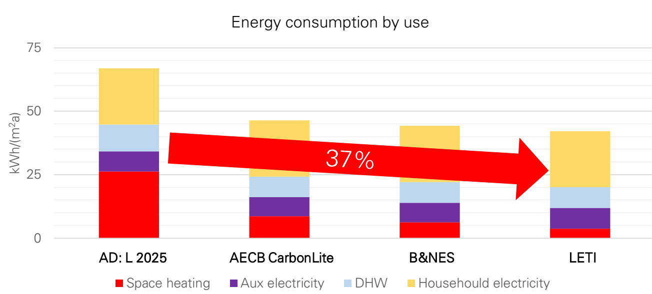
HT 421 - Operational Energy



AD L (Wales) 2025 upgrade to LETI						
Building Element				B&NES		LETI
Fabric	Double glazing to triple glazing	additional cost	+	£991.76	+	£991.76
	ASHP reducing in size	cost saving	-	£8,000.00	-	£8,000.00
	MVHR addition	additional cost	+	£7,000.00	+	£7,000.00
	MEV omission	cost saving	-	£1,800.00	-	£1,800.00
Generation	PV array decreasing in size	cost saving	-	£1,200.00	-	£1,600.00
TOTAL			-	**£3,008.24**	-	**£3,408.24**
Cost per unit			-	£1,504.12	-	£1,704.12
Cost per m² of GIA			-	£18.08	-	£20.48

Projected annual electricity bills

- AD:L (Wales) 2025 £1,274.00
- AECB CarbonLite £892.78
- B&NES £852.11
- LETI £815.36

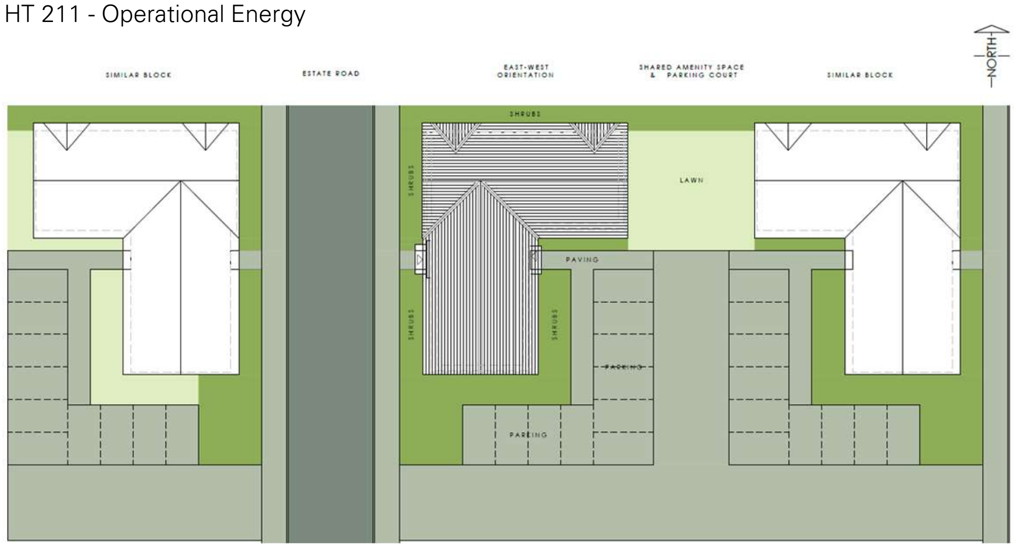
excludes standing charge & PV offsets

Headlines

- EUI & CO_2e reductions of 37% in upgrading **AD: L (Wales) 2025** to **LETI**
- ASHP reduce from 5 kW to 3.5 kW due to reduced space heating demand
- PV provision reduces 37%to achieve Net Zero with reduced EUI
- PV provisions for **AD: L (Wales) 2025** do not fit on a single roof slope

40

HT 211 - Operational Energy



Notional Site Layout

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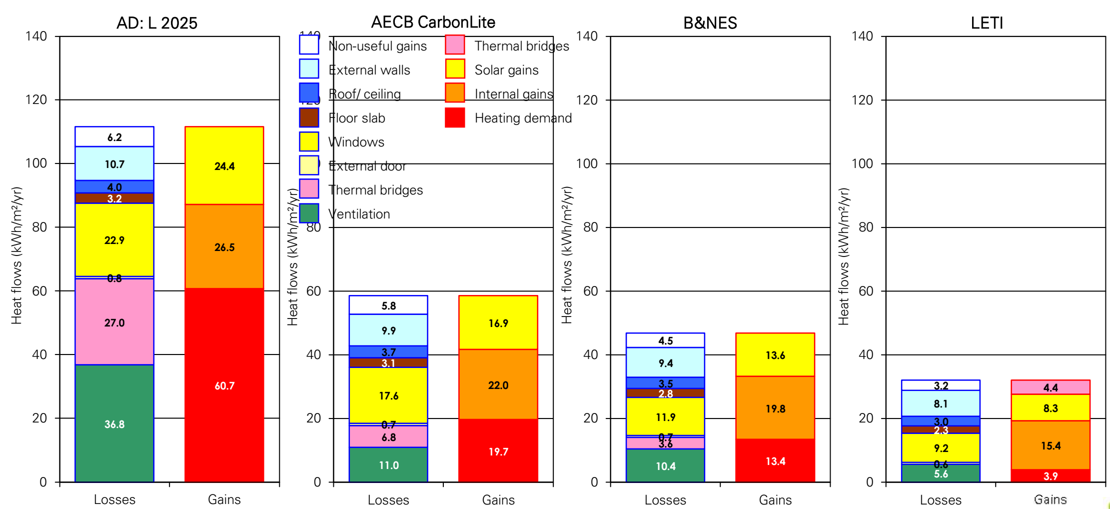
HT 211 - Operational Energy



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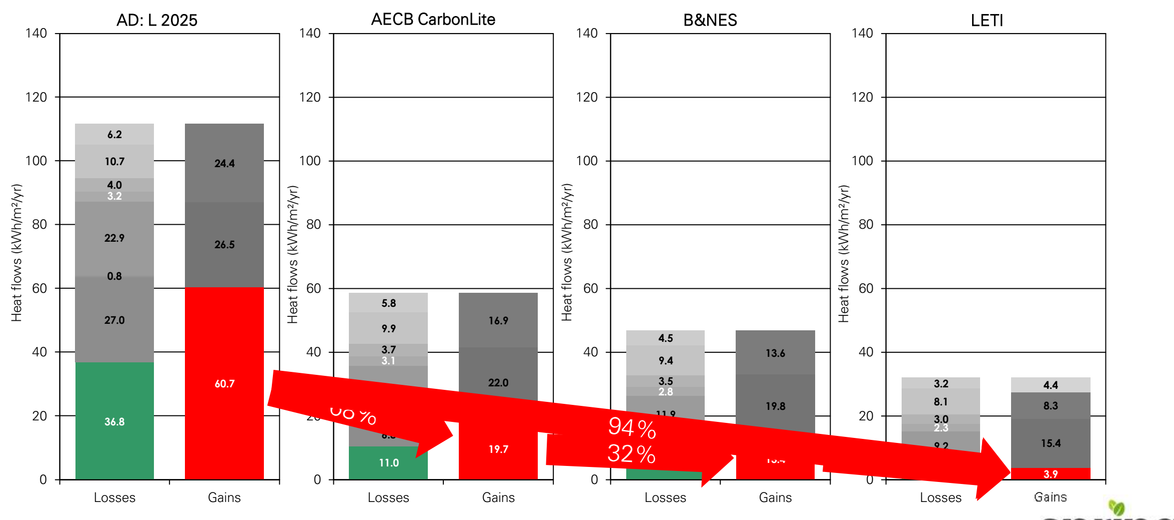
HT 211 - Operational Energy



spring design

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HT 211 - Operational Energy

Operational outputs					
Operational scenarios	Space heating demand	Energy use intensity (EUI)	Annual energy use per dwelling	CO_2e emissions ex. PV (60 yrs)	kWp of PV to Net Zero per dwelling
1 AD: L (Wales) 2025	60.7 kWh/m²/yr	44.9 kWh/m²/yr	2,686 kWh/yr	10.10 tonnes	4.0 kWp
2 AECB CarbonLite	19.7 kWh/m²/yr	37.5 kWh/m²/yr	2,244 kWh/yr	8.53 tonnes	2.9 kWp
3 B&NES	13.4 kWh/m²/yr	33.0 kWh/m²/yr	1,974 kWh/yr	7.49 tonnes	2.5 kWp
4 LETI	3.9 kWh/m²/yr	28.5 kWh/m²/yr	1,705 kWh	6.44 tonnes	2.4 kWp

27%

spring design

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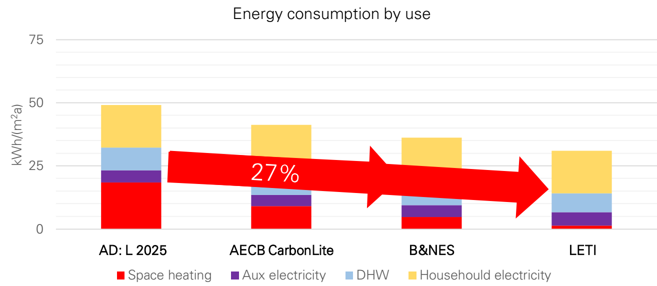
HT 211 - Operational Energy



AD L (Wales) 2025 upgrade to LETI				
Building Element			B&NES	LETI
Fabric	Double glazing to triple glazing	additional cost	+ £3,374.96	+ £3,374.96
	ASHP reducing in size	cost saving	N/A	N/A
	MVHR addition	additional cost	+ £27,000.00	+ £27,000.00
	MEV omission	cost saving	- £5,400.00	- £5,400.00
Generation	PV array decreasing in size	cost saving	- £9,450.00	- £11,250.00
TOTAL			**+ £15,524.96**	**+ £13,724.96**
Cost per unit			+ £1,725.00	+ £1,525.00
Cost per m² of GIA			+ £28.86	+ £25.49

Projected annual electricity bills

- AD:L (Wales) 2025 £658.07
- AECB CarbonLite £549.78
- B&NES £483.63
- LETI £417.73

excludes standing charge & PV offsets

Headlines

- EUI & CO_2e reductions of 40% in upgrading **AD: L (Wales) 2025** to **LETI**
- Fabric specification could lower and still achieve the highest operational standards, lowering embodied energy
- PV provisions for **AD: L (Wales) 2025** max-out the potential of the roofscape

spring design

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Operational Energy Scenario Cost Implications

AD L (Wales) 2025 upgrade to B&NES					
Building Element			HT 641 *1 unit*	HT 421 *2 units*	HT 211 *9 units*
Fabric	Double glazing to triple glazing	additional cost	+ £623.63	+ £991.76	+ £3,374.96
	ASHP reducing in size	cost saving	- £6,000.00	- £8,000.00	N/A
	MVHR addition	additional cost	+ £4,000.00	+ £7,000.00	+ £27,000.00
	MEV omission	cost saving	- £900.00	- £1,800.00	- £5,400.00
Generation	PV array decreasing in size	cost saving	- £1,200.00	- £1,200.00	- £9,450.00
TOTAL			**- £3,476.37**	**- £3,008.24**	**+ £15,524.96**
Cost per unit			- £3,476.37	- £1,504.12	+ £1,725.00
Cost per m² of GIA			- £31.49	- £18.08	+ £28.86

AD L (Wales) 2025 upgrade to LETI					
Building Element			HT 641 *1 unit*	HT 421 *2 units*	HT 211 *9 units*
Fabric	Double glazing to triple glazing	additional cost	+ £623.63	+ £991.76	+ £3,374.96
	ASHP reducing in size	cost saving	- £6,000.00	- £8,000.00	N/A
	MVHR addition	additional cost	+ £4,000.00	+ £7,000.00	+ £27,000.00
	MEV omission	cost saving	- £900.00	- £1,800.00	- £5,400.00
Generation	PV array decreasing in size	cost saving	- £1,200.00	- £1,600.00	- £11,250.00
TOTAL			**- £3,476.37**	**- £3,408.24**	**+ £13,724.96**
Cost per unit			- £3,476.37	- £1,704.12	+ £1,525.00
Cost per m² of GIA			- £31.49	- £20.48	+ £25.49

spring design

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5. Embodied Carbon

spring design

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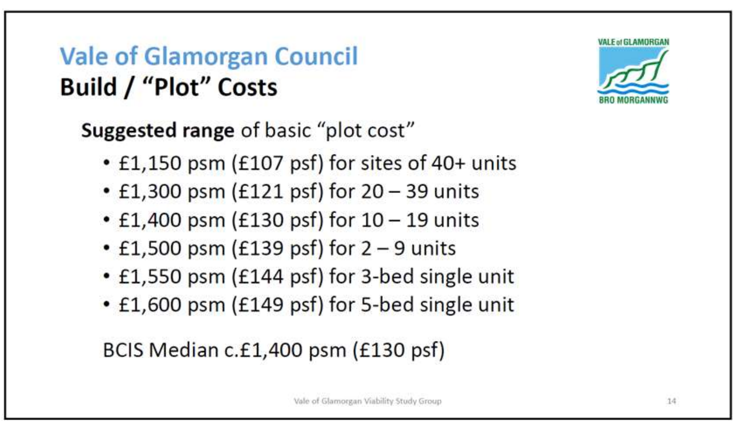

Vale of Glamorgan Council
Build / "Plot" Costs

VALE of GLAMORGAN
BRO MORGANNWG

Suggested range of basic "plot cost"
- £1,150 psm (£107 psf) for sites of 40+ units
- £1,300 psm (£121 psf) for 20 – 39 units
- £1,400 psm (£130 psf) for 10 – 19 units
- £1,500 psm (£139 psf) for 2 – 9 units
- £1,550 psm (£144 psf) for 3-bed single unit
- £1,600 psm (£149 psf) for 5-bed single unit

BCIS Median c.£1,400 psm (£130 psf)

Vale of Glamorgan Viability Study Group 14

RPA costings exclude:
- *land & legal costs, professional & statutory fees, utility connections, preliminaries, enabling works, civil engineering, landscaping, SuDS, EV chargers & contingencies*
- *AD: B (Wales) 2020 requirement for active fire suppression (sprinklers)*

+ £2,550 per dwelling

spring design

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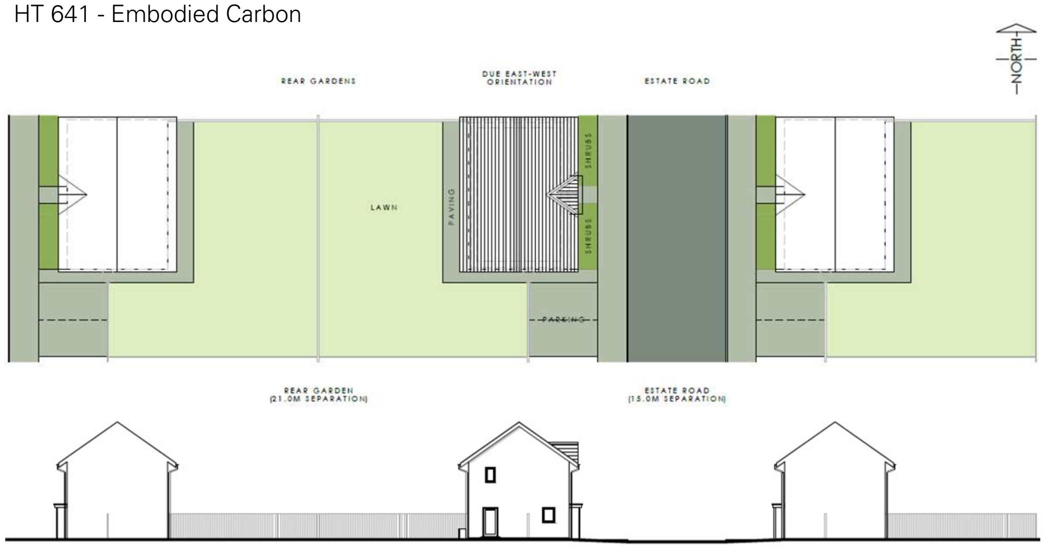
HT 641 - Embodied Carbon



Notional Site Layout & Street Scene

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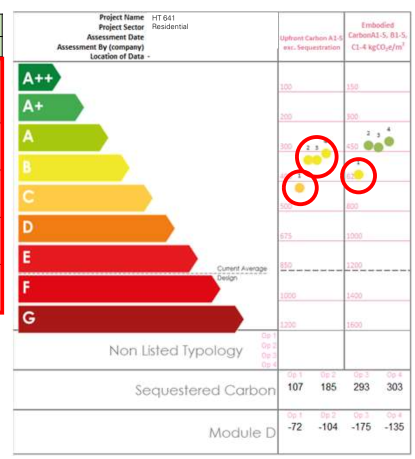
HT 641 - Embodied Carbon

Embodied outputs				
Scenario		LETI 2030		
	RIBA/ RIAI 2030 targets (cradle to grave)	Upfront carbon A1-5	Embodied carbon A1-5, B1-5, C1-4	Sequestered carbon
1 Masonry	/48 $kgCO_2e/m^2$	422 $kgCO_2e/m^2$	589 $kgCO_2e/m^2$	107 $kgCO_2e/m^2$
2 Framed	580 $kgCO_2e/m^2$	327 $kgCO_2e/m^2$	420 $kgCO_2e/m^2$	185 $kgCO_2e/m^2$
3 Timber	593 $kgCO_2e/m^2$	326 $kgCO_2e/m^2$	433 $kgCO_2e/m^2$	293 $kgCO_2e/m^2$
4 Timber Opt.	560 $kgCO_2e/m^2$	305 $kgCO_2e/m^2$	400 $kgCO_2e/m^2$	303 $kgCO_2e/m^2$



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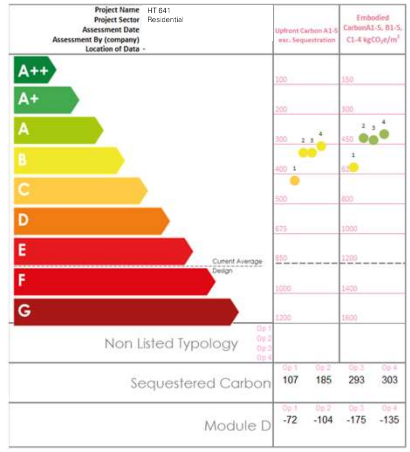
HT 641 - Embodied Scenario Costs

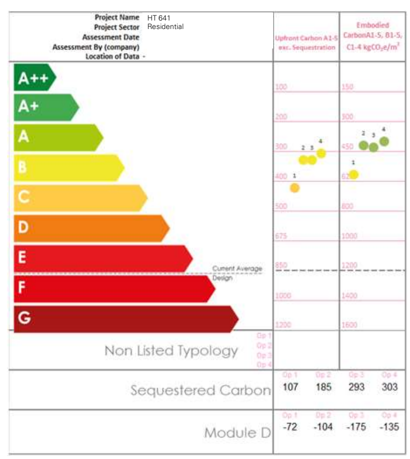
Cost Analysis to AD: L (Wales) 2025				
Construction	1 Masonry	2 Framed	3 Timber	4 Timber Opt.
Foundations	£8,750.00	£8,750.00	£25,550.00	£8,750.00
Ground floor	£19,345.00	£16,790.00		£8,030.00
External walls	£54,230.00	£58,990.00	£59,960.00	£60,960.00
Party walls	N/A			
Internal walls	£9,435.00	£13,875.00	£13,875.00	£16,095.00
Inter. floor	£5,225.00	£5,775.00	£5,775.00	£6,600.00
Separating floor	N/A			
Roof	£15,958.00	£18,148.00	£23,258.00	£34,208.00
Doors / windows	£7,018.76	£7,018.76	£7,018.76	£7,018.76
M&E	£31,200.00	£31,200.00	£31,200.00	£31,200.00
TOTAL	**£150,861.76**	**£160,246.76**	**£166,336.76**	**£172,561.76**
Cost per unit	£150,861.76	£160,246.76	£166,336.76	£172,561.76
Cost per m²	£1,366.50	£1,451.51	£1,506.67	£1,563.06

6%

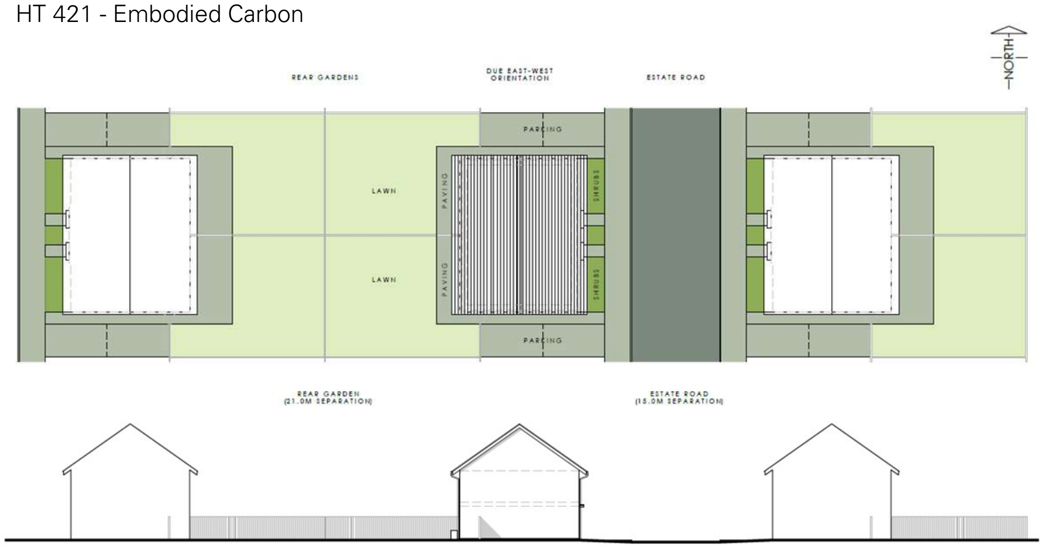


HT 641 - Embodied Scenario Costs

Cost Analysis to LETI				
Construction	1 Masonry	2 Framed	3 Timber	4 Timber Opt.
Foundations	£8,750.00	£8,750.00	£25,550.00	£8,750.00
Ground floor	£19,345.00	£16,790.00		£8,030.00
External walls	£54,230.00	£58,990.00	£59,960.00	£60,960.00
Party walls	N/A			
Internal walls	£9,435.00	£13,875.00	£13,875.00	£16,095.00
Inter. floor	£5,225.00	£5,775.00	£5,775.00	£6,600.00
Separating floor	N/A			
Roof	£15,958.00	£18,148.00	£23,258.00	£34,208.00
Doors / windows	+ £623.63			
M&E	- £4,100.00			
TOTAL	- £3,476.37			
Cost per unit	- £3,476.37			
Cost per m²	- £31.49			



HT 421 - Embodied Carbon



Notional Site Layout & Street Scene

spring design

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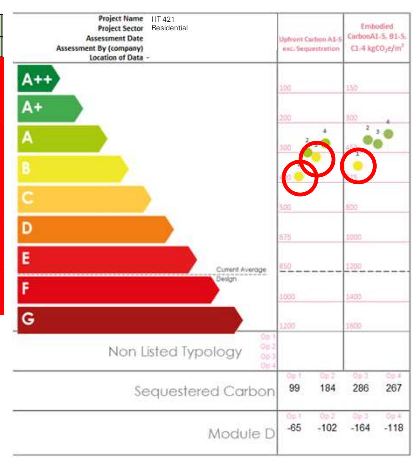
HT 421 - Embodied Carbon

Embodied outputs				
		LETI 2030		
Scenario	RIBA/ RIAI 2030 targets (cradle to grave)	Upfront carbon A1-5	Embodied carbon A1-5, B1-5, C1-4	Sequestered carbon
1 Masonry	602 $kgCO_2e/m^2$	378 $kgCO_2e/m^2$ ✗	531 $kgCO_2e/m^2$ ✗	99 $kgCO_2e/m^2$
2 Framed	460 $kgCO_2e/m^2$	300 $kgCO_2e/m^2$ ✓	390 $kgCO_2e/m^2$	184 $kgCO_2e/m^2$
3 Timber	480 $kgCO_2e/m^2$ ✓	314 $kgCO_2e/m^2$ ✗	410 $kgCO_2e/m^2$ ✓	286 $kgCO_2e/m^2$
4 Timber Opt.	429 $kgCO_2e/m^2$	266 $kgCO_2e/m^2$ ✓	359 $kgCO_2e/m^2$	267 $kgCO_2e/m^2$

2.7x



spring design

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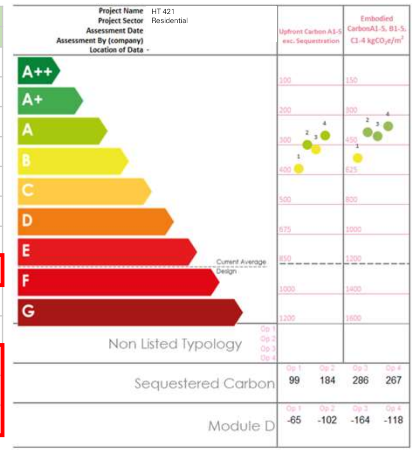
HT 421 - Embodied Scenario Costs

Cost Analysis to AD: L (Wales) 2025				
Construction	1 Masonry	2 Framed	3 Timber	4 Timber Opt.
Foundations	£13,000.00	£13,000.00	£38,500.00	£13,000.00
Ground floor	£29,150.00	£25,300.00		£12,100.00
External walls	£67,298.00	£73,258.00	£74,408.00	£75,648.00
Party walls	£5,752.50	£11,700.00	£16,185.00	£16,185.00
Internal walls	£15,300.00	£22,500.00	£22,500.00	£26,100.00
Inter. floor	£8,360.00	£9,240.00	£9,240.00	£10,560.00
Separating floor	N/A			
Roof	£24,200.00	£27,500.00	£35,200.00	£51,700.00
Doors / windows	£10,822.40	£10,822.40	£10,822.40	£10,822.40
M&E	£49,800.00	£49,800.00	£49,800.00	£49,800.00
TOTAL	**£223,982.90**	**£243,120.40**	**£256,655.40**	**£265,915.40**
Cost per unit	£111,991.45	£121,560.20	£128,327.70	£132,957.70
Cost per m²	£1,346.05	£1,461.06	£1,542.40	£1,598.05

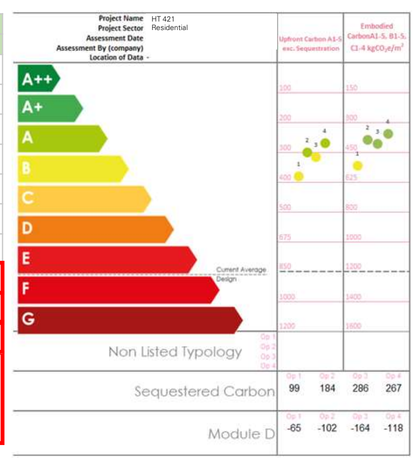
12%



55

HT 421 - Embodied Scenario Costs

Cost Analysis to LETI				
Construction	1 Masonry	2 Framed	3 Timber	4 Timber Opt.
Foundations	£13,000.00	£13,000.00	£38,500.00	£13,000.00
Ground floor	£29,150.00	£25,300.00		£12,100.00
External walls	£67,298.00	£73,258.00	£74,408.00	£75,648.00
Party walls	£5,752.50	£11,700.00	£16,185.00	£16,185.00
Internal walls	£15,300.00	£22,500.00	£22,500.00	£26,100.00
Inter. floor	£8,360.00	£9,240.00	£9,240.00	£10,560.00
Separating floor	N/A			
Roof	£24,200.00	£27,500.00	£35,200.00	£51,700.00
Doors / windows	+ £991.76			
M&E	- £4,400.00			
TOTAL	- £3,408.24			
Cost per unit	- £1,704.12			
Cost per m²	- £20.48			



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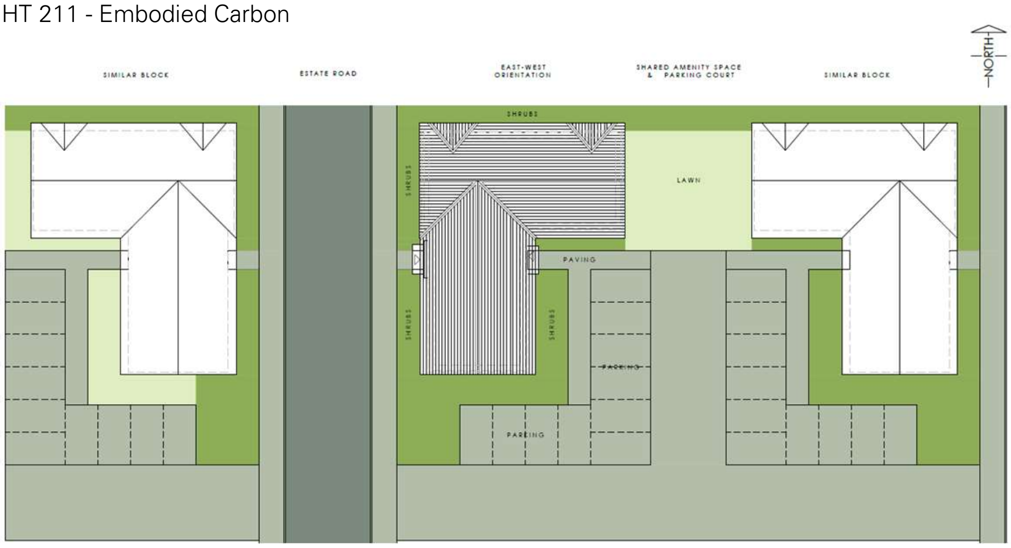
HT 211 - Embodied Carbon



Notional Site Layout

spring design

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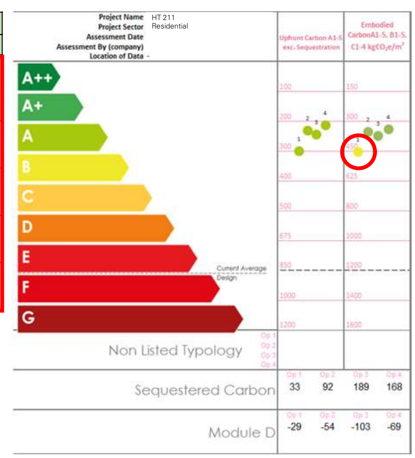
HT 211 - Embodied Carbon

Embodied outputs				
Scenario		LETI 2030		
	RIBA/ RIAI 2030 targets (cradle to grave)	Upfront carbon A1-5	Embodied carbon A1-5, B1-5, C1-4	Sequestered carbon
1 Masonry	486 $kgCO_2e/m^2$	298 $kgCO_2e/m^2$	457 $kgCO_2e/m^2$	33 $kgCO_2e/m^2$
2 Framed	389 $kgCO_2e/m^2$	234 $kgCO_2e/m^2$	359 $kgCO_2e/m^2$	92 $kgCO_2e/m^2$
3 Timber	405 $kgCO_2e/m^2$	242 $kgCO_2e/m^2$	376 $kgCO_2e/m^2$	189 $kgCO_2e/m^2$
4 Timber Opt.	373 $kgCO_2e/m^2$	212 $kgCO_2e/m^2$	343 $kgCO_2e/m^2$	168 $kgCO_2e/m^2$

5X



spring design

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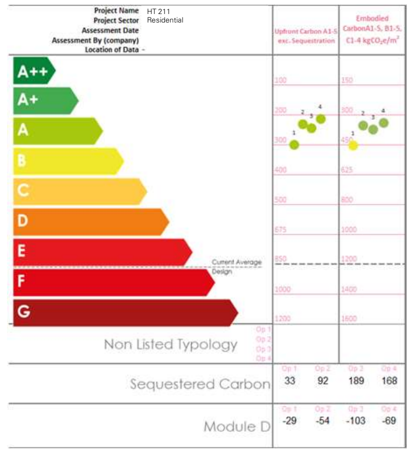
HT 211 - Embodied Scenario Costs

Cost Analysis to AD: L (Wales) 2025				
Construction	1 Masonry	2 Framed	3 Timber	4 Timber Opt.
Foundations	£22,750.00	£22,750.00	£75,600.00	£22,750.00
Ground floor	£57,420.00	£49,680.00		£23,760.00
External walls	£148,203.00	£166,263.00	£163,788.00	£166,428.00
Party walls	£29,057.50	£59,100.00	£81,755.00	£81,755.00
Internal walls	£35,190.00	£43,470.00	£51,750.00	£60,030.00
Inter. floor	N/A			
Separating floor	£95,400.00	£97,200.00	£97,200.00	£97,200.00
Roof	£47,736.00	£54,216.00	£69,336.00	£101,736.00
Doors / windows	£19,736.00	£19,736.00	£19,736.00	£19,736.00
M&E	£156,150.00	£156,150.00	£156,150.00	£156,150.00
TOTAL	**£611,642.50**	**£668,565.00**	**£713,315.00**	**£729,545.00**
Cost per unit	£67,960.28	£74,285.00	£79,257.22	£81,060.56
Cost per m²	£1,135.62	£1,241.30	£1,324.39	£1,354.52

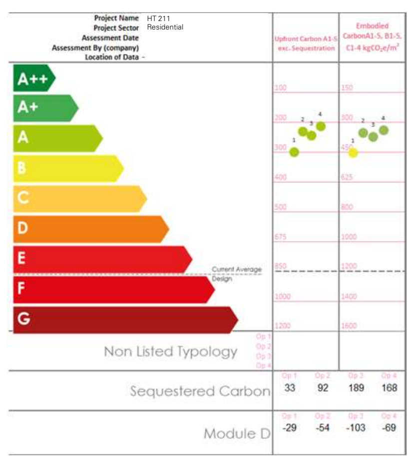
8% 19%



spring design

HT 211 - Embodied Scenario Costs

Cost Analysis to LETI				
Construction	1 Masonry	2 Framed	3 Timber	4 Timber Opt.
Foundations	£22,750.00	£22,750.00	£75,600.00	£22,750.00
Ground floor	£57,420.00	£49,680.00		£23,760.00
External walls	£148,203.00	£166,263.00	£163,788.00	£166,428.00
Party walls	£29,057.50	£59,100.00	£81,755.00	£81,755.00
Internal walls	£35,190.00	£43,470.00	£51,750.00	£60,030.00
Inter. floor	N/A			
Separating floor	£95,400.00	£97,200.00	£97,200.00	£97,200.00
Roof	£47,736.00	£54,216.00	£69,336.00	£101,736.00
Doors / windows	+ £3,374.96			
M&E	+ £10,350.00			
TOTAL	+ £13,724.96			
Cost per unit	+ £1,525.00			
Cost per m²	+ £25.49			



spring design

6. Conclusions

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Conclusions for residential typologies

- Performance of identical buildings is significantly impacted by airtightness, thermal bridging & ventilation > 80% reduction of heating demand possible
- EUI & CO_2e reductions of 35% in upgrading **AD: L (Wales) 2025** to **LETI** requires fewer PV panels to achieve Net Zero balance, reducing capital cost
- Better form factor/ higher density development significantly reduces heating demand of buildings
- Optimised development could justify lower fabric specification, reducing insulation & realising capital cost saving

Conclusions for operational scenarios

- Less efficient operational scenarios that omit MVHR can cost more to achieve Net Zero due to larger PV arrays & heating systems
- Not benefitting from COP of ASHP will require significantly larger PV arrays to balance energy consumption: such arrays unlikely to fit on most typologies
- Building to **LETI** demonstrates cost parity with **AD: L (Wales) 2025** when achieving Net Zero operational energy
- Energy efficiency is recognised as contributing to desirability, increased and market-resilient property prices

Headlines for embodied scenarios

- Masonry construction costs least but is the most carbon intensive option, failing to achieve **RIBA/ RIAI 2030** and **LETI 2030** targets for most typologies
- Changing from masonry to timber frame reduces CO_2e by 20-30% for a 6-18% uplift in capital cost
- Timber frame with biogenic insulants can sequester 3-5x as much CO_2e as masonry construction with PIR
- External finishes can have significant impact on project costs, sales values and embodied carbon - but do not directly impact building performance

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7. Questions

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8. Thank you!

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