Designing to net-zero targets: is our best good enough?

Meeting the embodied carbon targets of the UK Net Zero Carbon Buildings Standard will require both efficient and sustainable designs and innovations in material science and production techniques. Ben Gholam explores what can be achieved today when designing multistorey residential buildings and what might help to bridge the gap in future years.

Reaching net zero

The UK government is aiming to build 1.5M houses over the next few years, and a significant percentage of these will need to be in medium- or high-rise blocks in cities. The most sustainable way of doing this would be to reuse and refurbish existing structures. However, as there is limited stock of suitable buildings, new build will be the only viable option in many cases. New buildings will almost certainly be constructed in reinforced concrete, which has a very high embodied carbon intensity because of the amount of cement and steel required. The large size and area of these buildings mean they will have a significant overall impact.

Other material types are, of course, available, but reinforced concrete is most commonly used. First, because it is relatively cheap, but also because it solves so many of the design issues associated with these types of buildings, with inherent robustness, fire and acoustic resistance, ease of service coordination and established, reliable procurement routes. With such a large volume of construction proposed, minimising embodied carbon in this typology becomes more important than ever.

In parallel to this, the first full edition of the UK Net Zero Carbon Buildings Standard (NZCBS) has recently been launched (www.nzcbuildings.co.uk). This excellent document is the industry's first attempt at a comprehensive, cross-discipline guide to measuring and tracking embodied carbon, with a clear path to net zero outlined. For each building type, a series of rapidly reducing annual targets has been plotted. The document gives an aim for a particular 'Residential Flats' category (**Figure 1**), as opposed to the broader 'Residential' category that would include single dwellings.

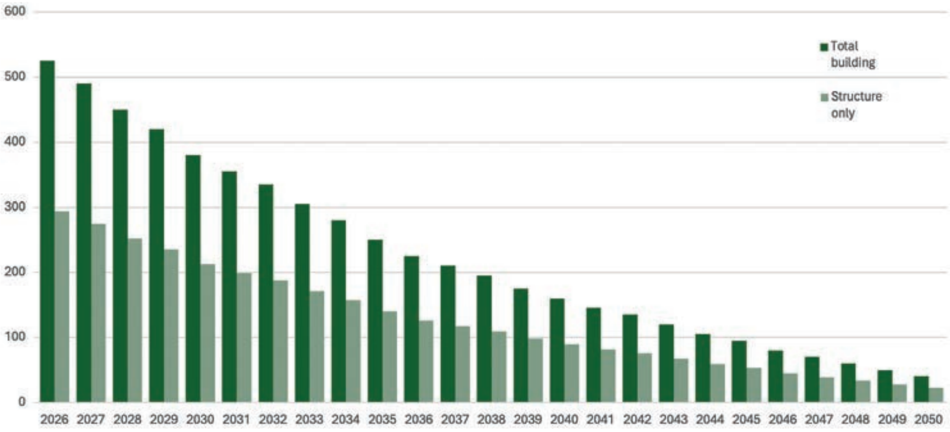

FIGURE 1: UK NZCBS embodied carbon limits for flats (kgCO$_2$e/m^2)

DATA SOURCE: UK NET ZERO CARBON BUILDINGS STANDARD

This article summarises a brief study investigating where current designs for these buildings sit in terms of carbon intensity, using the Price & Myers (P&M) Embodied Carbon Database and some high-level calculations, what current realistic minimums are, and what can be done to achieve the ambitious UK NZCBS targets.

Price & Myers database

This publicly available embodied carbon database has been developed by P&M over the past few years and is, to our knowledge, the largest of its kind in the UK, or beyond. As of the end of 2025, it contained nearly 700 calculations for more than 500 unique buildings.

The firm's work covers all building types and sizes, from small residential extensions to hyperscale data centres. However, multistorey residential buildings, including student residential, are the building type most commonly entered into the database, representing around 25% of all entries, but more than 50% of all designed floor area. Of these, 70% are concrete framed. Using the database, we can quickly see that the average carbon across these buildings is **316kgCO$_2$e/m^2** across all design stages – aligning almost exactly with the overall average for all building types.

The UK NZCBS 2026 target for this building category – flats – is **525kgCO$_2$e/m^2** for new builds. This relates to the entire building envelope, of which the structure is only a part. The technical guidance behind the document puts the estimated structural percentage at 56% of this, or **294kgCO$_2$e/m^2** – just below the database average. These figures provide a benchmark for where we are now.

The question is: is it possible for the structural embodied carbon to reduce at the same rate as the UK NZCBS targets or will this reach a lower limit? Buildings require a minimum quantity of materials and, unless the embodied carbon of those materials reduces quickly, a practical minimum will be reached.

We can try and determine a figure for the lowest practical carbon intensity using current carbon factors. Our database also gives us the granularity to see where the embodied carbon sits within these structures. When designing them, we tend to focus on the floor slabs, and the

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database shows that, on average, these contain 42% of all the embodied carbon – the largest single percentage. We can therefore use a few simple rules to estimate a minimum carbon level.

If we rule out post-tensioning, which is a good option in certain situations, but often difficult to procure, the lowest practical floor-slab thickness is probably 200mm, weighing, say, 480kg/m^2. Thicknesses below this are possible but will start to cause issues with cast-in proprietary products, congestion at slab edges and space between reinforcement.

In terms of reinforcement, if we can position our columns regularly and at relatively tight centres, then we can probably achieve a low reinforcement rate in the region of, say, 20kg/m^2. A very quick carbon calculation gives an estimate of 62kgCO$_2$e/m^2 for the concrete and 43kgCO$_2$e/m^2 for the reinforcement in this generic square metre of slab, covering modules A1–A3 (production), A4 (transport) and the relevant parts of A5 (A5.3 wastage). Note that this calculation utilises global carbon factors, which is the appropriate way of assessing at early stages.

Based on the material percentages in the slabs noted above (42%), we get an overall carbon estimate for the frame of **250kgCO$_2$e/m^2** ((62+43)/0.42). This is dependent on all other structural elements of the building, other than slabs, being similarly refined and optimised to their limits. We are assuming no basement for this example, as it is intended to demonstrate an approximation. Our 'optimised' figure now represents a healthier 48% of the overall building UK NZCBS target for 2025, rising to 66% by 2030.

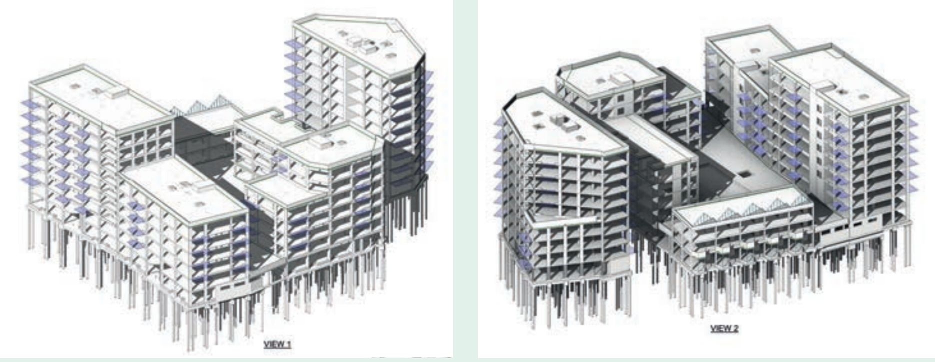
UK NZCBS demonstrator

As engineers, we don't work in isolation, and even if our material usage remained unchanged, the other core disciplines would still be able to make savings. To test this, we took it one step further, by assembling a team to determine what was likely achievable in a 'best case' scenario for our concrete-framed apartment building.

Example: Vincent Street, Newham, London

The innovative design for this 150-unit Passivhaus development in east London has achieved an embodied carbon level of around 265kgCO$_2$e/m^2 in the structure while assuming global average levels of ground granulated blast-furnace slag and recycled steel, well below our typical average for an *in situ* reinforced concrete frame.

After being appointed to the project on a pre-construction services agreement, Price & Myers worked with the contractor (Hill Partnerships) and the other members of the design team to implement a 'material-first' approach to the design. This process involved redesigning the column layout to ensure slabs could work at 200mm with minimum reinforcement across much of their area. Tricky details and transfers were avoided as far as possible, and strategic use of structural downstands, coordinated with service positions, provided additional stiffness in areas of higher loading because of balconies or masonry support systems.



P&M teamed up with Buttress Architects and Max Fordham to produce a design for a hypothetical building **(Figure 2)**, with the aim of comparing this against the UK NZCBS targets. The selected scheme was for a building in central Manchester – roughly based on a real project and representative of the sort of design that could be replicated in any city across the UK.

The height was kept at six storeys to avoid the need for two staircases. It would sit on piled foundations with no basement. Our design was based on the principles of the earlier example but designed to a RIBA stage 2/3 level of detail, with 200mm slabs and all aspects of the structure optimised to the code-compliant minimum.

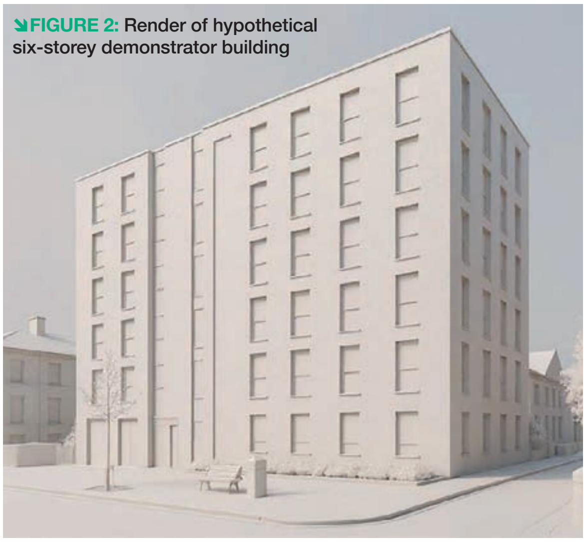


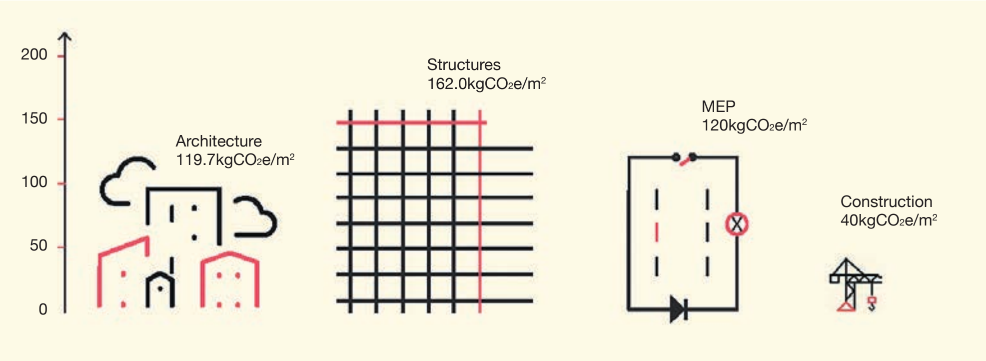
FIGURE 2: Render of hypothetical six-storey demonstrator building

As a team, we prepared our design and then carried out a full embodied carbon assessment to see where it would sit. Without the complexities and limitations of a real-world project, all disciplines were able to make the design as lean as theoretically possible while still complying with all necessary legislation, design codes and building regulations. Our structure came in at 162kgCO$_2$e/m^2 and formed around 37% of the overall embodied carbon **(Figure 3)**.

Although this was only a brief exercise, the implications are quite clear. In relation to the targets set within the UK NZCBS, the project came in just under the limit for 2028 of 450kgCO$_2$e/m^2. The targets are based on the year works commence on site, so this would represent projects that many of us will likely be working on now.

One big caveat to this is the embodied carbon factors used. To gauge what would be considered 'best' case, we utilised above-average levels of ground granulated blast-furnace slag (25%) and assumed the reinforcement steel was manufactured in an electric-arc furnace. These represent levels far above the global average availability

– particularly for reinforcement. If we look at the structural design produced for the demonstrator but recalibrate to a more 'global' level of material use, then approximately 90kgCO$_2$e/m^2 is added to our original estimate, bringing the structural embodied carbon to just over 250kgCO$_2$e/m^2 – justifying our first estimate. The overall building total sits at 536kgCO$_2$e/m^2, suggesting that even the 2026 target would be missed.



↗**FIGURE 3:** Embodied carbon distribution of demonstrator project

Conclusion

This brief exercise aimed to determine what the lowest practical level of embodied carbon is for the chosen building typology in the current market, by first using estimates based on averages from our database and then by direct calculation for a theoretical, simplified design. When compared directly with corrected carbon factors, both results came to a similar conclusion in terms of embodied carbon level. Clearly, in both cases, some large assumptions have been made, but as is always the case with carbon calculations, we need to focus on the wider aspects and not the intricate details, as everything is based on broad assumptions.

The results show that, for the chosen building typology and construction type, even the most optimised design is likely already close to or past the point where these targets are achievable with current materials and design practices.

A more detailed analysis of our database shows that there is some cause for hope. The average given above was a broad figure across all project stages and years. When we break this down further, we can see a downwards trend, with the average material intensities dropping over the five-year collection period. This is a more reliable measure than simply carbon factors, for some of the reasons listed above; in particular, the choice of carbon factor.

What does this mean for the future?

As structural engineers working on new builds, our focus should be to get our designs as close to (or hopefully better than!) this theoretical minimum as possible. Our current average is quite a lot higher than it needs to be and there will be many familiar factors that can lead to this. As shown, we need to work with and push the rest of the design team and client to make effective design choices, such as removing large transfers, eliminating tricky details and ensuring sensible slab spans where possible.

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> **THE DECISIONS WE MAKE TODAY WILL DEFINE THE ENVIRONMENTAL LEGACY OF OUR GENERATION**

Despite these actions, we will still soon hit our code-compliant minimums, and it may be time to get a bit more radical, by straying outside our 'business-as-usual' comfort zone and challenging some of the constraints put upon the structure by other stakeholders. A quick survey of colleagues provided the following examples where a 'carbon-focused' approach would likely lead to different design outcomes:

- →| The requirement for a second staircase above six storeys makes a lot of sense for safety reasons but the additional material, coupled with a loss of floorspace, has a notable impact on carbon intensity. Are better options available?
- →| Basements are often provided simply to satisfy planning requirements for parking, refuse and cycle stores. Given the impact these have on overall carbon intensity, they should be limited as much as possible.
- →| In London, the 30m limit on buildings before additional planning costs are incurred results in storeys being 'squeezed' into the envelope. Would a simple storey limit be more sensible than a seemingly arbitrary height, noting that cladding and heating costs will put a natural break on excessive storey heights anyway?
- →| While fire risk and water ingress in mass timber structures present design challenges, these can be mitigated through sensible design approaches – as is done in many parts of the world. Do we in the UK need to be braver and push these further as an alternative to concrete?
- →| Large parts of inner London consist of mansion blocks, mostly formed in loadbearing masonry; however, the disproportionate collapse limits make new structures over four storeys prohibitively difficult to achieve in masonry. Is this too restrictive? Finding ways of safely and easily allowing larger buildings of six to eight storeys to be constructed in masonry would potentially enable this to become the preferred material for many low- to medium-rise buildings again, avoiding huge amounts of concrete.

These are just some suggestions and there are likely to be many more.

The final point is that all paths to net zero are also heavily reliant on improvements and innovations in material science and production techniques. We should therefore ensure we work to support new technologies and promote and specify them wherever possible. The decisions we make today will define the environmental legacy of our generation. As engineers, equipped with both data and duty, we must lead by example – designing structures that are safe, efficient and truly sustainable for the future.

HAVE YOUR SAY

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