# Building the Case for Net Zero:

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

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**Advancing Net Zero Programme Partners**

Lead Partner:

Programme Partners:

# Foreword

Climate change is one of the greatest challenges of our time. We are already seeing a range of environmental changes around us: the increase in severity and frequency of extreme weather events, rising temperatures, flooding risks and impacts on human health. Global warming will impact biodiversity, agriculture, infrastructure, educational environments, living conditions and business productivity. The economic consequences of not controlling greenhouse gas emissions will be significant and impact us all.

The built environment sector, responsible for nearly half of global greenhouse gas emissions, remains relatively inefficient and is ripe for radical change.

There is an opportunity for built environment professionals to work together to reduce carbon in new buildings and existing stock. This report shows how designs for residential and workplace buildings can be influenced to improve resource efficiency, reduce running costs and get to net zero carbon. This should be the target for all new buildings by 2030.

The findings of the study show that the increased capital investment in net zero buildings needn't cost the earth. Failure to mitigate climate change will however, impacting everyone including those not living and working in the new buildings that are being constructed.

It's time we see net zero buildings as an opportunity to innovate, explore better building techniques and collaborate on a joint vision. We will face challenges. The supply chain needs to make and install materials and systems differently. We need to build skills and capacity. Buildings will look slightly different to how they do now, but not much. Using materials with lower embodied carbon may be unfamiliar to us but there are lessons and shared from successful design solutions. We also need to be better at measuring and monitoring building performance when buildings are handed over. Outcomes matter.

**Ashley Bateson**
Partner, Hoare Lea,
Advancing Net Zero
Programme Partner

# Executive Summary

In late 2018, the IPCC issued a stark warning. It clearly established that achieving the ambitions of the Paris Climate Agreement and limiting warming to 1.5°C to avoid the most catastrophic impacts of climate change will require action at an unprecedented pace and scale.[1] The UK's target to reach net zero emissions by 2050 reinforces the imperative for businesses to assess their operating models in line with climate science. By better understanding the practical implications of achieving net zero carbon, businesses can be made more resilient to future operating conditions and pivot to embrace the upcoming change.

The World Green Building Council (WorldGBC) is catalysing the construction and property industry to lead the transition to a net zero carbon built environment through its Advancing Net Zero campaign. The campaign is calling for all buildings to be net zero carbon by 2050 and for all new buildings to be net zero in operation and to reduce embodied carbon by 40% by 2030.[2]

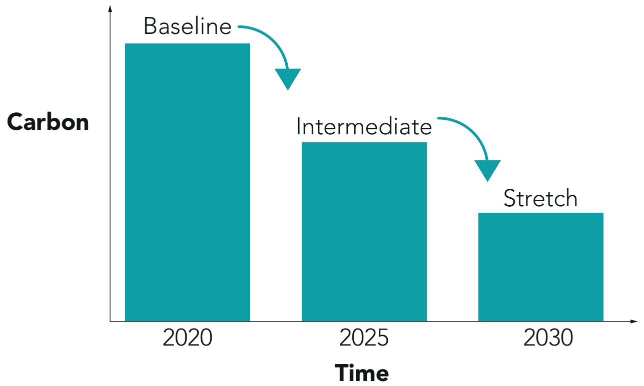
In the UK, the operation of buildings accounts for around 30% of emissions, mainly from heating, cooling and electricity use.[3] For new buildings, the embodied emissions from construction can account for up to half of the carbon impacts associated with the building over its lifecycle[4]. UKGBC's Advancing Net Zero programme is helping to drive the transition to net zero carbon buildings, including through its publication of the Net Zero Carbon Buildings Framework[5] in 2019.

In addition, a growing body of guidance is helping the buildings sector better understand the key requirements for new net zero buildings, such as performance targets developed by UKGBC,[6] LETI[7] and RIBA.[8] However, there is currently a limited understanding of the practical implications for designing and delivering these buildings including, critically, an evaluation of the cost impacts.

## PURPOSE

This report presents the findings of a feasibility study that shines a light on the real-world implications for achieving new net zero buildings. It illustrates how new buildings can be designed to reach net zero performance targets and the effect this has on cost. The findings are intended to improve the collective understanding for the buildings sector and help build the case for new net zero buildings.

**Figure 1:** A representation of the step change in building performance required to meet future net zero targets and drastically reduce carbon




The report's findings are separated into two main sections:

### 1. Design changes

The study is based on two real-world projects that were in concept design stage at time of publishing – an office tower and a residential block. UKGBC convened the project teams for both schemes to iterate the existing designs – considered the 'baseline scenario' representing business as usual – to achieve two net zero design scenarios. In comparing these different design scenarios, the findings are intended to provide insight into some of the key changes required to the way buildings are currently designed and delivered.

The two net zero design scenarios were based on future net zero performance targets for embodied carbon and operational energy published by UKGBC, LETI and RIBA. An 'intermediate scenario' uses net zero targets for 2025 to represent buildings that are in, or will soon be in, design, and a 'stretch scenario' uses net zero targets for 2030 to represent design changes that may be seen as challenging today but will need to become the norm over the next decade.

The project teams' brief was to deliver the same building that had achieved planning approval (i.e. same overall volume, external massing, site conditions), with free reign to alter all other design parameters (e.g. structure, HVAC system, tenant requirements etc.) to achieve, or get as close to achieving, the net zero performance targets. Given this brief, some net zero targets have not been achieved as these would have required radical changes to the original building design.

### 2. Cost changes

In parallel, an analysis of the effect on cost across the design scenarios has been undertaken to estimate the changes required in the financing of new net zero buildings. The focus of this analysis has been on changes to capital cost and does not seek to make the value case for net zero buildings. The value case is significant when considering current market trends, such as investor pressure through the Task Force on Climate-related Financial Disclosure (TCFD), stranded asset risks, corporate ESG drivers, and increasing occupier interest in net zero. Future studies could explore this context further and the wider benefits of net zero buildings.

The cost uplift for the intermediate scenarios were calculated as 6.2% for office and 3.5% for residential compared to the baseline scenarios. This cost uplift can be considered feasible today given these costs will likely be offset by the value benefits, including increased rental premiums, lower tenancy void periods, lower offsetting costs, and lower operating/lifecycle costs.

However, the cost uplift for the stretch scenarios were more significant at 8-17% for office and 5.3% for residential. This is perhaps not surprising as the net zero targets for 2030 are substantially more demanding and the marketplace is not yet geared up to delivering them at scale. To overcome this, we need a long-term consistent regulatory trajectory that tightens standards over time so as to provide the certainty and level playing field required for the supply chain to innovate and costs to come down.

This report represents a step towards building the case for net zero buildings. It provides the facts and figures for two typical developments, whilst signalling broader structural changes required for the buildings sector. A supplementary publication will examine the market transformation in detail, and future studies could branch into other relevant areas, such as different building types, retrofit of existing buildings, and enabling green finance mechanisms.

# Snapshot of findings

## NET ZERO OFFICE

**The baseline design is for a new 16 storey city office building** – see "Project overviews" on page 13

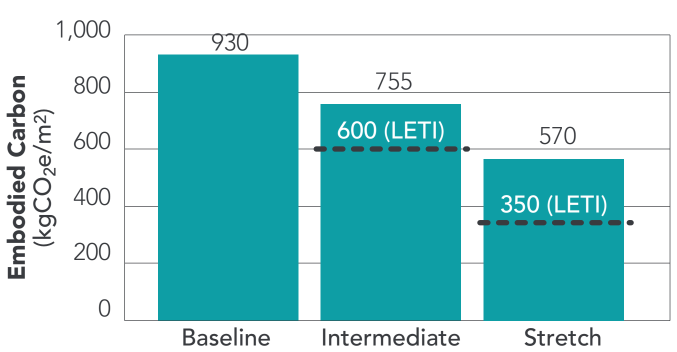
**Key design changes for stretch scenario** See pages 18-19

**1. Replacement of steel and concrete in structure:** Incorporating a fully timber structure along with the removal of a concrete basement helped reduce total upfront carbon by 39%, compared to the baseline. However, the larger-sized timber beams and columns did result in one floor being lost to maintain the same building height, which would impact the building's value.

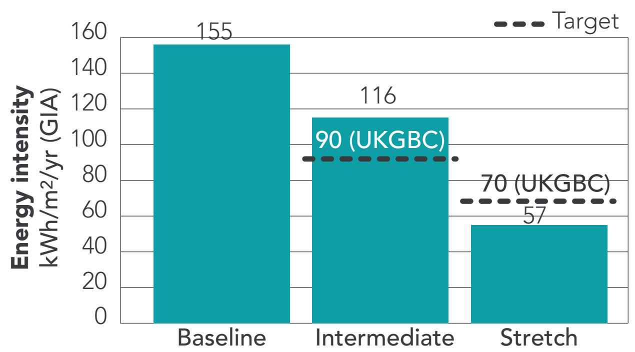
**2. Introduction of mixed mode ventilation:** Relaxing the internal comfort conditions helped to reduce heating and cooling loads by over half (compared to the baseline) and allowed the introduction of openable windows for passive cooling in the spring and autumn.

**3. Dematerialisation of fitout and removal of server room:** By simply not installing a suspended ceiling, a 14% saving in embodied carbon was made. Utilising offsite servers helped achieve a 78% decrease in IT energy usage, however shifting some energy use to a scope 3 emission.

**Results** See pages 20-27




**Upfront embodied carbon***
(LCA module A; $kgCO_2e/m^2$)




**Energy performance**
(whole building; $kWh/m^2$ (GIA) / year)

**Cost change** (shell and core; £/$m^2$ GIA) See pages 40-46

£3,125

6.2% increase (£3,320)

8-17% increase (£3,370 to £3,660)

*Not including sequestration (capture of carbon in timber building materials)

## NET ZERO RESIDENTIAL

**The baseline design is for a new 18 storey city residential building** – see "Project overviews" on page 13

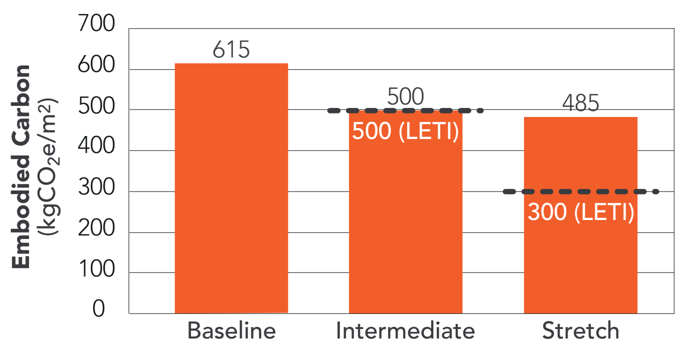
**Key design changes for stretch scenario** See pages 28-29

**1. Replacement of concrete structure with timber frame:** The use of a timber frame (beams, decking and columns) helped reduce total upfront carbon by 21%, compared to the baseline. However, given the increased depth of timber beams, two floors had to be removed to maintain the overall building height.

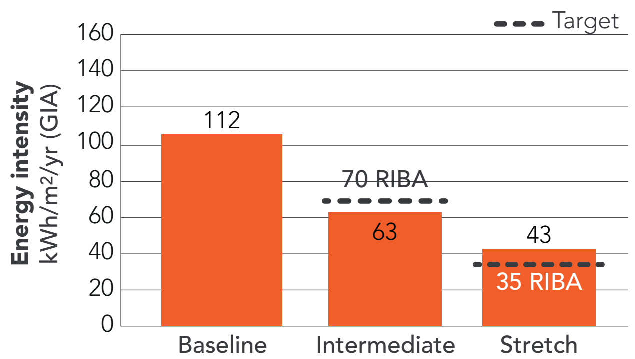
**2. Reduction of glazing areas to reduce heat loss:** The glazing ratio is reduced from 51% to 29% through reducing bedroom window sizes and removing bedroom balconies. This is in addition to incorporating triple glazing and reducing the wall u-value.

**3. Replacement of gas boiler with air source heat pump:** The switch to an air source heat pump significantly reduces operational energy demand. Approximately half of the final energy demand in the stretch scenario comes from unregulated loads.

**Results** See pages 30-37




**Upfront embodied carbon***
(LCA module A; $kgCO_2e/m^2$)




**Energy performance**
(whole building; $kWh/m^2$ (GIA) / year)

**Cost change** (shell and core; £/$m^2$ GIA) See pages 47-51

£2,715

3.5% increase (£2,810)

5.3% increase (£2,860)

*Not including sequestration (capture of carbon in timber building materials)

Together for a better built environment

**UK Green Building Council**

The Building Centre
26 Store Street
London WC1E 7BT

T 020 7580 0623
E info@ukgbc.org
W ukgbc.org