Passivhaus: a route to net zero Operational carbon

We are in a climate crisis. When determining the most impactful way to cut emissions in the built environment, we must holistically consider embodied and operational carbon. This primer focuses on operational carbon. Please also refer to *Passivhaus: a route to net zero - Embodied carbon* and *Passivhaus: a route to net zero - Retrofit.*

Passivhaus Trust

PHT PRIMER

EFFICIENCY FIRST

If we are to live within the means of our global system we need to radically reduce energy demand and drive efficiency. We cannot simply generate more zero carbon energy supply, due to the limitations of grid capacity, peak load and demands for renewable energy from other sectors.

Passivhaus buildings are optimised for net zero and meet the predicted capacity of our future decarbonised grid.

Passivhaus delivers outstanding levels of energy efficiency, typically using half the energy of a new-build home. It therefore enables the levels of demand reduction that we will need in order to achieve net zero nationally and globally.

Passivhaus also provides exceptional levels of interior comfort, health and wellbeing, affordability, resilience and durability.

DEFINING ZERO OPERATIONAL CARBON FOR BUILDINGS

Setting a Zero Operational Carbon target for our new buildings would be a clear and bold step to achieve genuine emissions reductions and many cities and regions are moving towards this goal. For true Zero Operational Carbon we must account for all of the carbon emissions generated during the building's lifetime relating to its use, including how that operational energy is generated, stored and delivered. The carbon emissions from a building can vary over time as the carbon factors associated with different energy sources change. In contrast, the energy demand of a building will be relatively consistent throughout its life. As such this Primer will generally refer to Operational Energy.

PASSIVHAUS SOLUTIONS

Passivhaus is an international tool backed by 30 years of evidence, it provides us with a range of proven approaches to deliver new and existing buildings optimised for net zero. This is no time to reinvent the wheel - the tools we need to deliver on our climate pledges exist today, so let's get to work! The Passivhaus standard provides solutions to the current hurdles to achieving net zero in the UK.

1 The performance gap

Passivhaus buildings have been consistently shown to perform to design targets with no performance gap between predicted and actual energy use. By contrast the performance gap in non-Passivhaus new-build homes is well documented and a conservative estimate of its size is 60% additional space heating demand.

2 Seasonal disparity

The seasonal disparity between energy demand and renewable generation results in a need for inter-seasonal energy storage, which will lead to storage losses. Once these storage losses, together with the performance gap, have been taken into account for a typical 68m² home, the image on the right shows how our energy demand looks for a:

- Home built to the 2021 building regulations
- Passivhaus home

- both fitted with air source heat pumps.

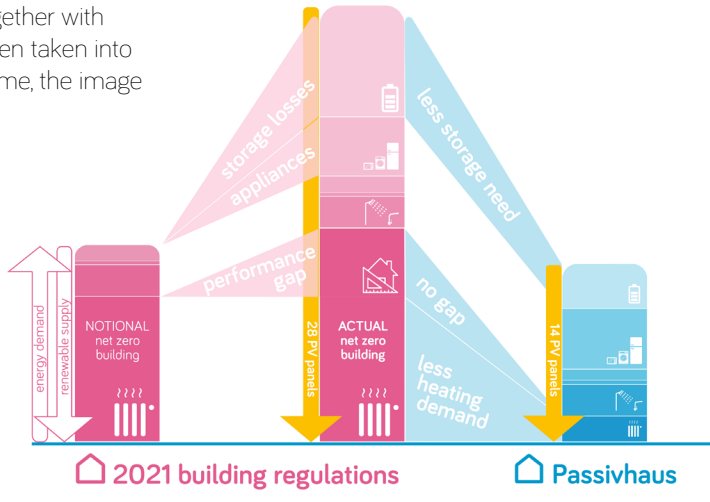
3 Renewable energy needs

The building regulations net zero home requires 7700 kWh/year of renewable energy to achieve net zero, more than twice as much as the Passivhaus home.

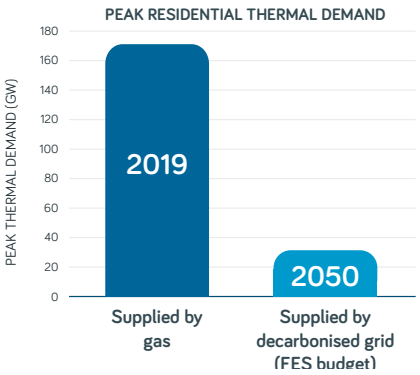
4 Grid capacity

Passivhaus also meets the predicted capacity of our future decarbonised grid. There is a limit to how much renewable energy can be deployed and managed through the national grid. As it is decarbonised, there is an increasing case to use more electricity for heating purposes. The total amount of renewable energy we can generate over the course of each year is not the only limiting factor. Perhaps more of an issue is the peak load that the national grid is able to deliver.

It is estimated that the peak thermal load currently demanded by our homes and delivered by gas is 170GW. The current electric grid capacity is around 100GW. In 2050, all our sectors, particularly transport, will be drawing from this source of low



carbon energy, and National Grid ESO has allocated only 30GW for domestic heat in their 2050 FES budget. Again, demand reduction is going to be needed to enable us to achieve a net zero balance.

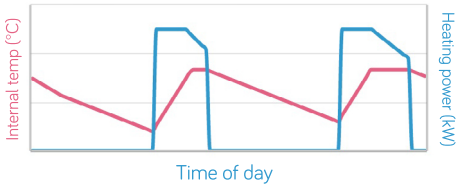


To make a decarbonised grid work we need heating loads, and critically peak loads, to reduce to Passivhaus levels of building performance, to allow us to make this switch to electrical heating and so realise the reduced emissions that the decarbonisation strategy envisages.

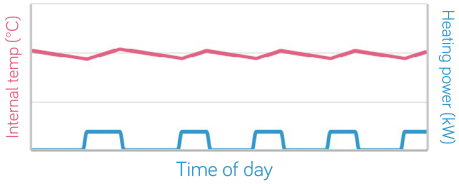
LOAD SHIFTING

In all future scenarios we need to reduce our peak load. In our buildings we can do this using demand response and load shifting to spread the peak out over the day.

Typical home

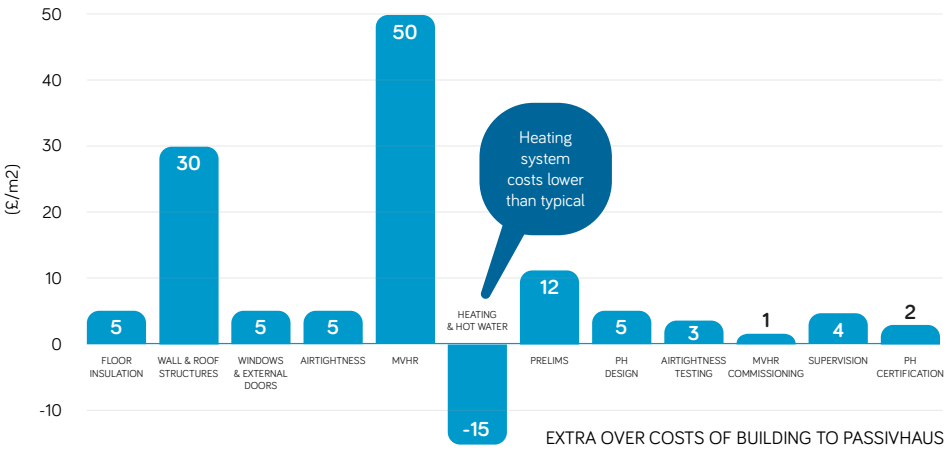


Passivhaus home



In a typical home, with a daily periodic temperature swing, the heating input cannot be shifted, as the house will not be warm when required. In a Passivhaus the heat can be input at any time of the day, as the internal temperature remains constant. This home acts as a thermal store, so we can quite happily load shift around the day, reducing the demand at peak times.

An efficiency first approach is crucial. Passivhaus is the most effective and robust way to achieve the necessary energy reductions.



EXTRA OVER COSTS OF BUILDING TO PASSIVHAUS

DOES PASSIVHAUS COST MORE?

Innovation costs associated with early Passivhaus projects are now reducing as the methodology becomes more widely adopted. Analysis carried out by the Trust in 2018 showed that the extra costs associated with building to the Passivhaus standard in the UK were around 8% higher than comparable non-Passivhaus projects, reducing to 4% with further development of skills, expertise and supply chain maturity.

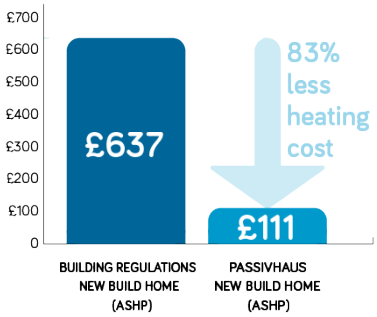
It is important to note that these additional costs result in a better quality product, with lower running costs, lower maintenance costs and a higher capital value.

> "Investing in value instead of energy consumption requires little financial efforts but rather creativity and intelligent solutions"
>
> *Wolfgang Feist, Founder, Passivhaus Institut*

When Passivhaus is adopted from the very start of a project it can be used to drive efficiency improvements through the early design decisions relating to the overall building form, orientation, window design and then later simplification of the detailed design. By offsetting these design efficiency savings against the extra costs shown in the graph above, it is possible to deliver higher quality Passivhaus buildings at no extra cost.

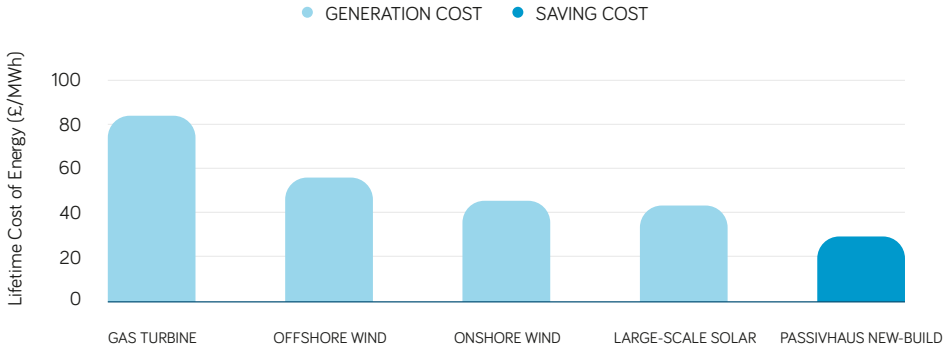
HEATING COSTS

A Passivhaus will have significantly lower heating bills than a typical new-build equivalent.



COST COMPARED TO ENERGY GENERATION

The cost of building more efficiently is 3-4 pence per kWh. The cost of generating that kWh rather than saving it is more expensive, in every scenario, for all forms of renewable energy. Passivhaus provides savings beyond those shown in the graph below, through significant reductions in energy storage costs. These have not yet been included in our analysis as storage technologies are not yet mature and future costs remain uncertain.



WHOLE LIFE VALUE

Lower running costs mean that Passivhaus homes offer significant whole life cost savings over a building regulations home.

A Passivhaus building is already optimised for net zero, and will not need future retrofitting to meet zero carbon targets. By contrast, a building constructed to current building regulations compliance may need substantial investment in disruptive fabric upgrades.

Additional financial benefits such as better mortgage rates and lower maintenance costs result in even quicker payback periods and larger whole life benefits.

PASSIVHAUS BENEFITS

With outstanding levels of building performance, Passivhaus delivers exceptional levels of interior comfort, health and wellbeing, affordability, resilience and durability. Individual homeowners will be interested in comfort and lower energy bills, Local Authorities may focus on tackling fuel poverty, improving health outcomes, and meeting zero carbon pledges. Government and energy suppliers may be attracted to the sound economics of lowering peak demand, minimising budgets for large scale infrastructure costs, and amplifying the resilience of a national grid that's fit for the 21st century.

1 - BUILDING PERFORMANCE

Passivhaus delivers exceptional levels of comfort and outstanding levels of building performance – less than half the energy use of a typical new-build home. The standard addresses the performance gap and delivers high quality buildings.

2 - PASSIVHAUS AND THE CLIMATE EMERGENCY

Decarbonisation is a critical part of our journey to net zero. Passivhaus enables the levels of demand reduction that we will need to achieve net zero.

3 - HEALTH AND WELLBEING

Warmth and ventilation are the top building performance issues affecting health. Both are optimised in a Passivhaus building. Other criteria address indoor environmental issues such as overheating and noise. The result is significant improvements in health and wellbeing for those living and working in Passivhaus buildings.

PASSIVHAUS BUILDINGS

1. are optimised for Net Zero
2. consistently perform to design targets
3. are the best fit for a decarbonised grid
4. deliver many health and wellbeing benefits
5. tackle fuel poverty

4 - PEOPLE PERFORMANCE

Evidence points to the need for good air quality, thermal comfort, and a quiet environment for optimal learning, and optimal performance at work. The improved living and working environment offered by Passivhaus can improve people's productivity, learning outcomes and reduce absenteeism.

5 - FINANCIAL BENEFITS

Passivhaus isn't just more affordable to run, it can also offer lower maintenance costs, reduced fuel poverty and access to green finance or cheaper mortgages. Passivhaus can be used to drive efficiency improvements through the early design decisions and through simplification of the detailed design. In this way it is possible to deliver higher quality Passivhaus buildings at no extra cost.

6 - SOCIAL RETURN

There are many second order effects of living and/or working in a Passivhaus. Improved wellbeing and productivity reduces the load on health and social care and gives people better life chances. These are potentially some of the biggest and most far-reaching benefits and are often difficult to quantify – but shouldn't be ignored.

DOWNLOAD PASSIVHAUS BENEFITS GUIDE

ANALYSIS SHOWS THAT PASSIVHAUS IS THE ONLY REALISTIC WAY TO ACHIEVE ZERO CARBON WITHOUT MASSIVE RENEWABLE ENERGY EXPANSION COUPLED WITH A SIGNIFICANT, AND EXPENSIVE, INVESTMENT IN GRID CAPACITY.

PASSIVHAUS STANDARDS: CLASSIC, PLUS & PREMIUM

As Passivhaus continues to grow both in the UK and the rest of Europe, many projects are using the Passivhaus Standard to deliver against Net Zero targets. A robust way to achieve this is to reduce energy demand to the Passivhaus Classic Standard level and source renewable energy to meet the remaining demand. The renewable energy might be generated on site or at a more economic scale; large scale renewables have the potential for a much lower life cycle cost and lower embodied carbon than domestic building-mounted PV.

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For those who wish to demonstrate compliance with emerging definitions of Net Zero at the building level, 'Passivhaus Plus' and 'Passivhaus Premium' offer a rigorous methodology. These standards include the use of renewable energy generation in the certification assessment. They also require a further reduction in demand, making them suitable for more ambitious projects.

The **Passivhaus Plus** standard not only drastically reduces energy use, but it also produces as much energy as occupants consume, turning them into Passivhaus Powerhouses. The energy generated must come from renewable sources and provide enough energy to operate the building throughout the whole year. By most definitions these would be considered Net Zero buildings - although this is not the most efficient way to meet national or global Net Zero targets.

In a **Passivhaus Premium**, typically far more energy is produced than needed, even once storage losses are accounted for. It is therefore a goal for the particularly ambitious: building owners and designers who want to go beyond what economic and ecological considerations already propose.

The Passivhaus Classic standard along with these additional classes make the Passivhaus standard the most appropriate target for our Net Zero future.

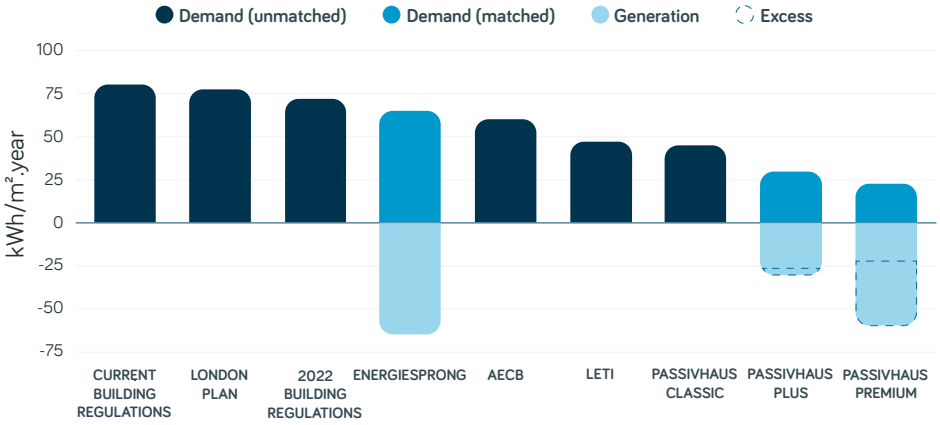
CONCLUSION

The 2021 IPCC report once again brought into sharp focus that we now only have a few years left to reduce emissions enough to avoid a catastrophic rise in global temperatures. Significantly reducing the emissions of our buildings is vital if the UK is to make a meaningful contribution and would lead by example when many countries are also struggling to understand how to reduce emissions sufficiently.

As explained in this primer and in *Passivhaus: the route to zero carbon*, zero carbon at the building level isn't necessarily the most efficient way to achieve regional, national and global zero carbon. When considering how to define a zero carbon building, it is essential to take into account the complete picture of how the building will use energy as well as the impact of the seasonality of renewable generation.

Analysis shows that reducing energy demands to Passivhaus levels is the only realistic way to achieve zero carbon without massive renewable energy expansion coupled with a significant, and expensive, investment in grid capacity.

However, even when using Passivhaus as a mechanism to significantly increase efficiency, achieving a zero carbon built environment is only really viable if the system boundary is extended beyond individual buildings. At any level, when considering zero carbon targets, it is essential to take into account the complete picture of how the building will use energy as well as the impact of the performance gap, storage losses and the seasonality of renewable generation.



"[The IPCC] report is a code red for humanity. The alarm bells are deafening, and the evidence is irrefutable: greenhouse-gas emissions from fossil-fuel burning and deforestation are choking our planet and putting billions of people at immediate risk."

António Guterres, UN Secretary-General

WHOLE LIFE CARBON

As set out in this primer, building to the Passivhaus standard is the optimal route to reducing operational carbon. As buildings become operationally efficient and the grid continues to decarbonise, the embodied carbon or the carbon emissions associated with the construction materials and building services within a building are increasingly important. Our primer *Passivhaus: a route to net zero - Embodied carbon* explores how Passivhaus can be used to drive efficient design solutions through the simplification and rationalisation of form factor, and the reduction in size of heating systems that automatically lead to a reduction in embodied carbon.

LEARN MORE

Learn more through our popular online course *Getting to Net Zero* - on demand modules available now.

Download the full report *Passivhaus: the route to zero carbon below.*

DOWNLOAD THE FULL REPORT

Other primers on retrofit and embodied carbon are available to download online.