POSITION PAPER

Better Net Zero Buildings

The Passivhaus Answer to the Carbon Challenge

April 2026

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Executive summary

We are in a climate crisis, and the UK is committed to achieving net zero by 2050 (2045 in Scotland) to reduce the risk of the most damaging impacts of climate change. Buildings have a central role to play in meeting that goal. Yet defining a "net zero building" is not straightforward. Every building carries a carbon footprint from its materials, construction, operation, maintenance and eventual deconstruction. Even when operational energy use is reduced dramatically, the wider electricity grid and supply chains remain outside the control of any single project. On-site renewable generation can rarely match demand at the exact time it is needed, and embodied carbon can never be reduced to nothing. For this reason, net zero at building level is always a matter of boundaries, definitions and trade-offs.

Different approaches to net zero place emphasis on different things: operational energy, upfront and whole life carbon, renewable generation, in-use verification, or alignment with wider carbon budgets (see **Appendix 4**)[1]. Existing definitions and guidance documents have already done much of the work of setting out these approaches[2], and this paper does not seek to replace them. Instead, it asks a simpler and more practical question: what kind of buildings best support net zero goals in reality?

The answer is not simply buildings that can be described as net zero, net zero-ready or net zero-aligned on paper. It is buildings that perform well in use, reduce energy demand as far as possible, place less strain on the electricity grid, remain affordable to run, minimise whole life carbon, and at the same time support health and comfort. These are what we describe as **better net zero buildings**.

The publication of the Future Homes and Buildings Standards in March 2026[3] is an important step forward. The new standards are intended to produce homes that are "future-proofed" with low-carbon heating and high levels of energy efficiency, so that they will not require retrofit to become zero carbon in use once the electricity grid is fully decarbonised. That is a significant improvement on previous minimum standards. It does not, on its own, provide a complete definition of a good low-carbon building. A narrow focus on electrification and future grid decarbonisation can still leave buildings using more energy than necessary, adding to peak electricity demand, exposing occupants to higher running costs, and failing to address the wider system impacts of high-demand buildings.

The publication of Version 1 of the UK Net Zero Carbon Buildings Standard in March 2026 is also an important development. By using limits, targets and verification requirements, it offers a more rigorous approach to net zero claims than simple design-stage carbon accounting or "net zero ready" assumptions. In particular, its emphasis on measured in-use performance is a significant advance. Passivhaus aligns strongly with key elements of the Standard, and provides a robust route to achieving them. As such, it has been deemed

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[1] Throughout this paper, "carbon" is used as shorthand for greenhouse gas emissions, typically expressed as carbon dioxide equivalent (CO_2e).

[2] See *Improving Consistency in Whole Life Carbon Assessment and Reporting: Carbon Definitions for the Built Environment, Buildings & Infrastructure* (WLCN, 2023) https://www.leti.uk/carbondefinitions, *Net Zero FAQs* (LETI/CIBSE, 2022) https://www.leti.uk/netzero and *Net Zero Whole Life Carbon Roadmap: A Pathway to Net Zero for the UK Built Environment* (UKGBC, 2021) https://ukgbc.org/our-work/topics/whole-life-carbon-roadmap.

[3] https://www.gov.uk/government/publications/the-future-homes-and-buildings-standards-building-circular-012026

to satisfy the requirements of aligned elements of the standard at practical completion. **Appendix 1** sets out this relationship in more detail.

Yet neither the Future Homes Standard nor the UK Net Zero Carbon Buildings Standard makes health and comfort fully central in the way that Passivhaus does. Good indoor air quality, comfortable temperatures, protection against condensation, mould and overheating, and the quality assurance needed to deliver these outcomes in practice are not optional extras. They are part of what makes a building genuinely fit for the future. This is why the Passivhaus Trust uses the phrase **better net zero buildings**.

> Passivhaus is more than simply compatible with net zero goals. In the current UK context, it provides the strongest established route to delivering better net zero buildings.

In this paper we propose that better net zero buildings should be based on five key goals:

- **Minimise operational energy demand and peak load**
- **Prioritise health and comfort**
- **Close the performance gap**
- **Minimise whole life carbon**
- **Optimise renewable generation**

Targeting all of these aims together provides a clearer and more robust basis for good outcomes than carbon balancing alone.

Passivhaus offers a strong route to achieving these outcomes in practice. By incentivising optimisation of all aspects of design, encouraging simplicity and efficiency, and combining clear performance criteria with accurate modelling and quality assurance through design, construction and commissioning, Passivhaus reduces operational energy demand and helps close the performance gap. At the same time, it supports health, comfort, resilience and affordability for occupants. It can also contribute to reducing upfront and whole life carbon, while Passivhaus Plus and Premium provide established routes for integrating renewable generation where appropriate.

For these reasons, we conclude that Passivhaus is more than simply *compatible* with net zero goals. In the current UK context, it provides the strongest established route to delivering better net zero buildings.

Why "net zero ready" is not enough

Future Homes Standard: a significant step, but not the whole answer

The government published updated Approved Documents L and F in March 2026, alongside its Future Homes and Buildings Standards consultation response. The new regulations are due to come into force on 24 March 2027, subject to transitional provisions. The standards are intended to “future-proof” new homes with low-carbon heating and high levels of energy efficiency, so that they will not require retrofit to become zero carbon in use once the electricity grid is fully decarbonised.

In this sense, the Future Homes Standard takes a “net zero ready” approach: new homes are designed on the assumption that grid decarbonisation will complete the job of eliminating operational carbon. That is an important improvement on previous minimum standards, but it does not by itself define a good low-carbon building.

Grid decarbonisation is not a substitute for demand reduction

A strategy based mainly on electrification and future grid decarbonisation risks treating the energy system as an unlimited resource rather than a constrained shared infrastructure. Electricity network constraints are no longer a hypothetical future risk: they are already delaying housing delivery in parts of the UK. In west London, grid capacity shortages linked to rising demand from data centres have led to housing developments being paused or delayed, – in November 2022, some 5,300 homes were waiting for a confirmed connection. Short-term fixes have since enabled connections for over 12,000 homes, but the London Assembly’s Gridlocked report[4] warned that without long-term strategic planning, constraints will worsen as data centre electricity demand is projected to rise from 2025 levels by between 200% and 600%, reaching 30-71 TWh in 2050. These pressures are not confined to London: grid connection delays of eight to ten years are now reported across the country, and Ofgem’s major reform package (December 2025) acknowledged a systemic problem affecting housing, clean energy and demand from energy-intensive sectors alike.

The scale of the challenge is significant. Peak electricity demand is projected to rise from around 58 GW in 2023 to an estimated 110 GW by 2050. The transition to electric heat is happening alongside rising demand from transport, data infrastructure and industrial electrification. At the same time, a major expansion in energy storage capacity – from around 9.6 GW today to an estimated 56 GW by 2050 – will be needed to manage fluctuations in renewable generation, and all storage involves conversion losses that must be factored into total demand[5]. The Good Homes Alliance, in a letter to government backed by over

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[4] *Gridlocked: how planning can ease London’s electricity constraints* (December 2025) https://www.london.gov.uk/who-we-are/what-london-assembly-does/london-assembly-work/london-assembly-publications/gridlocked-how-planning-can-ease-londons-electricity-constraints

[5] *FES 2025: NESO Pathways to Net Zero* (NESO, 2025) https://www.neso.energy/publications/future-energy-scenarios-fes

250 industry organisations, estimated that over £22.6 billion could be saved in electrical generation investment over the next 20 years through improvements to the fabric and ventilation of new dwellings alone[6].

If buildings remain relatively energy-hungry, even when heated by efficient heat pumps, they still add to total electricity demand and to peak load at the times when the grid is under greatest strain. Reducing operational demand in buildings therefore remains essential: lower-demand buildings place less strain on the grid, reduce the scale of reinforcement required, and make it easier to manage both seasonal and daily peaks in demand. A highly efficient building fabric also enables load-shifting — allowing heat input to be timed away from peak periods, because internal temperatures remain stable. This kind of consumer-led flexibility is a central part of the government's grid management strategy, with a target to reduce peak demand by 10–12 GW by 2030.

Buildings designed to Passivhaus standards are particularly well suited to this, because their thermal stability allows heat to be input at any time of day without compromising comfort.

A "net zero ready" approach can also obscure the wider system impacts of high-demand buildings. Additional generation, storage and grid reinforcement all require land, materials and infrastructure, and therefore carry their own resource use and embodied carbon impacts, even where these sit outside the building boundary. Offloading the problem onto the wider energy system does not remove it; it simply moves it elsewhere.

Affordability, fuel poverty and health

There is also a direct consequence for building users. Electrification without sufficient demand reduction risks exposing occupants to higher running costs under current pricing structures, even where heat pumps are much more efficient than direct electric or fossil fuel systems. Electricity currently costs around four times as much as gas per unit of energy. If new homes are to be genuinely future-proofed, they must be not only lower carbon, but also affordable to run.

> If new homes are to be genuinely future-proofed, they must be not only lower carbon, but also affordable to run.

This matters for everyone, but it matters most in the context of fuel poverty. Where energy costs are unaffordable, people do not simply go into debt: they reduce or stop heating their homes. The consequences are well documented in our existing stock – cold indoor temperatures, increased condensation and mould growth, and measurable impacts on respiratory health, cardiovascular health and mental wellbeing, particularly among children, older people and those with existing health conditions[7]. A building standard that addresses carbon without adequately reducing demand risks replacing one form of harm with another.

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[6] See https://goodhomes.org.uk/future-home-standard-response-1

[7] Kate de Selincourt, *Heath, Wellbeing and People Performance* (PHT, 2023). Available online: https://pht.guide/HealthandWellbeing

The fabric of a building also determines comfort in ways that go beyond air temperature. Thermal comfort depends as much on the temperature of surrounding surfaces – the mean radiant temperature – as on the temperature of the air. In poorly insulated buildings with cold walls, floors and windows, occupants can feel cold even when the thermostat reads 21°C[8].

Occupants of retrofitted homes sometimes use more energy than predicted, not because the insulation has failed, but because they are finally warm. The so-called “rebound effect” is often better understood as people achieving the comfort and health that the building should have provided all along. Good fabric, not just efficient heating systems, is the foundation of a comfortable and healthy home.

Passivhaus addresses this directly by combining very low energy demand with stable internal comfort, helping to reduce bills while supporting healthier indoor conditions.

Performance in use still matters

The Future Homes Standard response does not fundamentally resolve the performance-gap problem. Instead, government says it intends to publish a call for evidence and consider research on the energy performance gap and building performance evaluation. It has also strengthened guidance on commissioning, fixed building services and Home User Guides, which are useful but incremental steps rather than a full in-use verification regime. This means that design compliance remains only part of the story. A better route to net zero buildings must give greater confidence that energy and carbon targets will actually be achieved in use, rather than simply assumed at design stage.

> The evidence shows that Passivhaus buildings, in contrast to most UK new build, reliably perform as designed.

In the UK, the performance gap has been found to result in a 60% increase in space heating demand in residential and often considerably more in non-residential buildings. The evidence shows that Passivhaus buildings, by contrast, are reliably found to perform as designed[9].

Mitigation is not enough without adaptation

Focusing too narrowly on carbon accounting also risks missing other aspects of good building performance. Buildings must provide healthy indoor air quality, comfortable temperatures in winter and summer, and robust protection against condensation, mould and overheating.

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[8] Lloyd Alter, 'What the hell happened to "Fabric First?"' https://lloydalter.substack.com/p/what-the-hell-happened-to-fabric

[9] See R. Mitchell and S. Natarajan, 'UK Passivhaus and the energy performance gap', *Energy and Buildings* (2020) https://doi.org/10.1016/j.enbuild.2020.110240; and D. Johnston, M. Siddall et al., 'Are the energy savings of the Passive House standard reliable? A review of the as-built thermal and space heating performance of Passive House dwellings from 1990 to 2018’ *Energy Efficiency* (2020) https://doi.org/10.1007/s12053-020-09855-7

As the climate changes, this means thinking not only about mitigation, but also about adaptation.

The government's March 2026 response included only a call for evidence on Part O (overheating) rather than a major new regulatory step. But in future climates, higher summer temperatures could tip more homes into uncomfortable and even dangerous conditions.

The Passivhaus standard addresses summer comfort with limits for overheating as well as stress tests for future climates and other variables.

Embodied carbon: still outside the regulatory framework

Embodied carbon also remains outside the scope of the Future Homes and Buildings Standards. The government has said it intends to consult separately on how to measure and reduce it in due course. In July 2025, MHCLG published a research report by AECOM[10] exploring the practical, technical and economic impacts of addressing embodied carbon in new buildings, but was careful to note that publication did not indicate any specific future regulatory action.

This position is increasingly out of step with the wider industry. The Part Z campaign, backed by over 200 organisations including RIBA, IStructE, CIBSE and UKGBC, continues to call for mandatory whole life carbon assessment and embodied carbon limits to be introduced through the Building Regulations. A private member's bill proposing such regulation has been tabled in Parliament. In November 2025, the UKGBC Embodied Carbon Summit – co-hosted with IStructE and RICS – brought together developers, engineers, architects, local authorities, insurers and academics, and concluded that voluntary action alone will not deliver change at the speed required. Summit participants called for clear government direction, noting a growing risk of fragmentation as different local authorities introduce different requirements in the absence of a national framework. Internationally, the EU has mandated member states to report embodied carbon by 2028 and implement limits by 2030; in this context, the UK is at risk of falling behind.

As operational carbon falls with grid decarbonisation, embodied carbon accounts for an increasing share of a building's total lifecycle emissions — in some cases more than half. It is released upfront, at the point of construction, and cannot be reduced retrospectively. Continuing to regulate operational energy while leaving embodied carbon entirely unaddressed is an increasingly difficult position to defend.

A better net zero building is therefore not simply one that is "ready" for a lower-carbon grid. It is one that reduces demand, limits peak load, supports health and comfort, addresses the performance gap, responds to the wider system and climate context in which it will operate, and begins to take seriously the carbon embedded in its materials.

The Passivhaus approach supports this by reducing demand, simplifying systems, and encouraging durable, well-resolved construction[11].

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[10] https://www.gov.uk/government/publications/consideration-of-embodied-carbon-in-new-buildings

[11] *Passivhaus and Embodied Carbon* (PHT, 2022) https://pht.guide/EmbodiedCarbon

Five goals for better net zero buildings

Rather than relying on the grid to decarbonize, or making complex calculations, often using offsetting, a simpler and more robust approach to net zero at the building level is to focus on reliably reducing energy use in our buildings, reducing carbon emissions from construction materials, and increasing on site renewable energy generation where feasible, while at the same time safeguarding health and comfort.

We propose that better net zero buildings should be based on five key goals:

Minimise operational energy demand and peak load

Operational energy demand should be minimised as far as possible in order to reduce both annual energy use and peak electricity demand. This supports a more affordable and resilient transition to an all-electric grid, reduces pressure on energy infrastructure, and helps protect occupants from high running costs. Passivhaus provides a proven route to achieving very low operational energy demand in practice.

Prioritise health and comfort

Net zero buildings must also be healthy and comfortable buildings. Good indoor air quality, comfortable summer and winter temperatures, and robust control of condensation, mould and overheating should be treated as core outcomes, not optional extras. These outcomes are built into the Passivhaus standard, rather than treated as secondary benefits.

Close the performance gap

Design intent alone is not enough: buildings must perform in use as intended. Closing the performance gap requires accurate modelling, clear performance targets, and rigorous quality assurance through design, construction and commissioning. Passivhaus combines these elements in a single design and certification methodology.

Minimise whole life carbon

Operational energy is only part of the picture. Whole life carbon should also be minimised, including upfront embodied carbon, through efficient design, simplified form, appropriate material choices, and avoiding unnecessary building services complexity. The Passivhaus approach supports this by reducing demand, simplifying systems, and encouraging durable, well-resolved construction.

Optimise renewable generation

Renewable energy generation should be optimised where it is practical and appropriate, once demand has first been reduced as far as possible. This may include on-site generation, such as photovoltaics, or wider system-based solutions, and should support the transition to a low-carbon all-electric energy system without displacing more important efficiency measures. Passivhaus Plus and Premium provide established routes for integrating renewable generation where appropriate.

Why Passivhaus is the strongest route

Passivhaus combines energy targets with a design and delivery methodology that incorporates clear performance criteria, accurate modelling, and rigorous quality assurance through design, construction and commissioning. This is what makes it such a strong route to better net zero buildings: it does not rely on theoretical compliance alone, but provides a practical framework for delivering low-energy, comfortable, healthy buildings in reality.

Low demand and peak load

Passivhaus delivers reduced operational energy demand through a fabric-first approach based on optimised and well-installed insulation, excellent airtightness, careful control of thermal bridging, and efficient ventilation with heat recovery. This reduces both annual energy use and peak heating demand, making buildings easier and cheaper to run and reducing pressure on the wider energy system.

In an all-electric future, lower peak load makes it easier to shift demand away from periods of system stress, improves the potential for demand flexibility, and reduces the scale of generation, storage and network reinforcement needed to support new development.
In a Passivhaus building, heat can be input at different times of day because the internal temperature remains stable. The building fabric acts as a thermal store, allowing load-shifting without sacrificing comfort.

This is one reason why a fabric-first approach is so important: it helps make consumer-led flexibility possible in practice, allowing occupants to benefit from more flexible pricing. In this way, Passivhaus helps make grid decarbonisation more achievable.

Health, comfort and adaptation

A low-carbon building must also be a good building to live in. Passivhaus integrates comfort, indoor air quality and building health into the core of the standard, rather than treating them as optional co-benefits. Good ventilation, stable internal temperatures, reduced draughts, warmer internal surface temperatures and lower risk of condensation and mould are all part of the intended outcome.

> Good fabric, not just efficient heating systems, is the foundation of a comfortable and healthy home.

This is increasingly important not only for mitigation, but for adaptation. Buildings must be able to remain comfortable and safe through hotter summers as well as colder winters. In this respect, Passivhaus offers a broader and more human-centred definition of building performance than one based on carbon metrics alone.

Affordability and resilience

Buildings with very low energy demand are not only lower carbon: they are also more affordable and resilient. Lower running costs help protect occupants from volatile energy prices and reduce the risk of fuel poverty. Residents who struggle to afford their energy bills don't simply go into debt – they turn down their heating, increasing the risk of ill-health effects from cold and damp. At the same time, a highly efficient building fabric provides a degree of thermal resilience, helping to maintain safe and comfortable conditions during interruptions to energy supply or extreme weather events.

This makes Passivhaus relevant not only to climate targets, but also to public health, energy security and social value. A building that performs well in these respects is not simply more efficient; it is more robust.

Closing the performance gap

One of the strongest arguments for Passivhaus is that it addresses the performance gap directly. Many buildings use more energy in practice than predicted at design stage, undermining both carbon targets and energy planning. Passivhaus tackles this problem by combining detailed modelling through PHPP with a certification process that follows the project through design, construction and commissioning.

This means that Passivhaus is not only a way of setting better targets, but a way of improving confidence that they will actually be met. For clients and project teams seeking robust outcomes, this is a major advantage. It is also why Passivhaus aligns so well with frameworks which emphasise measured in-use performance, such as the UK NZCBS. Verification for the UK NZCBS takes place one year after completion of the building and is based on monitored performance. This makes it all the more important that a robust quality assurance process is in place throughout the construction period.

PHPP as a design tool for net zero buildings

Passive House Planning Package (PHPP) is used for designing and certifying Passivhaus buildings. PHPP has been proven to be reliable in giving accurate predictions of actual energy use in the finished building. Used at an early design stage, PHPP can help you quickly identify which details have the most impact and find opportunities for optimisation of both operational energy and upfront carbon.

Given that PHPP is an Excel-based modelling tool, additional plugins can be created to help meet specific national requirements and expand the scope of reporting.

These include PHribbon, which adds functionality to calculate upfront carbon emissions, whole life carbon emissions and GWP of refrigerants, as well as the UK NZCBS Design

AECB PHribbon

Alignment Tool, a free plugin developed by PHT members Delta Q and available from the Passivhaus Trust, which quickly and easily generates EUI and other relevant metrics from an active PHPP[12]. With these additions, PHPP becomes a complete modelling tool for designing net zero buildings.

EnerPHit and existing buildings

The case for Passivhaus is not limited to new build. If the UK is serious about reducing total energy demand, existing buildings must also be part of the picture. EnerPHit provides a Passivhaus-based route for retrofit, adapted to the realities and constraints of existing building stock.

Like Passivhaus for new build, EnerPHit offers a structured methodology for reducing demand while also improving comfort, air quality and resilience. It therefore supports the same core principles set out in this paper and should be seen as an important route to better net zero outcomes across the wider building stock, not only in new development.

Fig. 1: *Harpenden EnerPHit Plus, UK Passivhaus Awards finalist 2023*

For more on EnerPHit as a solution to the retrofit challenge, see *Passivhaus Retrofit in the UK* (PHT, 2026)[13].

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12 Available online at: https://aecb.net/phribbon-carbon-calculator/and https://passivhaus.uk/uk-nzcbs-design-alignment-tool/

13 Available online at https://pht.guide/retrofit

Whole life carbon and renewables

Whole life carbon still matters

Operational energy is only part of the picture. If net zero is to mean anything useful at building level, embodied carbon must also be considered, including upfront carbon emissions, emissions from maintenance and replacement, and end-of-life impacts. This does not weaken the case for reducing operational demand. It strengthens the case for doing both. A building with low operational demand and lower whole life carbon is better than one that performs well on one measure and poorly on the other.

Passivhaus is compatible with this wider view. Good form factor, compact design, rationalised glazing, smaller heating systems, and well-resolved construction can all help reduce material use as well as operational demand. Durable components and longer building life also support lower whole life impacts. Many aspects of Passivhaus design are therefore compatible with lower upfront carbon, even where some individual components may carry a higher embodied impact. For a fuller discussion of this, see *Passivhaus and Embodied Carbon* (PHT, 2022)[14].

Whole life carbon is not an alternative to operational efficiency

There is sometimes a tendency to set fabric efficiency and whole life carbon reduction against each other, as though one must come at the expense of the other. That is not a helpful way of thinking about the problem.

A building's performance over time depends on an interrelationship between fabric, services, build quality, maintenance, adaptability and lifespan. Looking only at individual components can miss the effect of better overall design. In practice, reducing demand, simplifying systems, and building for longevity often support lower whole life carbon as well as lower operational energy. The right conclusion is not to relax operational standards in order to minimise upfront carbon. It is to design carefully enough to reduce both.

Renewable generation has an important role

Renewable generation is also part of the picture. It can reduce reliance on fossil-fuelled electricity, support the wider energy transition, and in some cases lower grid imports over the year. Passivhaus Plus and Premium provide established routes for integrating renewable generation where appropriate.

At the same time, renewable generation is not the foundation of a good low-carbon building. A building that uses more energy than necessary remains a burden on the wider energy system, even if it generates part of that energy on site. Demand reduction comes first.

This is why Passivhaus Classic still has an important place. In many cases, the priority should be to minimise demand first and then add renewable generation where it is practical and appropriate. Site constraints, roof area, heritage constraints, density and local grid conditions may all affect whether on-site generation is the best solution. A building can still make an exemplary contribution to operational decarbonisation without being required to generate a fixed proportion of its own electricity on site.

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[14] https://pht.guide/EmbodiedCarbon

The role of local generation and storage

Building to Passivhaus standards with a heat pump for heating and hot water already delivers very low and predictable operational energy demand. Adding local solar PV can significantly reduce grid imports over the year, and on-site storage, such as home or communal batteries, can help shift when electricity is used, allowing buildings to make better use of the renewable energy they generate. Although storage does not reduce overall energy demand, it can lower peak imports and support the wider decarbonisation of the grid by aligning consumption with periods of high renewable output.

Some energy suppliers also offer commercial tariff models that guarantee low or no energy bills for a fixed period for homes with high-efficiency fabric, sufficient on-site generation and storage, and smart controls[15]. These schemes are not part of net zero definitions, nor a requirement for Passivhaus, but they illustrate how low-demand buildings can participate in emerging energy-system models that reward predictability, load-shifting and reduced peak demand.

Intelligent control of heat pumps, batteries and electric-vehicle chargers can shift electrical loads to periods of excess renewable generation, and in some cases export stored electricity back to the grid during peak demand. These strategies can support operational net zero goals at system level, but they sit alongside, not in place of, the fundamental role of demand reduction through high-performance building fabric.

On-site and off-site generation are not the same question as building performance

The argument for renewable generation can become muddled if it is treated as the defining feature of a net zero building. On-site generation may be valuable, but it does not remove the need to consider seasonality, winter demand, storage, or the wider system boundary. Nor does it solve problems of comfort, overheating, poor air quality, condensation, mould, or the performance gap.

There is also a whole life carbon question here. Renewable technologies have their own material impacts, replacement cycles and service lives. Those impacts need to be considered realistically rather than ignored simply because they sit within the energy system or outside the immediate building boundary.

For these reasons, renewable generation should be understood as an essential complement to energy demand reduction, not as a substitute for it. The same is true of whole life carbon: it is a necessary part of the picture, but not an argument for relaxing operational performance.

Taken together, whole life carbon reduction and renewable generation help complete the picture of a better net zero building. Neither changes the central point of this paper: reducing demand, protecting comfort and health, and closing the performance gap remain the foundation.

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[15] For example, Octopus Energy operates a Zero Bills™ tariff for homes which meet their minimum efficiency requirements, and requirements for on-site generation and battery storage, assessed on a case-by-case basis. This qualifies them for a period of 5-10 years of no energy bills. Because of its excellent and reliable low energy use, a Passivhaus is likely to need less PV and storage to qualify, than a similar home built to the current building regulations.

UK NZCBS: a valuable framework, and how Passivhaus supports it

The publication of Version 1 of the UK Net Zero Carbon Buildings Standard (UK NZCBS)[16] is an important step forward for the UK construction sector. By using limits, targets and verification requirements, it offers a more rigorous approach to net zero claims than simple design-stage carbon accounting or "net zero ready" assumptions. In particular, its emphasis on measured in-use performance is a significant advance.

Passivhaus aligns strongly with key parts of the Standard, especially in relation to operational energy demand and space heating demand, and Version 1 explicitly recognises Passivhaus within its deemed-to-satisfy framework for certain Practical Completion "on track" requirements.

But Passivhaus does more than simply support compliance. It also offers a proven route to reducing delivery risk, closing the performance gap, and integrating comfort, health and quality into the core of the building standard.

For this reason, we see the UK NZCBS as a valuable framework, and Passivhaus as currently the strongest available route to achieving it well.

UK Net Zero Carbon Buildings Standard

Version 1, Rev 1
April 2026

A fuller discussion of the relationship between Passivhaus and the UK NZCBS is set out in Appendix 1.

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[16] *UK Net Zero Carbon Buildings Standard Version 1* (March 2026) - available online: https://www.nzcbuildings.co.uk/the-standard

Conclusion

The publication of the Future Homes and Buildings Standards and Version 1 of the UK Net Zero Carbon Buildings Standard mark an important moment in the development of low-carbon building policy in the UK, and further progress is expected soon in Scotland with the publication of the Passivhaus Equivalent standard later in 2026. The two standards published in March 2026 both represent progress. The Future Homes Standard raises minimum expectations for new homes, while the UK NZCBS provides a more rigorous framework based on limits, targets and verification.

Even so, neither framework on its own fully captures what makes a building a good outcome in practice. A building can be lower carbon on paper while still using more energy than necessary, adding to peak electricity demand or exposing occupants to higher running costs. Even where these outcomes are avoided, it may still fail to provide healthy and comfortable conditions in use, unless these are equally prioritised.

A better net zero building must do more than contribute to meeting carbon targets. It must also work well for the people who live in it, and for the wider energy system on which it depends.

A better net zero building must do more than contribute to meeting carbon targets. It must also work well for the people who live in it, and for the wider energy system on which it depends.

That is why this paper has proposed five key aims for better net zero buildings:

- minimise operational energy demand and peak load;
- prioritise health and comfort;
- close the performance gap;
- minimise whole life carbon; and
- optimise renewable generation where practical and appropriate.

Passivhaus is the strongest established route currently available in the UK for achieving these outcomes. The benefits delivered by Passivhaus buildings are far-reaching and relevant to a wide range of stakeholders. For occupants, they include comfort, health and lower running costs. For local authorities and housing providers, they include reduced fuel poverty, better health outcomes and greater confidence in delivery. For government and energy system planners, they include lower peak demand, reduced pressure on infrastructure and a more resilient route to decarbonisation.

We therefore propose certified Passivhaus as the foundation for better net zero buildings, complemented by whole life carbon reduction, all-electric heating with efficient heat pumps where appropriate, renewable generation where practical, and the additional reporting needed to align with frameworks such as the UK Net Zero Carbon Buildings Standard.

APPENDIX 1:

Passivhaus and the UK Net Zero Carbon Buildings Standard

What is the UK Net Zero Carbon Buildings Standard?

The UK Net Zero Carbon Buildings Standard (UK NZCBS) is a voluntary technical standard that defines what it means for a building to be “Net Zero Carbon Aligned” in the UK context. Version 1 was published in March 2026, with third-party verification due to become available in Q2 2026.

The Standard goes beyond operational energy alone. It includes limits, targets and reporting requirements relating to embodied carbon, renewable generation, fossil fuel use, refrigerants, operational water use, and electricity demand management, as well as operational energy. A key feature of the UK NZCBS is that it is fundamentally based on verified performance, rather than design intent and construction evidence alone. Full verification depends on measured in-use data one year after completion and occupation.

How does Passivhaus align with the UK NZCBS?

The Passivhaus criteria align closely with key parts of the UK NZCBS, particularly in relation to operational energy and space heating demand. For Passivhaus Premium, and in most cases Passivhaus Plus, there is also alignment with on-site renewable generation targets.

A different emphasis

However, the overlap is not exact, either in terms of the actual limits, or in what is covered by each standard. The UK NZCBS additionally considers matters not explicitly addressed by Passivhaus certification, including embodied carbon (initially upfront carbon only), operational water use, refrigerants and fossil fuel systems. Conversely, Passivhaus includes requirements that are not addressed within the UK NZCBS, such as ventilation performance, moisture risk, minimum surface temperatures and overheating criteria.

This reflects a difference in emphasis between the two standards. While the UK NZCBS is focused primarily on carbon emissions, Passivhaus prioritises comfort and quality alongside operational energy.

Verification vs quality assurance

But perhaps the most significant difference between the two standards is that UK NZCBS verification takes place one year after completion of the building and is based on monitored performance. By contrast, a Passivhaus Certifier is usually engaged at RIBA Stage 3 or 4, and provides concurrent quality assurance throughout design, construction and commissioning.

Limits and targets

In Version 1 of the UK NZCBS, a space heating demand limit is set only for residential new build (including student residential and care homes). Here, in most cases, the limit is 15 kWh/m².a (GIA), close to the Passivhaus standard's 15 kWh/m².a (TFA)[17]. For single family homes, UK NZCBS is slightly more lenient, allowing up to 20 kWh/m². For all other sectors, there is an intention to add space heating demand limits to future versions of the standard.

For operational energy, the two standards use different metrics. The UK NZCBS uses EUI, whereas Passivhaus uses PER. Both standards specify different limits for different building types. It's also worth noting that the NZCBS limits for operational energy are scheduled to become more stringent year on year.

This means the alignment between Passivhaus and UK NZCBS is not exact. In practice, however, this is not a major problem. The limits are close enough that the two standards point in the same direction, and PHPP can be supplemented with additional reporting to show EUI as well as PER (see further below).

The confidence problem: retrospective verification is not enough

The UK NZCBS is rightly focused on verified performance in use. But this creates a practical challenge: how can clients and project teams have confidence, at design stage and through delivery, that the completed building will meet the required limits one year after occupation?

This is where Passivhaus offers a particular advantage. It is not simply a set of energy targets. It is a design and delivery methodology combining:

- clear performance and comfort criteria
- detailed modelling using PHPP
- rigorous quality assurance through design, construction and commissioning.

This matters because buildings designed to meet theoretical targets do not always achieve those targets in practice. The performance gap remains a well-recognised problem in UK construction. Passivhaus provides the strongest established route currently available to reduce that risk and to improve confidence that a building designed to align with UK NZCBS will be capable of achieving verification in use after a year's post-occupancy monitoring.

Practical completion is typically a key contractual milestone. Where compliance with a defined standard matters to the client or project team, there is a practical need to demonstrate at or around that point that the building is on track, rather than waiting a further year for in-use verification.

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[17] Note that the metric for floor area in the UK NZCBS is gross internal floor area (GIA), rather than treated floor area (TFA), as used in the Passivhaus standard. TFA counts only useful area, excluding areas like staircases, and is generally about 90% of GIA. This means that the annual space heating demand (kWh/m².a) reported for the UK NZCBS will be lower than that reported for Passivhaus for the same building – that is, 15 kWh/m².a in the Passivhaus standard is more stringent than the space heating demand target in the UK NZCBS.

PC-on-track and deemed-to-satisfy

In recognition of market need, considering both risk management and contractual structures, Version 1 of the UK NZCBS includes an optional PC-on-track route in Annex E, which sets out checks that may be undertaken and verified at practical completion in order to determine whether the building is on track to achieve conformity with the standard once occupied and in-use. This route includes a commitment to proceed to full verification as soon as it becomes possible.[18]

For the parts of Annex E relating to operational energy (E2.3), space heating (E2.8), and renewable generation (E2.4), certification to the Passivhaus standard (Passivhaus Classic, Plus or Premium) is deemed to satisfy the core requirements.

With regard to renewable generation, the target set for Passivhaus Premium comfortably exceeds the targets set by the UK NZCBS, so certification alone is sufficient. In the case of Passivhaus Classic and Plus, a supplementary calculation must be supplied to demonstrate that the modelled generation meets the UK NZCBS target.

As discussed above, the operational energy metric for the UK NZCBS is EUI, not PER, so a separate EUI calculation showing that the UK NZCBS limits have been met must also be supplied. The Passivhaus Trust provides a free plugin for PHPP[19], developed by PHT members Delta Q, which quickly and easily generates this output from an active PHPP.

These calculations must be submitted to the verifier. The submission must also include a copy of the final Passivhaus certificate and building documentation from the certifier, Building Control Part L sign off and the Part L Building Logbook, and evidence that metering and submetering for energy and heating has been installed and commissioned.

The other requirements of PC-on-track must, of course, also be met. These relate to the upfront carbon assessment (E2.2) and, where applicable, calculations around district heating/cooling networks (E2.7), as well as evidence that metering and submetering has also been installed and commissioned for operational water use (E2.5) and electricity demand management (E2.6).

For full compliance details, see Annex C and Annex E of the UK NZCBS.[20]

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[18] Once the PC-on-track checks have been completed and verified, the following statement may be used to refer to the building:
"As of [insert practical completion date], this building was predicted to be able to achieve all the requirements of the UK Net Zero Carbon Buildings Standard once fully in use. The claimant commits to completing full or landlord-only verification to the Standard once occupied. Where ownership or control of the building transfers, responsibility for progressing to verification shall pass to the successor claimant."
For short-form language, the following may be used:
"At practical completion, this building was predicted to be on track to meet the UK Net Zero Carbon Buildings Standard". However, the longform version should be used wherever possible.

[19] Free to download at https://passivhaus.uk/uk-nzcbs-design-alignment-tool/

[20] *UK Net Zero Carbon Building Standard Version 1* (March 2026), available online at: https://www.nzcbuildings.co.uk/the-standard

Other recognised schemes

The details of Passivhaus as deemed-to-satisfy are set out in Annex C of the UK NZCBS. Annex C also sets out circumstances in which other recognised schemes may be deemed to satisfy certain requirements.

Passivhaus is currently the only scheme recognised within the Standard's deemed-to-satisfy framework for non-office buildings. This is significant because other recognised operational performance schemes, such as NABERS, are themselves based on post-occupancy verification. Passivhaus addresses a different part of the problem: not only how to verify a good outcome once the building is in use, but how to design and deliver in a way that makes that good outcome more likely.

CIBSE TM54 and PHPP

PC-on-track verification can also be achieved without Passivhaus certification. In this case, Annex E requires operational energy modelling in accordance with CIBSE TM54.

CIBSE TM54 is a methodology for evaluating and communicating operational energy use, and it is not tied to a single modelling tool. Although powerful dynamic simulation modelling tools (DSM), such as Design Builder, EDSL TAS, Energy+ and IES Virtual Environment, can be used, in most cases a steady-state energy balance model is both more practical and more straightforwardly aligned with required outputs.

PHPP can be used within a TM54-style process, provided that appropriate scenarios and assumptions are included. In LETI's Operational Modelling Guide[21], it is the only steady-state modelling tool considered suitable for this purpose.

For most building types, steady-state modelling has important advantages. PHPP's month-by-month approach correlates closely with the kinds of data that will later be metered and reviewed in use, while avoiding the risk of unnecessary complexity or data overload. Dynamic simulation has an important role in more complex or sensitive cases, but in many situations PHPP remains the most practical and informative design-stage tool.

In practice, this means that even where a project is not pursuing Passivhaus certification, PHPP may still be the most practical and reliable tool for showing that it is on track to meet the operational requirements of the UK NZCBS.

Comfort, health and resilience

Passivhaus does not only reduce energy demand. It also supports the conditions for good building performance in use: healthy indoor air quality, comfortable summer and winter temperatures, reduced condensation and mould risk, and a robust ventilation strategy.

These outcomes are not incidental. They are part of what makes Passivhaus a better route to net zero buildings. A building that achieves low carbon outcomes but performs poorly for the people using it cannot be considered a fully successful model for decarbonisation.

This is an important difference in emphasis. The UK NZCBS is designed to verify carbon-aligned performance. Passivhaus, by contrast, integrates comfort, health and building quality into the core standard. That broader performance focus is one reason why it offers not only a route to lower emissions, but a route to genuinely better buildings.

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[21] *Operational Modelling Guide* (LETI, 2023), available at https://www.leti.uk/omg

The place for renewables

Passivhaus Classic should not be dismissed simply because it does not mandate on-site generation. In many cases, the priority should be to minimise demand first and then add renewables where they are practical and appropriate. Site constraints, roof area, heritage constraints, density and wider system considerations may all affect whether on-site generation is the best solution. A building can still make an exemplary contribution to operational decarbonisation without being required to generate a fixed proportion of its own electricity on site.

While Passivhaus Plus and Premium include energy generation targets, requiring a fixed amount of on-site renewables, such as PV complemented by domestic batteries, is not universally agreed as essential for zero carbon-aligned performance. On-site generation can help meet operational targets, but high-quality design, ventilation, and energy efficiency remain the primary levers for achieving net zero carbon.

Decisions on renewables deployment may be better guided by energy return, local grid capacity, or wider infrastructure priorities, rather than by strictly matching a building's electricity consumption. In this sense, renewables should be viewed as one route to compliance, rather than as a universal prerequisite.

PER / occupancy / floor area

Another consideration is fairness in the way operational targets are normalised by floor area. A simple kWh/m^2 metric can favour large, lightly occupied buildings over smaller, denser and often more socially valuable ones. Passivhaus has begun to address this with the PER correction in PHPP 10, which accounts more explicitly for occupancy-related demand and can therefore produce fairer comparisons across building types.

Comparing Passivhaus and the UK NZCBS

The table below compares Passivhaus Classic and Passivhaus Plus showing how closely the standards align and the additional benefits of Passivhaus. For more on health and comfort in Passivhaus, see *Passivhaus Benefits* and *Health, Wellbeing and People Performance*[22].

	Passivhaus Classic	**Passivhaus Plus**	**UK NZCBS**
TARGETS AND LIMITS			
Final energy	√*	√*	√
On-site energy generation	-	√	√
Space heating demand	√	√	√
Cooling demand	√	√	√
Upfront carbon	**	**	√
GWP of refrigerants	**	**	√
ENERGY SUPPLY			
Low energy bills	√	√	√
Lowest peak demand on the grid	√	√	√
On-site quality assurance process	√	√	-
Design and construction methodology to reliably close the performance gap	√	√	-***
COMFORT			
Summer comfort	√	√	-
Winter comfort	√	√	-
Good internal air quality	√	√	-
Protection against condensation and mould	√	√	-
Better quality components	√	√	-

** PHPP measures total energy use for the PER calculation. EUI can be reported from PHPP with a plugin.*

*** Can be reported using a PHPP plugin, but are not officially part of the Passivhaus standard.*

**** UK NZCBS recognises Passivhaus as a route to close the performance gap via PC-on-track deemed to satisfy*

Table 1: *Comparing Passivhaus and the UK NZCBS*

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[22] See https://pht.guide/Benefits and https://pht.guide/HealthandWellbeing

APPENDIX 2:

Statutory net zero building standards

The statutory pathway to deliver net zero buildings in England is Approved Document L. Other parts of the UK (Scotland, Wales, and Northern Ireland) have their own regulations, which may be based on or similar to Part L, but often have variations.

England

Details of the next uplift to Approved Document L, called the Future Homes Standard, was published in March 2026, and is to be implemented in March 2027[23]. The FHS will require new homes in England to be built with some upgrades to the fabric efficiency standards of Approved Document L Volume 1 2021. The route to compliance will still be using a notional building will now includes improved airtightness and a low carbon heating system. It will be mandatory to install photovoltaics on suitable roofs only, based on a ‘reasonable output’ calculation, to reduce energy bills on homes, with the aim to ease the transition from gas to electric heat rather than to balance energy use. This means new homes will be designed to reduce carbon emissions through switching to heat pumps.

The proposed goal is for new homes to be “zero-carbon ready”, without the need for future retrofits to become net zero when the National Grid fully decarbonises. FHS does not consider upfront or whole life carbon, but there have been calls to introduce regulation in this area via a new Part Z.

Scotland

Scotland aims to reach net zero carbon by 2045 and has set higher standards than Approved Document L. Zero direct emissions heating (ZDEH) systems have been mandated since 2024 though the New Build Heat Standard (NBHS). In 2023 it was announced that the Scottish Government plans to introduce new minimum environmental design standards for all new-build housing to meet a Scottish equivalent of the Passivhaus standard, to improve energy efficiency and thermal performance. A two-stage consultation process is underway, and detailed proposals are planned to be released for the second stage consultation in 2026[24]. The PHT has been closely involved in developing this standard.

In addition, the Scottish Futures Trust (SFT) Learning Investment Program awards funding to new schools based on in-use performance data. To gain maximum funding, schools must achieve a maximum Energy Use Intensity (EUI) of 67 kWh/m^2.a, though energy efficient design and operation[25].

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[23] The PHT position on the FHS can be found online at: https://pht.guide/PHvFHS

[24] Round One consultation proposed a voluntary standard from 2026, becoming mandatory from 2028.

[25] https://www.gov.scot/publications/learning-estate-investment-programme-funding-details/

Wales

Wales published new Approved Document L 2026 in April 2026, to take effect on 4 March 2027. As in England, the Welsh uplift is based on a notional dwelling with low-carbon heating and on-site renewable generation, typically an air source heat pump and photovoltaics.

However, the Welsh approach places greater emphasis on energy demand alongside carbon emissions. In particular, it introduces Energy Use Intensity (EUI) as a core compliance metric, replacing earlier proxy measures linked to EPC ratings. This reflects a shift towards directly limiting energy use and associated running costs, rather than relying primarily on modelled carbon factors. This aligns more closely with emerging frameworks such as the UK Net Zero Carbon Buildings Standard, which also emphasise measured or measurable energy performance.

Wales also maintains a strong policy focus on fuel poverty alongside decarbonisation. Programmes such as Warm Homes Nest sit alongside Building Regulations to support fabric improvements and reduce energy bills, reinforcing the link between low energy demand, affordability and occupant wellbeing.

Northern Ireland

In Northern Ireland, Part F of the Building Regulations covers conservation of fuel and power in buildings, and is supported by Technical Booklets F1 (for dwellings) and F2 (for buildings other than dwellings). The current booklets came into effect in June 2022, and brought energy performance standards in line with NZEB (Nearly Zero Energy Buildings). A further review of energy efficiency requirements and related areas of the Building Regulations was consulted on in 2023, including Part F, ventilation, overheating and EV infrastructure, but no replacement for the 2022 Technical Booklets has yet been published.

Northern Ireland’s wider Energy Strategy, 'The Path to Net Zero Energy', sets a direction towards net zero energy by 2050 and at least 80% renewable electricity consumption by 2030, following the passing of the Climate Change Act (Northern Ireland) 2022. As of late 2025, reports indicate that while the 80% target is legally binding, progress is considered to be significantly behind schedule.

APPENDIX 3:

Factoring in the grid

When talking about a "fully decarbonised grid", it's easy to forget that the energy measured at the meter in a building is not the end of the story. Even in a system supplied largely by renewable electricity, more energy must be generated at source than is finally delivered to the building, because energy is lost in transmission, distribution and storage. And the infrastructure needed to generate, store and deliver that energy carries its own upfront and whole life carbon impacts.

To understand these wider system effects, it will be helpful to look more closely at the different metrics used to report operational energy in buildings, and trace the energy back to its source.

Energy Use Intensity (EUI)

Energy Use Intensity (EUI) is a metric for **final energy**, also called **delivered energy** - it reports the energy delivered to the building. It includes both regulated and unregulated energy (that is, appliances and plug loads as well as heating, hot water, lighting and fans etc). It is a helpful metric for comparison and verification purposes, as it can easily be monitored using meter readings. EUI is a measure of intensity, rather than total usage, and is reported relative to the building's gross internal area (GIA). Note that in PHPP, final energy is instead calculated relative to TFA (total floor area), which is smaller than GIA - see Appendix 1.

EUI, or final energy, does not account for inefficiencies in energy supply – distribution and storage losses – and the way these vary seasonally.

Primary Energy (PE)

Primary energy starts to look behind the meter. It describes energy in its natural form before conversion or transformation, for example gas in the ground, or renewable energy available from wind or sunlight. A Primary Energy Factor expresses how much primary energy is needed to supply one unit of final energy to a building. In conventional methods such as SAP, this helps account for upstream energy use in producing and delivering energy, including generation or transformation losses and transmission and distribution losses.

It should be noted that SAP only counts regulated energy (heating, hot water, lighting and fans), and excludes unregulated energy (appliances and plug loads) and will therefore always underestimate a building's actual energy use. Furthermore, primary energy does not fully capture the extra generation and storage needed in a future energy system supplied mainly by renewables, which will predominantly be variable. This is the problem that the PER metric was developed to address.

Primary Energy Renewable (PER)

Since 2015, Passivhaus has primarily used the metric **Primary Energy Renewable (PER)**. PER anticipates a future energy system supplied by renewable resources, and reflects the renewable primary energy needed to cover a building’s final energy demand, including distribution and storage losses[26].

A key feature of PER is that the factors vary by application – for example heating, cooling or household electricity – because different kinds of demand place different burdens on a renewable supply system. Heating demand often occurs in periods of lower renewable availability and may require more storage, especially seasonally, so it can be more resource-intensive to supply than uses that align better with renewable generation. PER factors also vary by location and by final energy carrier, that is, the form of energy delivered to the building, such as electricity or district heat. In PHPP, these factors are provided automatically with the climate data.

Whole life carbon of the energy supply

The metrics above all measure energy, not carbon. To calculate the operational carbon emissions, fuel-specific carbon factors must be applied to the building's final energy. For electricity, these will include transmission and distribution losses and well-to-tank (WTT) emissions. However, until the implementation of HEM, which applies half-hourly carbon factors, seasonal variation is generally under-considered.

Even after seasonality is factored in, this still does not yet fully account for all the emissions associated with operational use of a building. Delivering a decarbonised grid also carries its own upfront and whole life carbon emissions, through manufacturing, installing, maintaining and replacing renewable generation, storage technologies and grid infrastructure.

A grid supplied largely by renewable energy is therefore not carbon free in an absolute sense. When considering the emissions associated with building operation, we must also remember that the wider energy supply system also has material and carbon impacts. Reducing energy demand in buildings remains important not only because it lowers operational demand at the meter, but because it also reduces the scale of generation, storage and infrastructure needed behind the scenes.

When considering whole life carbon assessments of a building, if the life-cycle carbon at the building level is considered, while life-cycle carbon at grid level is not, the carbon cost of on-site renewables and improved fabric will be overweighted, and the carbon cost of decarbonising the grid overlooked.

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[26] https://passipedia.org/basics/energy_and_ecology/primary_energy_renewable_per

APPENDIX 4:

Definitions of "net zero", energy and carbon terms

Discussions of "net zero" at the building level can sometimes confuse different elements of the energy and carbon challenge.

Net zero (ready)
Considers only carbon emissions from operational energy (heating, cooling, lighting, appliances, etc.) and relies solely on the decarbonisation of the National Grid and a move to all-electric heating systems. Taking this approach, no further energy efficiency measures or renewable energy generation would need to happen, as theoretically all our energy would be carbon free. This is the basis of the Future Homes Standard in England and related regional regulations. This definition does not consider embodied carbon from materials through construction, maintenance and end-of-life.

Net zero (operational energy)
Refers only to operational energy which is balanced (net) over a year with on-site energy generation. Typically, this is achieved through a combination of energy efficiency and renewable energy, usually photovoltaics. This is the basis for Nearly-Zero Energy Buildings (NZEB) and Passivhaus standards such as Plus and Premium. Carbon emissions from materials and construction are not considered.

Net zero (upfront carbon)
Refers to upfront carbon emissions before occupation. This requires reducing the carbon emissions associated with the manufacturing, transportation, and construction of a building before occupation and then offsetting what remains, via carbon offsetting schemes[27]. If you only offset upfront carbon, then other sources of emissions would not be accounted for. The UK NZCBS sets targets for reducing upfront carbon.

Net zero (whole life carbon)
Refers to both upfront and operational emissions over the entire lifespan of a building including ongoing maintenance, refurbishment, and end-of-life demolition. A net zero (whole life carbon) building is a much more complex assessment and relies on both carbon emissions reduction and carbon offsetting. The UKGBC have published guidance on delivering net zero whole life carbon. The UK NZCBS is intended to include targets for whole life carbon in future versions.

Net zero (aligned)
Extends the scope beyond carbon to include whole life emissions plus additional impacts such as water use and refrigerants. This approach allows for some carbon to be emitted from a building if the same amount is removed from the atmosphere as part of a wider national net zero strategy. Here the focus is on minimising energy use and whole life carbon and maximizing renewable energy generation. This approach is the basis for the UK Net Zero Carbon Building Standard (UK NZCBS) and our response to this can be found in Appendix 1.

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[27] *Carbon Offsetting and Pricing Guidance* (UKGBC, 2024) https://ukgbc.org/resources/carbon-offsetting-and-pricing-guidance/

Carbon definitions

In building policy and industry discussion, “carbon” is often used as shorthand for greenhouse gas emissions. Strictly speaking, these are usually measured and reported as carbon dioxide equivalent (CO_2e), which allows the combined impact of different greenhouse gases to be expressed in a single metric.

Some common terms for emissions from buildings are as follows:

- **Operational** carbon refers to the emissions associated with the energy used to run the building (operational energy, including both regulated and unregulated energy).
- **Upfront** carbon, or upfront embodied carbon, refers to emissions associated with the building’s construction before occupation. For materials and products, carbon emissions are reported in an Environmental Product Declaration (EPD).
- **Life cycle** embodied carbon includes both upfront carbon and emissions from maintenance, replacement of components, and the deconstruction of the building at the end of its life.
- **Whole life** carbon includes all of the above - i.e. all associated carbon emissions throughout the life of the building, resulting from both the energy used to run the building and from construction, maintenance and deconstruction.

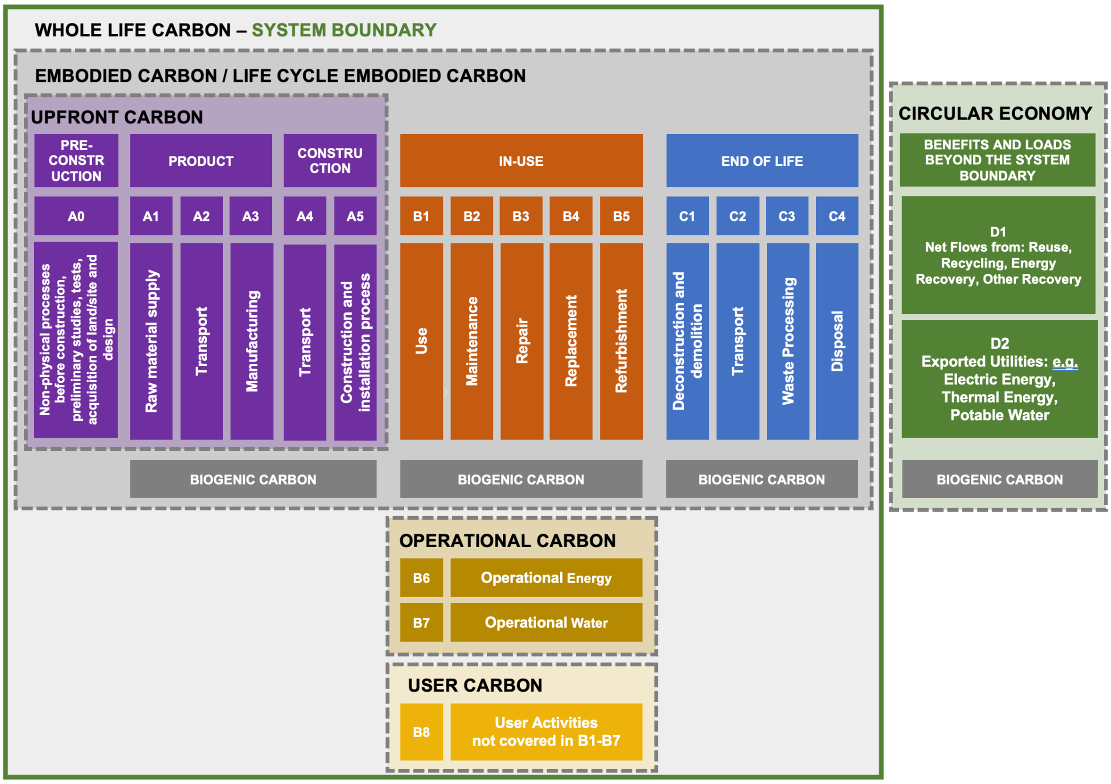

Fig. 2: *Showing the Life Cycle Modules adapted from BS EN 15978, BS EN 17472, PAS 2080: 2016 and expected in future updates. Source: 'Improving Consistency in Whole Life Carbon Assessment and Reporting: Carbon Definitions for the Built Environment, Buildings & Infrastructure' (WLCN, 2023) https://www.leti.uk/carbondefinitions*

The table below shows operational energy and the difference between the three classes of emissions.

	Operational energy	Operational carbon	Upfront embodied carbon	Life cycle embodied carbon	Whole life carbon
Construction			✓	✓	✓
In use	✓	✓			✓
Maintenance & replacement				✓	✓
Deconstruction				✓	✓

Table 2: *Operational energy, operational, upfront, and whole life carbon*

Comparing benefits and challenges of net zero

	Benefits	**Challenges**
Net zero ready building (operational carbon)	Easy to implement as relies on decarbonisation of the grid only	No incentive to reduce energy demand Further retrofit to building fabric may be needed Further renewable energy may need to be installed Energy bills may be high May create excess peak demand on the grid Does not include upfront or whole life carbon
Net Zero (operational energy)	Encourages energy demand reduction On site energy generation contributes to energy transition Reduces energy bills Simpler to assess	Dependent on available and suitable roof area More on-site renewable energy needs to be generated than used to account for losses in the grid More challenging for some building types e.g., tall buildings Does not include upfront or whole life carbon
Net zero (upfront carbon)	Encourages simpler building design and use of less carbon intensive materials On site energy generation contributes to energy transition	Difficult to get accurate and reliable data on embodied carbon in materials Complex to assess Does not address operational energy On-site renewable energy generation capacity may not be sufficient and further carbon offsetting needed
Net zero (whole life carbon)	Considers all emissions associated with a building Encourages simpler building design and use of less carbon intensive materials Encourages energy demand reduction On site energy generation contributes to energy transition	Difficult to get accurate and reliable data on embodied carbon in materials Complex to assess On site renewable energy generation capacity may not be sufficient and further carbon offsetting needed More challenging for some building types e.g., tall buildings
Net zero (aligned)	Includes all the emissions associated with a building Encourages energy demand reduction Reduces energy bills On site energy generation contributes to energy transition Addresses the challenge of different building types Uses in use data rather than design predictions	Difficult to get accurate and reliable data on embodied carbon in materials Complex to assess

Table 3: *Summary of the benefits and challenges of the different approaches to net zero*

The Passivhaus Trust is at the forefront of a transformative shift in the built environment, revolutionising how buildings are designed, constructed, retrofitted, and occupied. As the official UK arm of a global movement, we champion the international Passivhaus standard - proven to create healthy, resilient buildings that deliver immediate climate action.

Please find us on Linkedin, Instagram & YouTube @PassivhausTrust.

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