BCO

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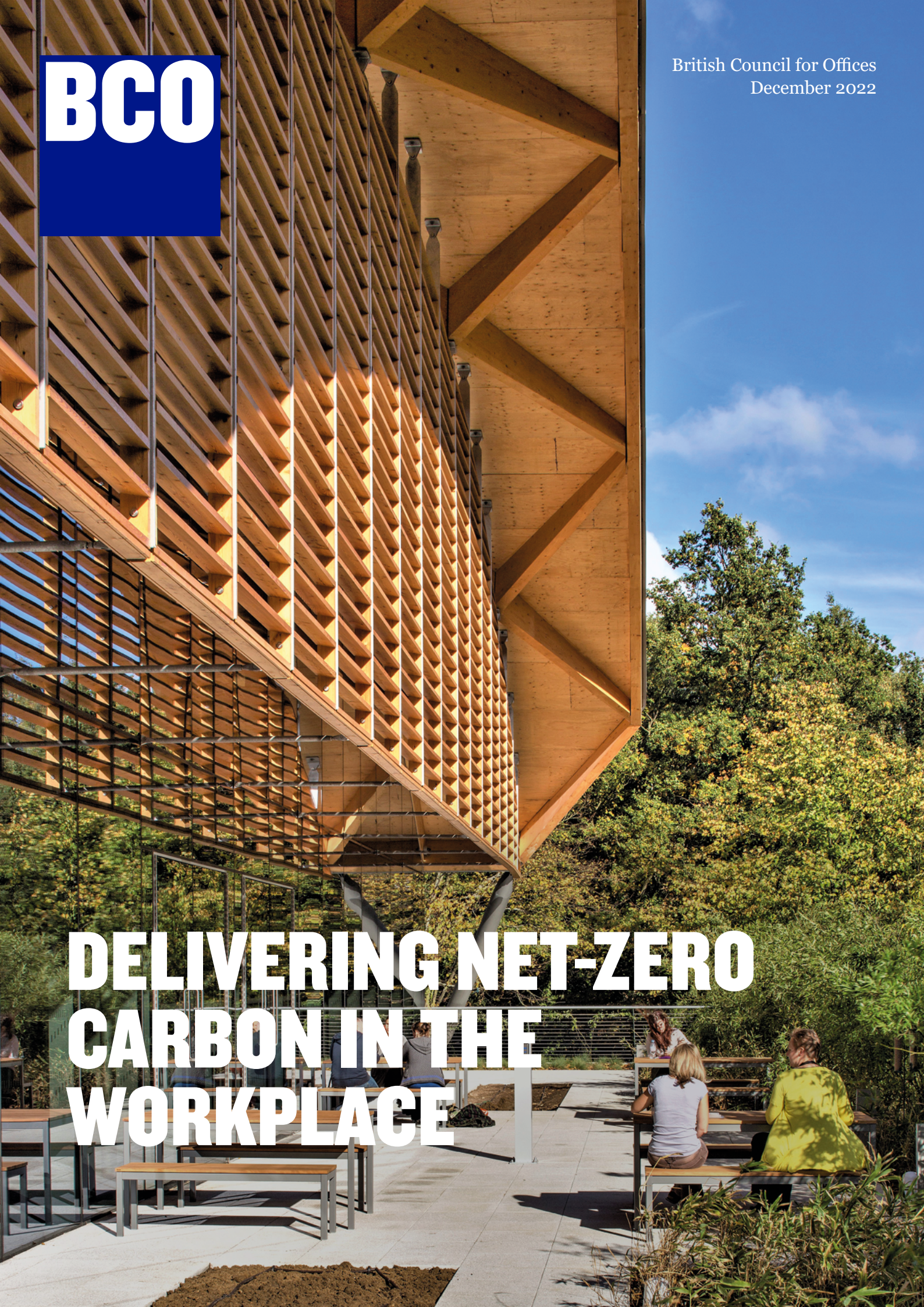

DELIVERING NET-ZERO CARBON IN THE WORKPLACE

ABOUT THE BCO

The BCO is the UK's leading forum for the discussion and debate of issues affecting the office sector. Established in 1990, its membership base comprises organisations involved in creating, acquiring or occupying office space, including architects, lawyers, surveyors, financial institutions and public agencies.

The BCO recognises that offices don't just house companies, they hold people and so what goes on inside them is paramount to workplace wellbeing.

ACKNOWLEDGEMENTS

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ABOUT THE AUTHORS

This report was written by Roderic Bunn (UCL IEDE and Inhabit), Anna Mavrogianni (UCL IEDE), Rayan Azhari (UCL Energy Institute) and Esfand Burman (UCL IEDE). Biographies of the authors are given on page 45.

COVER IMAGE *Living Planet Centre, WWF UK HQ. Courtesy of Hopkins Architects. Copyright Morley Von-Sternberg*

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CONTENTS

KEY MESSAGES

- A fundamental social and cultural change in our perception of the environmental quality of the workplace is required to achieve net-zero.
- The pursuit of net-zero greenhouse gas emissions is primarily driven by companies' environmental and social governance (ESG) objectives and increasing expectation from their customers, and ultimately the public, to respond to the climate emergency.
- Only around 12% of the business survey respondents took the view that commitments to net-zero operational carbon targets are being achieved in the building sector; 38% thought more needs to be done.
- 60% of the business survey respondents believe more needs to be done to meet embodied carbon commitments for building shell and core, services fit-outs, and fixtures and fittings.
- Survey respondents and interviewees issued a strong call for a more proactive approach from the government to facilitate the transition to net-zero buildings via mandatory requirements and financial incentives.
- Empirical evidence and robust tailored benchmarks are needed for both operational and embodied carbon. The ongoing industry-led initiative to develop a net-zero carbon buildings standard for the UK could help provide clear and consistent methodology along with supportive evidence.
- Improved green leases, pre-lets, and longer leases with tenants having more say over refurbishments were identified as key improvement measures. Greater flexibility in leasing arrangements requires careful attention to contractual arrangements.
- Greater energy and carbon accountability is essential, as is the ownership of energy management within corporate ESG strategies. More effective ESG frameworks require greater collaboration between landlord and building occupiers, along with data sharing and greater transparency.
- Occupier advisors and managing agents have a crucial role in communicating sustainability objectives. Initiatives such as the Managing Agents Partnership can help provide greater clarity, transparency and standardisation of professional sustainability services.
- There is a lack of verified net-zero targets, especially for tenant spaces. Net-zero targets must differentiate between different types of office and their intensity of operation.
- The property world's conventions for quoting energy use intensity (EUI) requires a rethink. EUI values are often quoted over gross floor area rather than net lettable area (NLA). The latter is more applicable to tenanted space. Even when energy targets are calculated over NLA, there is often a lack of robust and verifiable empirical data to support the targets.
- Although submetering is required under the UK Building Regulations, it is regularly not installed nor commissioned effectively to enable accurate disaggregation of energy consumption by end-uses.

11–21 Canal Reach, London
Courtesy of Bennetts Associates. Copyright Hufton+Crow

- Existing metering strategies in commercial offices that do not allow an effective disaggregation of energy use between landlord and occupier areas are a persistent problem.
- The use of locally sourced material with lower embodied carbon and verifiable Environmental Product Declarations (EPDs) must be prioritised, including recycled, reused and further recyclable office furniture.
- Clients and tenants must require building services system suppliers to provide estimates of the embodied carbon of their systems (e.g. conforming to the CIBSE TM65 methodology, *Embodied Carbon in Building Services*[1]).

Overall, the study has shown that many persistent and chronic shortcomings in building design, construction and operation need to be resolved if net-zero carbon targets are to avoid becoming hollow promises. These problems are perennial and familiar to most practitioners on both the demand and supply sides of building procurement. They may be boringly familiar but remain major barriers to achieving net-zero carbon in practice. They cannot be ignored, brushed off or allowed to continue unchecked. They will not self-correct simply because the energy-efficiency performance bar has been raised to net-zero.

The interviews and the business survey in this report clearly show the desire to deliver on the net-zero objectives in the commercial real estate sector. Fundamental changes in the way we procure buildings are required to make this happen. ■

EXECUTIVE SUMMARY

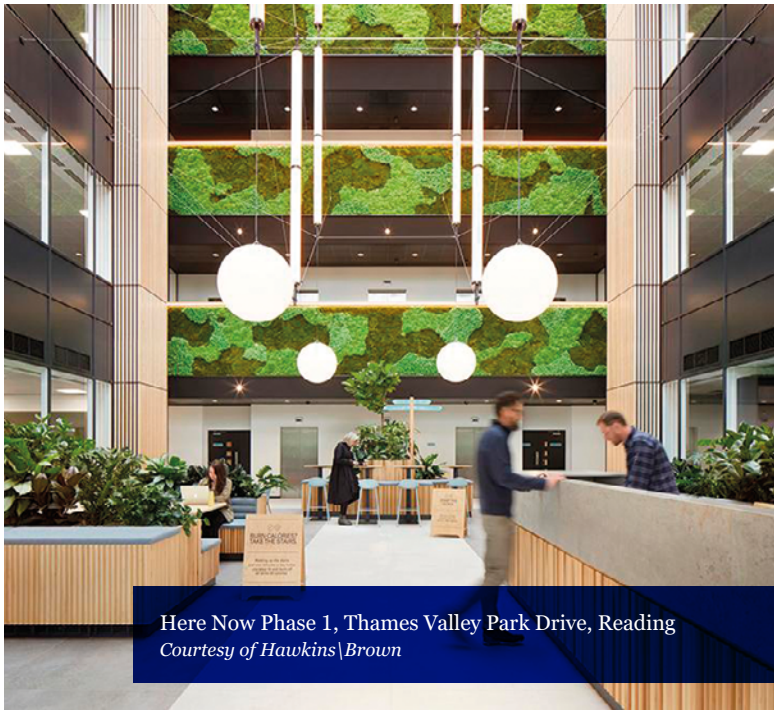
All sectors of the UK economy are required to achieve net-zero carbon emissions by 2050 – the abbreviated term 'net-zero' being the balance between the amount of greenhouse gases produced and the amount removed from the atmosphere. The UK construction industry has set itself goals to reach net-zero by 2030. For construction, net-zero requires the elimination of fossil fuels for building construction, fit-out, and operation by use of on-site and off-site renewable energy sources for all aspects of procurement.

Achieving net-zero carbon performance is increasingly a major component of environmental and social governance (ESG) in the commercial real estate sector. As 50% of the office building stock in the UK is tenanted, improving the energy performance of offices is particularly challenging. Such buildings tend to be heterogeneous in their in-built forms, their organisational infrastructures, and in the activities that go on inside them. Commercial relationships and interactions between landlords and tenants can also be significant factors in energy management.

This report presents a study carried out by UCL Consultants for the British Council for Offices (BCO). It examines where the carbon reduction opportunities lie in the commercial real estate sector, and how organisations can navigate the demands of regulators and other stakeholders. The report also identifies the key barriers that businesses are facing as they strive to pursue drastic reductions in carbon emissions.

As well as desk research and publicly available information, the project was informed by interviews and a business survey. Thirteen semi-structured interviews were conducted with building professionals involved in construction supply chains and building management to discuss their views about the drivers for, and barriers against, achieving net-zero in the building sector. The interviews were supported by an online business survey that was sent to the BCO membership. The survey was also made available to the memberships of the Chartered Institution of Building Services Engineers (CIBSE), the Low Energy Transformation Initiative (LETI) network and the Better Buildings Partnership (BBP). The survey received 102 responses from building professionals and occupiers.

The UK Green Building Council (UKGBC) Framework definition for net-zero, and the interim and Paris-proof targets set out for office base buildings and tenancies, emerged as the key metrics being adopted by the UK commercial real estate sector. However, the interviews revealed strong distinctions in the way organisations are approaching net-zero at the building level. Developers, designers and other professional practices directly involved in construction supply chains increasingly view net-zero building performance as an integral part of their value proposition to their clients, although commitment to net-zero needs to be verified with in-use performance for which sufficient data is not yet available. For most occupiers, however, building emissions are only one component, often a relatively modest one, of a much broader range of emissions they must consider. Moreover, organisations with strong ESG commitments are increasingly using Science Based Targets' *SBTi Corporate Net-Zero Standard*[2] to set emissions targets consistent with the 1.5°C global temperature rise scenario.



Here Now Phase 1, Thames Valley Park Drive, Reading
Courtesy of Hawkins\Brown

These distinctions have important implications for measures being adopted at the building level. The measures chosen depend on the contribution of real estate to overall emissions calculations, and the cost-effectiveness of those measures. For example, clients may opt to purchase green power and invest in carbon offsetting schemes rather than conduct deep (low-carbon) retrofits of their buildings, although there are important questions about the additionality of the green power and the credibility of these schemes that need to be addressed. Another problem is energy use intensity (EUI). The EUI values are often quoted for the gross floor area, not the net lettable area (NLA), which is more applicable to tenanted space. Even when energy targets are calculated over NLA, there is often a lack of robust and verifiable empirical data to support the targets and ways to achieve them.

Overall, two overarching themes emerging from the interviews were:

- Robust benchmarks and empirical data are required for net-zero commercial offices.
- Mandatory requirements and incentives from the government are essential to support the current market trends and achieve the critical mass required to facilitate the transition to net-zero.

The business survey echoed these findings in several ways. Respondents were generally positive about their organisational commitments and efforts made to achieve net-zero. However, only around 12% took the view that commitments to net-zero operational carbon targets are being achieved in the building sector, and 38% thought more needs to be done.

The feedback received for embodied carbon shows that more than 60% of respondents believe more needs to be done to meet embodied carbon commitments for building shell and core, services fit-outs, and fixtures and fittings.

Around 40% of survey respondents also thought the ESG objectives should be better aligned with net-zero carbon aspirations. Improved green leases, pre-lets and longer leases with tenants having more say (and with greater transparency) over refurbishments were identified as improvement measures. However, the emerging pattern since the COVID-19 pandemic suggests the market is heading towards more flexible leasing arrangements. This requires careful attention to contractual arrangements and energy and carbon accountability. Generally, there was a consensus that clear and standard definitions would help, along with legally binding commitments. Several respondents also highlighted the role of education and further collaboration to achieve better alignment of net-zero objectives.

Several drivers for and barriers against achieving net-zero performance in buildings were identified from the interviews and survey comments. This report provides a summary of the key challenges along with recommended actions. These were also informed by the authors' experience of building performance evaluations.

The key challenges and recommendations are itemised for existing office buildings, retrofits and fit-outs.

EXISTING BUILDINGS

A key challenge identified in both the interviews and the business survey is a lack of verified net-zero targets for the EUI of different types of offices, especially tenant space.

Although the UKGBC has issued interim and Paris-proof energy targets for tenant office space per NLA, these targets currently do not differentiate between different types of office and intensity of operation. This can make it difficult for building users to evaluate their current performance and improvement opportunities to get to net-zero operational performance.

Another challenge is that the existing metering strategies do not allow an effective disaggregation of energy use between landlord and occupier areas, a persistent problem across the built environment. Although this chronic problem is being addressed by the NABERS UK scheme,[3] the scheme itself is new and, in practice, currently mainly applies to high-end office buildings. It will take some years before enough evidence is gathered to know whether the problem is being solved by voluntary certification. Outside of NABERS UK, dysfunctional metering remains a problem in the vast majority of existing UK office buildings, many occupiers of which are attempting to adopt net-zero targets without knowing when and where their power is being consumed. Getting the metering strategy right must be the first step, and, if used appropriately, the data generated can often show easy routes to energy reduction.

It is helpful to view the UKGBC's or any similar EUI values as guidelines rather than as deterministic targets, before working out what is feasible given the actual building context. A simple energy monitoring and targeting (M&T) programme can yield significant savings in most new and existing offices that may be underperforming against either design expectations (the oft-quoted 'performance gap') or against prevailing best-practice energy benchmarks for offices. Savings can often be made at low or zero cost.

100 Liverpool Street, London
Courtesy Hopkins Architects. Copyright Janie Airey

The following measures can help building users improve the operational energy performance of their buildings and find a tailored pathway to net-zero:

- Clearly define energy ownership within the occupying organisation as part of the ESG strategy.
- Agree on a framework for collaboration with the landlord and other building occupiers. It is vital to agree on performance targets, these being progressive if appropriate. Even if this is not legally possible due to uncertainties, it is important to ensure the agreement promotes data sharing and transparency.
- Review the existing metering strategy for the building and attempt a reconciliation of energy sub-meter readings with the main meters. Resolve disparities to an acceptable level of accuracy (e.g. ±5%).
- Instigate an energy M&T programme defining the baseline year, net-zero guideline values and benchmarks available for offices. Identify the improvement opportunities for operational energy use through the M&T programme.
- Review annual energy performance regularly at different levels of disaggregation (e.g. total electricity use, heating, cooling, lighting, small power) to an appropriate level of additional granularity (e.g. hourly, daily, monthly). Review against the intensity of use and hours of occupation to identify improvement opportunities.
- Review regularly the existing performance against net-zero operational targets, and determine the necessary interventions to approach these targets by further incremental improvements and retrofit measures. It is also important to evaluate the cost and the embodied carbon of intervention measures to avoid unintended consequences.

The trend of underutilisation of office space after the COVID-19 pandemic was a concern raised in the interviews. Post-COVID changes in office utilisation[4] justify analysis of the savings possible from rationalising space and introducing demand-control strategies for energy-consuming systems. Changes to zone control strategies for systems such as ventilation and lighting may be required to ensure net-zero performance targets are not compromised by wasteful operation.

RETROFITS

Deep retrofit of office buildings, including measures that involve façade systems, is a particular challenge in commercial offices. This is due to technical uncertainties and the disruptive nature of such interventions in a commercial environment. Furthermore, it is vital to strike the right balance between operational and embodied carbon when improving building façades.

The funding of retrofit measures in multi-tenant buildings is also a financial challenge that needs to be tackled. There is currently considerable doubt (and often dispute) between landlords and leaseholders over the division of funding responsibility for net-zero improvements, particularly for short-term leases.

The following measures and trends can support retrofit projects:

- Follow the UKGBC framework for *delivering net-zero through commercial retrofits*.
- Identify a tailored net-zero pathway for operational and embodied carbon for a building (including tenanted space), considering the useful life of the building façade and plant equipment, potential operational savings and the embodied carbon of the suggested interventions.
- Define a collective mechanism for funding improvement interventions between the landlord and occupier(s), taking into account upfront funding through the service charge and/or a funding contribution commensurate with the benefits achieved. The mechanism must be clearly defined and legally binding.
- Consider careful phasing and use of prefabricated components to minimise on-site interventions in refurbishments, particularly where façade systems are involved. Such a strategy can also contribute to a circular economy through design for disassembly of prefabricated components. Upgrading of existing fabric components, however, should, when possible, take place on-site to avoid delays and minimise transportation emissions.
- Advances in building information modelling make it possible to link the digital twin of a building to a materials passport database. This is especially helpful in deep retrofits, where there is often an extensive list of materials. A project's budget must cover the development and ongoing management of a digital twin if it is to have any purpose or value after handover. Justification for a digital twin may lie in an occupier using it to demonstrate ongoing conformance to its ESG objectives.
- Plan for monitoring and performance verification to evaluate the real effects of the retrofit after handover (after all fit-out works, any phased occupation and resolution of defects, including sub-meter reconciliation).

Note that verification of net-zero performance achievements may require the definitions of 'practical completion' and 'outstanding defects' to be worded more appropriately to the shared expectations.

EightyFen, London
Courtesy of tp bennett. Copyright Hufton+Crow

FIT-OUTS

The material waste in ripping out Category A (Cat A) fit-out in favour of a bespoke Cat B fit-out by tenants was highlighted in several interviews and survey comments. Another key challenge identified was the uncertainties around embodied carbon of material, building services systems and office furniture.

The following measures and trends can support environmentally friendly fit-outs:

- Pre-let and long lease agreements – these typically involve large occupier organisations that wish to completely craft the space to suit their needs, and would be happy with a shell and core building to start.
- Cat A or Cat A+ (plug and play) fit-outs for shorter and more flexible tenancies – given the market trend after the COVID-19 pandemic, it is envisaged that most office spaces will benefit from these fit-outs.
- Prioritising the use of locally sourced material with lower embodied carbon and verifiable EPDs.
- Asking building services system suppliers for an estimation of the embodied carbon of their systems (preferably requiring the adoption of the CIBSE TM65 methodology, *Embodied Carbon in Building Services*[1]).
- Considering the use of platforms such as Globechain to offer and source stripped-out materials and systems.
- Considering the use of recycled, re-used and further recyclable office furniture – inform workers and clients about the environmental benefits. ■

INTRODUCTION

CONTEXT

Achieving net-zero carbon performance is increasingly a major component of environmental and social governance (ESG) in the commercial real estate sector. As 50% of the office building stock in the UK is tenanted, improving the energy performance of offices is particularly challenging. Such buildings and their occupiers tend to be heterogeneous in their in-built forms, their organisational infrastructures and the activities that go on inside them. Commercial relationships and interactions between landlords and tenants can also be significant factors in energy management.[5]

The significance of the carbon locked into construction materials, products, furniture, fixtures and fittings (the embodied carbon) rises as the carbon dioxide emitted during building operation (the operational carbon) is reduced, thanks to energy-efficiency measures and the adoption of renewable energy technologies. A key question, however, is whether building occupiers and other stakeholders are aware of the effect they have on the amount of embodied carbon in their offices, let alone equipped to make informed decisions about reducing their carbon burden.

This report presents a study carried out by UCL Consultants for the BCO to examine where the carbon reduction opportunities lie in the commercial real estate sector, and how organisations can navigate the demands of regulators and other stakeholders. The report identifies the key barriers that businesses are facing as they strive to pursue drastic reductions in carbon dioxide emissions.

All sectors of the UK economy are required to achieve net-zero carbon emissions by 2050 – the abbreviated term 'net-zero' being the balance between the amount of greenhouse gases produced and the amount removed from the atmosphere. The UK construction industry has set itself goals to reach net-zero by 2030, as described elsewhere in this report. For construction, net-zero requires the elimination of the use of fossil fuels for building construction, fit-out and operation by use of on-site and off-site renewable energy sources for all aspects of procurement.

AIMS AND OBJECTIVES

The aim of this study was to engage with building occupiers and building professionals to better understand their perspective and to identify the barriers and opportunities that exist in the transition to net-zero performance.

The key objectives of the study were to:

- identify the approaches taken to deliver on the net-zero carbon targets in the construction industry and the real estate sector through a review of the latest evidence in the literature
- carry out semi-structured interviews with occupiers and building professionals to provide a more in-depth understanding and analysis of their perspectives and requirements
- carry out a survey of a cross-section of stakeholders to identify the drivers for and barriers against achieving net-zero carbon targets in the commercial office sector
- review the current arrangements made in three case studies that have adopted different approaches to deliver on the net-zero targets.

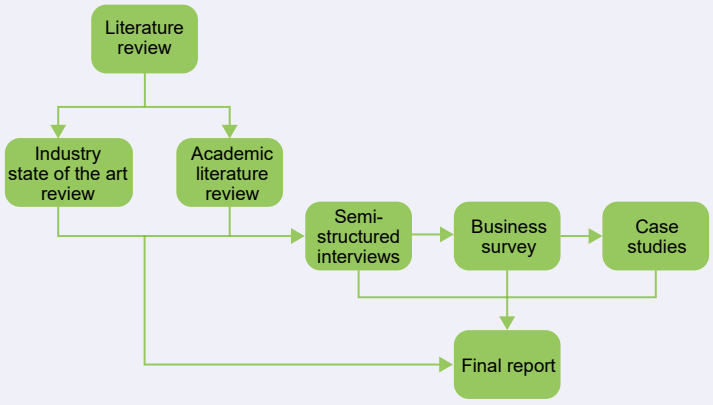


Figure 1
Research approach.

RESEARCH APPROACH

The project is informed by the following qualitative research methods, in addition to desk research of publicly available information reviewing the state of the art in the industry and the latest academic literature in the field, as shown in Figure 1.

- *Interviews*. Semi-structured interviews were conducted with stakeholders representing occupiers and building professionals. The interviews helped researchers identify the latest trends in the industry, and gain insights from key stakeholders into the drivers for and barriers against achieving net-zero building performance in the commercial office sector from both the operational and embodied carbon perspectives.
- *Business survey*. An online business survey was subsequently developed and deployed to seek feedback from a more representative sample of professionals around the themes identified in the interviews.
- *Case studies*. Case studies were sought to provide a review of the state-of-the-art in procuring buildings with net-zero aspirations. An appropriate case study was defined as providing good practice measures for operational and embodied carbon, relevant performance targets and key lessons that may have wider applicability in the industry.

  Three case studies were identified in the interviews with design professionals to provide examples of the state-of-the-art in the construction industry. These buildings are not completed and therefore verified operational figures were not available at the time of writing. Nonetheless, the performance targets set out by the design teams, and the measures used to achieve operational and embodied carbon targets, are representative of the best practice currently used in the industry. The case studies are presented in Appendix B. ■

BACKGROUND

LITERATURE REVIEW OBJECTIVES AND SEARCH STRATEGY

A review was carried out of the industry policy documents and guidelines, along with a high-level analysis of the peer-reviewed academic publications.

The focus of the industry review was the frameworks and guidance documents published by the key institutions and professional bodies driving the net-zero agenda in the UK construction industry. Much of the information reported is already in the public domain. Where appropriate, therefore, the review includes some critical analysis of the material, rather than just simple repetition.

For the purposes of the high-level academic review of the literature, combinations of the keywords 'net-zero', 'energy', 'occupier', 'tenant' and 'office' were used in the Web of Science platform to identify peer-reviewed papers in scientific journals and conference proceedings. The search was limited to papers in the English language published since 2010.

The literature review informed the development of the business interview questions and the survey questionnaire, and also helped in identifying stakeholders for interviews and suitable case studies.

Cadworks, Glasgow
Courtesy of Cooper Cromar

INDUSTRIAL AND COMMERCIAL LITERATURE

This section provides an overview of the institutions, professional bodies and schemes that have contributed to net-zero frameworks, along with their respective guidance documents, to represent the plethora of existing approaches to net-zero buildings in the industry.

BETTER BUILDINGS PARTNERSHIP (BBP)

The BBP is a collaboration of the UK's leading commercial property owners working together to improve the sustainability of existing commercial building stock. The BBP states its objective as 'supporting members and the industry to deliver excellent operational building performance'.

The BBP produces the Real Estate Environmental Benchmark (REEB), a set of operational energy benchmarks using the annual consumption data from BBP members' property portfolios. The REEB five-year report showed a clear trend of energy reduction in BBP members' office buildings. The total energy use was reported as having improved by 26% in the previous nine years, with an annual reduction rate of 3.7%.[6] However, these reported trends were based on a small number of large offices that may not represent the whole office stock.

In 2019, the BBP launched its climate commitment, the Net Zero Carbon Pathway Framework.[7] This commitment led to 27 signatories covering over 11,000 properties in the UK. The initiative lays down the transformation required across the real estate sector to deliver net-zero buildings by 2050. It requires signatories to publish net-zero carbon pathways and delivery plans, disclose their assets' energy performance and develop comprehensive climate resilience strategies.

The UK's lack of a rating scheme to disclose operational energy performance in the commercial sector encouraged the BBP to support a UK version of the Australian energy rating scheme (NABERS). The scheme promotes the voluntary rating and disclosure of UK offices' operational energy efficiency.[3, 8]

NABERS UK

NABERS originated in New South Wales in 1998 as the Australian Building Greenhouse Rating (ABGR), before being incorporated into the federal NABERS scheme and extending nationwide in 2009.[9, 10]

The NABERS Commitment Agreement framework was introduced in 2002 for new Australasian office buildings and major refurbishments. It requires clients, developers and their teams to sign up to a NABERS Commitment Agreement to design, construct and manage buildings to achieve agreed levels of actual in-use energy performance.[9]

NABERS is based on 12 months of metered energy data adjusted for local weather conditions and hours of use, converted to carbon emissions and normalised by floor area. Energy performance was represented initially on a 1–5 star scale, with 2.5 stars representing average performance and 4.5 stars representing industry 'best practice'. A sixth star was added in 2011 as the performance of Australasia's commercial buildings had improved. The 6-star rating marks the halfway point between 5 stars and net-zero carbon emissions.

NABERS rates the building as a whole, but it also separates the 'base building' controlled by the landlord from the space occupied by the tenant (the tenancy rating). It requires an energy metering structure that separates the landlord's services from the tenant's energy uses. Such separation is common in Australia but not in the UK. Although submetering is required under UK Building Regulations, it is regularly not installed or

commissioned effectively to enable accurate disaggregation of energy consumption by end-uses.[11]

A UK version of the NABERS scheme was launched in the UK in 2020, initially to cover landlord (i.e. base building) energy services. Championed by the BBP, the NABERS UK scheme (incorporating the Design for Performance methodology inspired by the NABERS Commitment Agreement in Australia[12]) aims to help bridge the performance gap between the design and operational energy performance of offices in the UK. At the time of writing this report, fourteen office projects were categorised as NABERS UK pioneers by the certifying authority, with a further seventeen office projects categorised as Design for Performance projects.[13]

The NABERS UK Design for Performance is a voluntary mechanism that has three requirements:

- Advanced dynamic simulation, including detailed modelling of heating, ventilation and air-conditioning (HVAC) systems, indicating that a design can achieve the proposed rating.
- Review of design documentation and the simulation model by members of a Building Research Establishment (BRE) Independent Design Review Panel.
- After construction, validation of the in-use energy performance against the design prediction, and the subsequent award of a NABERS UK base-building star rating.

In July 2022, the BBP announced that the NABERS UK scheme will be extended to cover whole buildings and tenancies. As with the base-building NABERS ratings (and the achievement of any other net-zero performance targets), in-use verification will rely heavily on the quality, accuracy and reliability of the energy submetering systems installed for the landlord services and tenants' services. Accurate reconciliation of sub-meters with the fiscal metering installed by the energy supplier(s) will also be a conditional requirement.

While NABERS UK is not strictly a scheme for achieving net-zero operational energy performance, it is perfectly possible to use it with net-zero operational energy targets. Although, at the time of writing, NABERS UK applies only to offices rather than all types of non-domestic buildings, in theory there are no technical or skills barriers to its wider implementation. However, NABERS UK (and the Design for Performance methodology) demands a level of technical expertise and resources that are not normally available on modest construction projects and/or those with tight cost caps (such as centrally funded schools). On such projects the design and construction teams are largely, if not wholly, focused on achieving minimum standards of regulatory compliance at the point of design, pertaining to the Building Regulations covering conservation of fuel and power (e.g. Part L2A, 2022 edition). The regulatory requirements are far less stringent than required under NABERS UK.

UK GREEN BUILDING COUNCIL (UKGBC) GUIDANCE

The UKGBC has published a raft of guidance relating to the net-zero imperative. The UKGBC is a charity of 600 member organisations established to offer clarity, cohesion and leadership to the disparate construction and property sectors, and to campaign for a sustainable built environment.

Two publications are particularly relevant to the net-zero topic as it affects office developers and occupiers alike: *Net Zero Carbon Buildings: A Framework Definition*,[14] and *Embodied Carbon: Developing a Client Brief*.[15] The former was assembled by an industry task group of businesses, trade associations and non-profit organisations and was published in April 2019. The latter guide, issued in March 2017, is aimed at those with limited knowledge of embodied carbon who need to write effective briefs for commissioning embodied carbon evaluations.

Two more recent UKGBC publications provide practical guidance as to how net-zero could be achieved in new and existing offices. The first was a guidance document entitled *Building the Case for Net Zero*,[16] published in September 2020. It provides a feasibility study method for the design, delivery and cost of new net-zero carbon buildings. It presents the improvements required to meet net-zero embodied and operational targets using a modelling approach and compares the required improvements against a baseline office design (a current standard practice office building). The guidance suggests an estimated cost premium of 8–17% for a baseline office design to get to net-zero, depending on the range of measures used to improve both embodied and operational carbon. The second publication is guidance for existing offices, *Delivering Net Zero: Key Considerations for Commercial Retrofit*,[17] published in May 2022, which provides a framework for light and deep retrofits in the commercial office sector.

UKGBC, *Net Zero Carbon Buildings: A Framework Definition*

The UKGBC net-zero framework provides clear definitions for both net-zero operational energy and net-zero embodied carbon.[14] The UKGBC defines operational net-zero as:

> *When the amount of carbon emissions associated with the building's operational energy on an annual basis is zero or negative. A net-zero carbon building is highly energy-efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset.*

It defines embodied carbon as the total greenhouse gas emissions generated to produce a built asset. This includes emissions caused by extraction, manufacture/processing, transportation and assembly of every product and element in the asset. Net-zero embodied carbon is therefore achieved:

> *When the amount of carbon emissions associated with a building's product and construction stages up to practical completion is zero or negative, through the use of offsets or the net export of on-site renewable energy.*

Both definitions rely on two key variables to turn carbon-positive budgets into net-zero: the amount of energy generated on-site that can be exported and the use of carbon offsets. The veracity of calculations of net-zero therefore depends, to a lesser or greater degree for each project, on:

- accurate monitoring and reporting of on-site zero-carbon energy exported over the life of the building
- how carbon offsets are calculated

- the evidence to support the claimed value of the carbon offsets
- the longevity of those offsets underpinning the period assumed or otherwise used in the original project calculations of net-zero
- the monitoring and verification procedure for quality assurance tracking purposes.

It is important to note that the UKGBC was careful to draw distinctions between a building's gross internal area (GIA) and net lettable area (NLA). It is therefore recommended that tenant energy use and associated carbon dioxide emissions in net-zero calculations and declarations are calculated over NLA to avoid double-counting with respect to other tenancies and landlord/building owner areas.

Table 1 shows the energy targets laid down in the 2019 UKGBC report,[14] along with equivalent Display Energy Certificate (DEC)[a] and NABERS UK ratings for public and commercial offices, respectively. Note that the 2025 and 2030 target values do not match the Royal Institute of British Architects (RIBA) sustainable outcome metric targets (see page 14), as the RIBA values do not distinguish between GIA and NLA area metrics, nor is tenant energy disaggregated from the whole-building energy. As such, the UKGBC values may be more applicable to commercial offices. It should also be noted that DEC and NABERS UK rating schemes allow for extended hours of use and for special uses, offering a more tailored approach to individual public and commercial offices. Figure 2 shows the suggested incremental improvements in DEC and NABERS UK certifications for public and commercial buildings, respectively.

In its client guide for embodied carbon,[15] the UKGBC lays down specific requirements for construction clients. These requirements are broadly transferable to occupiers in terms of decision-making required to achieve net-zero ambitions in their premises developments and business activities:

- Clarify the client's corporate goals for net-zero carbon and circular economy[b] developments that embrace embodied carbon reductions.
- Develop financial structures within a developer's business for allocating funds across research and development and pilot projects.

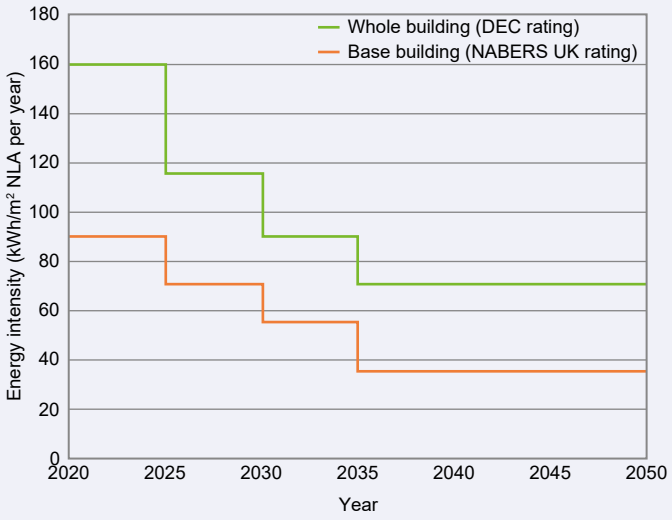


Figure 2
UKGBC trajectory of tightening energy performance targets.
Source: UKGBC, Delivering Net Zero: Key Considerations for Commercial Retrofit[18]

- Identify employees across the client's business who will be responsible for net-zero carbon, circularity and embodied carbon performance outcomes.
- Specify in project briefs that developments will have low embodied carbon, adopting the principles of reuse and refurbishment over new build, and requiring a comprehensive embodied carbon-reduction strategy, stipulating embodied carbon performance targets.
- Appoint design teams (designers and contractors) with experience of conducting embodied and whole-life carbon analysis and reduction strategies
- Specify contracts for embodied elements that the principal contractor will monitor and report as being 'as constructed', and in so doing demonstrate compliance with embodied carbon performance targets.

These requirements link to the non-domestic building targets in the *RIBA 2030 Climate Challenge*[19] and whole-life carbon targets guidance (see page 14).

Scope	Metric	Interim target			Paris-proof target 2035–2050
		2020–2025	2025–2030	2030–2035	
Whole-building energy	kWh_e/m^2 NLA per year	160	115	90	70
	kWh_e/m^2 GIA per year	130	90	70	55
	DEC rating	D90	C65	B50	B40
Base-building energy	kWh_e/m^2 NLA per year	90	70	55	35
	kWh_e/m^2 GIA per year	70	55	45	30
	NABERS UK star rating	4.5	5	5.5	6
Tenant energy	kWh_e/m^2 NLA per year	70	45	35	35

GIA, gross internal area; NLA, net lettable area.

Table 1
UKGBC's energy performance pathways to net-zero for buildings targeting net-zero carbon for operational energy[18]

[a] An operational energy rating scheme that is mandatory for public buildings.

[b] The circular economy is based on three principles driven by design: eliminate waste and pollution, circulate products and materials (at their highest value), and regenerate nature.

THE LONDON PLAN 2021

The Mayor of London declared a climate emergency in 2018 and set ambitious goals for London to be a zero-carbon city by 2030.[20] The London Plan 2021[21] is the spatial development strategy for Greater London. It sets out a framework for how London will develop over the next 20–25 years and the Mayor's vision for Good Growth. The Plan is part of the statutory development plan for London, meaning that the policies in the Plan should inform decisions on planning applications across the capital. Local borough plans must be in general conformity with the London Plan.

One element of the Plan is the 'Be Seen' post-construction monitoring requirement for the planning, design, construction, delivery and operation of new major developments[c].[22] The Be Seen requirement demands monitoring and reporting of the actual operational energy performance of major developments for at least five years via a Be Seen monitoring portal. This requirement establishes monitoring as good practice, enabling developers and building owners to understand their buildings better and identify methods for improving energy performance from the project inception stage and throughout the building's lifetime. This policy recognises that to achieve truly net-zero carbon buildings their actual operational energy performance needs to be better understood.[22]

LOW ENERGY TRANSFORMATION INITIATIVE (LETI)

LETI is a network of over 1,000 built environment professionals working together to put the UK on the path to a zero-carbon future. The LETI group has published a large number of guides, all of which are freely available via the LETI website,[d] ranging from one-page documents on net-zero definitions and targets (operational and embodied) to more detailed guidance on achieving net-zero aimed at practitioners. A selection most applicable to office owners and occupiers is discussed below.

LETI Climate Emergency Design Guide

In January 2020, the LETI group published the *LETI Climate Emergency Design Guide*.[23] The publication gives guidance on delivering both operational and embodied net-zero carbon outcomes. For operational net-zero, the LETI guidance includes the carbon dioxide and equivalent global warming potential (GWP) of gases associated with the in-use operation of a building. This not only covers the carbon dioxide emissions associated with heating, hot water, cooling, ventilation and lighting systems, but also those associated with cooking, equipment and lifts (i.e. both regulated and unregulated energy uses).

The LETI definition of embodied carbon (Figure 3) includes the emissions associated with the extraction and processing of materials and the energy and water consumption used by the factory in producing products and constructing the building. It also includes the in-use stage (maintenance, replacement and emissions associated with refrigerant leakage) and end-of-life stage (demolition, disassembly and disposal of any parts of a product or building), plus any transportation relating to the above.

LETI published a supplement to the *LETI Climate Emergency Design Guide*[23] covering embodied carbon: the *LETI Embodied*

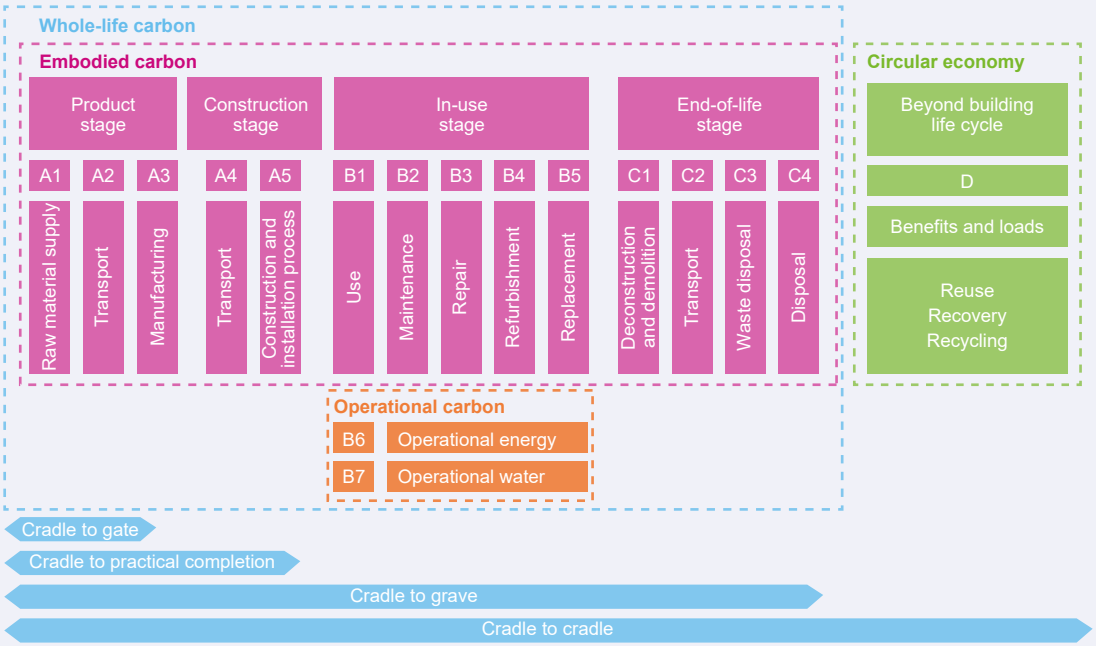


Figure 3
LETI definitions for whole-life and embodied carbon.
Source: LETI Climate Emergency Design Guide[23]

[c] Major developments, under the London Plan, are generally defined as: (1) the development of dwellings where 10 or more dwellings are to be provided, or the site area is 0.5 ha or more; and (2) the development of other uses, where the floor space is 1,000 m² or more, or the site area is 1 ha or more.

[d] LETI: https://www.leti.uk/publications (accessed 15 November 2022).

Carbon Primer.[24] The supplementary guidance set the requirements as best practice targets for embodied carbon, with buildings to be made from reused materials that can be disassembled at the end of life in accordance with circular economy principles. This guidance was expanded upon in the *LETI Client Guide for Net Zero Carbon Buildings*[25] (see below).

Although the LETI definition of net-zero, for both operational and embodied carbon, is building area agnostic, most references are for GIA. However, as with the UKGBC guidance, adoption of LETI net-zero calculations by office occupiers will need to reference tenanted NLA, both to avoid double counting of emissions from elsewhere and to avoid inflating area metrics to improve the carbon emission values.

LETI Client Guide for Net Zero Carbon Buildings

In August 2021, LETI published the *LETI Client Guide for Net Zero Carbon Buildings*.[25] The guidance pulls together key findings and recommendations from numerous LETI publications covering the ways in which the processes of briefing, design, procurement, construction, occupation, management and valuing of building development must change to fulfil zero-carbon objectives.

On new build, the *Client Guide* defines net-zero carbon in operation as a building that does not burn fossil fuels, is 100% powered by renewable energy, and achieves a level of energy performance in-use in line with the UK national climate change targets. The *Client Guide* requires all new buildings to be designed by 2025 to deliver operational net-zero carbon. Consequently, LETI calls for the whole construction industry to be equipped with the knowledge and skills necessary to hit this target.

On embodied carbon, the *Client Guide* restates the requirements laid down in the earlier *LETI Embodied Carbon Primer*,[24] stating that best practice targets for embodied carbon should be met. Buildings should also be made from reused materials, and designed and constructed in such a way that enables disassembly at end of life, in accordance with circular economy principles.

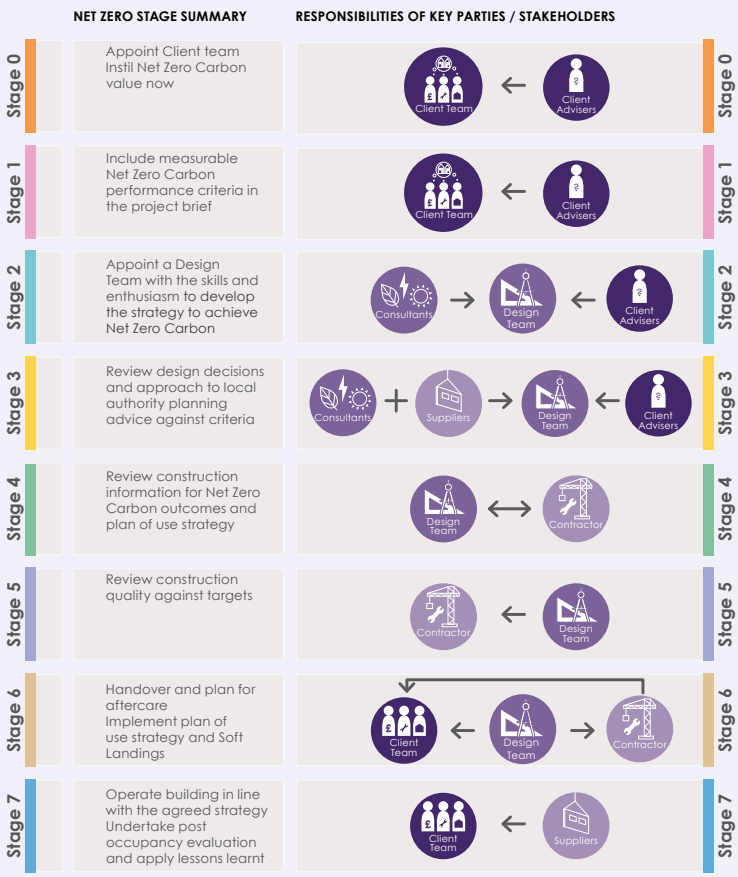


Figure 4
The LETI client procedure mapped against the 2018 RIBA Plan of Work. The LETI Client Guide provides extra detail on requirements for each RIBA stage.
Source: LETI Client Guide for Net Zero Carbon Buildings[25]

LETI recommendations for commercial offices

The LETI guidance stipulates the following operational net-zero design measures for commercial offices:

- enhanced envelope thermal insulation with mechanical ventilation and heat recovery (MVHR)
- maximum approx. 10 W/m² peak heat loss (including ventilation losses)
- use of European Water Label (EWL) compliant hot water outlets (e.g. certified 6 l/min shower heads, not using flow restrictors)
- use of room water-source heat pumps (WSHP) to provide heating and cooling (both sourced from a heat-sharing network operating at 15–25°C), which allows redistribution and reuse of waste heat within a building
- all-electric services, using room-exposed thermal mass to smooth peak demands by 25%
- connection to a community-wide heat-sharing network to allow any excess heat from cooling to be made available to other buildings, in particular, difficult-to-upgrade residential building stock with residual heating and domestic hot water (DHW) demand.

As part of the process for achieving the requirements for commercial offices, LETI laid down specific recommendations on data gathering and reporting (Figure 4):

- ensure data upload and access can be automated through other platforms by including a web accessible application programming interface (API)
- check information as it is inputted and provide feedback to catch mistakes
- apply an average annual grid carbon factor to fuel consumption to estimate carbon dioxide emissions
- provide simple email messaging to remind users about reporting due dates
- for existing buildings, encourage and allow voluntary upload of energy consumption
- encourage voluntary sharing of further detail, such as breakdown of consumption by end-use, by landlord areas and tenancies, and by any unusual energy-intensive activities.

INSTITUTIONAL GUIDANCE

Several professional institutions have published guidelines for net-zero for their members. For example, RIBA has defined voluntary performance targets for operational energy use and embodied carbon, in addition to water use, in the context of the climate emergency. The *RIBA 2030 Climate Challenge*[19] provides a set of performance outcome targets for RIBA Chartered Practices to aim towards. Figure 5 shows the target metrics set out for new-build offices. The targets are based on GIA and can be achieved using a 'fabric first' approach for operational energy followed by energy efficiency measures and on-site renewables. For embodied carbon, whole-life carbon analysis (WLCA) is recommended, following the guidance published by the Royal Institute of Chartered Surveyors (RICS).[26] It is also recommended that circular economy strategies are used, and that carbon offsetting is used only as a last resort. CIBSE together with LETI has also published *Net Zero FAQs: What Does Net Zero Mean?*[27] to clarify net-zero definitions for operational and embodied carbon and ensure these definitions are used consistently in the industry.

CONSTRUCTION LEADERSHIP COUNCIL PERFORMANCE FRAMEWORK

The Construction Leadership Council (CLC) is a government-led body co-chaired by the Minister for Business and Industry at the Department for Business, Energy and Industrial Strategy (BEIS). It works with government and industry organisations to promote a range of industry-improvement initiatives and runs twelve workstreams that 'work collaboratively to address the biggest issues facing the industry'.

In terms of net-zero, the CLC published a performance framework[28] in November 2021 that laid down some basic requirements for operational and embodied energy. The guidance states that, from 2025, emissions from new commercial buildings should be reduced by at least 27% compared with 'current standards'. The current standards are not defined, but may be taken to mean minimum standards prevailing in the Building Regulations covering conservation of fuel and power (Approved Document L). For example, in terms of the construction process, the CLC called for 78% of diesel plants to be eliminated from construction sites by 2035.

The performance framework includes a sector-level dashboard[29] that reports on progress towards net-zero. It is aimed at motivating businesses to take action. The CLC collates data for the dashboard on a quarterly basis (although not every metric will be available quarterly). The data itself will be drawn from sources that already aggregate it, known as data-point owners. Figure 6 shows an example of the dashboard published in March 2022 (the latest available at the time of writing).

CLC Priority 8 covers the net-zero targets. Some objectives are derived from Construction Industry Council (CIC) targets (aka data points). At the time of writing this report, data on Priority 8 progress was "under collection", as were many other priority areas. Priority areas quoting percentage improvements over time are largely confined to training and qualification initiatives, and energy and emissions improvements to domestic dwellings achieved under the Building Regulations.

On embodied net-zero, the CLC is relatively vague in its ambitions compared with, for example, the LETI and RIBA requirements. It merely states that it will support the development of innovative low-carbon materials, and advance low-carbon solutions for

RIBA Sustainable Outcome Metrics	Business as usual (new build, compliance approach)	2025 targets	2030 targets	Notes
Operational energy kWh/m² per year	130 kWh/m² per year DEC D (90)	<75 kWh/m² per year DEC B (50) and/or NABERS Base build 5	<55 kWh/m² per year DEC B (40) and/or NABERS Base build 6	Targets based on GIA. Figures include regulated and unregulated energy consumption irrespective of source (grid/renewables). 1. Use a 'Fabric First' approach 2. Minimise energy demand. Use efficient services and low carbon heat 3. Maximise onsite renewables
Embodied carbon $kgCO_2e/m^2$	1400 $kgCO_2e/m^2$	<970 $kgCO_2e/m^2$	<750 $kgCO_2e/m^2$	Use RICS Whole Life Carbon (modules A1–A5, B1–B5, C1–C4 incl. sequestration). Analysis should include minimum of 95% of cost, include substructure, superstructure, finishes, fixed FF&E, building services and associated refrigerant leakage. 1. Whole Life Carbon Analysis 2. Use circular economy strategies 3. Minimise offsetting and use as last resort. Use accredited, verifiable schemes (see checklist) BAU aligned with LETI band E; 2025 target aligned with LETI band C and 2030 target aligned with LETI band B
Potable water use litres/person per day	16 litres/person per day (CIRA W11 benchmark)	<13 litres/person per day	<10 litres/person per day	CIBSE Guide G.

Figure 5
The *RIBA 2030 Climate Challenge* target metrics for new build offices
Source: RIBA 2030 Climate Challenge[19]

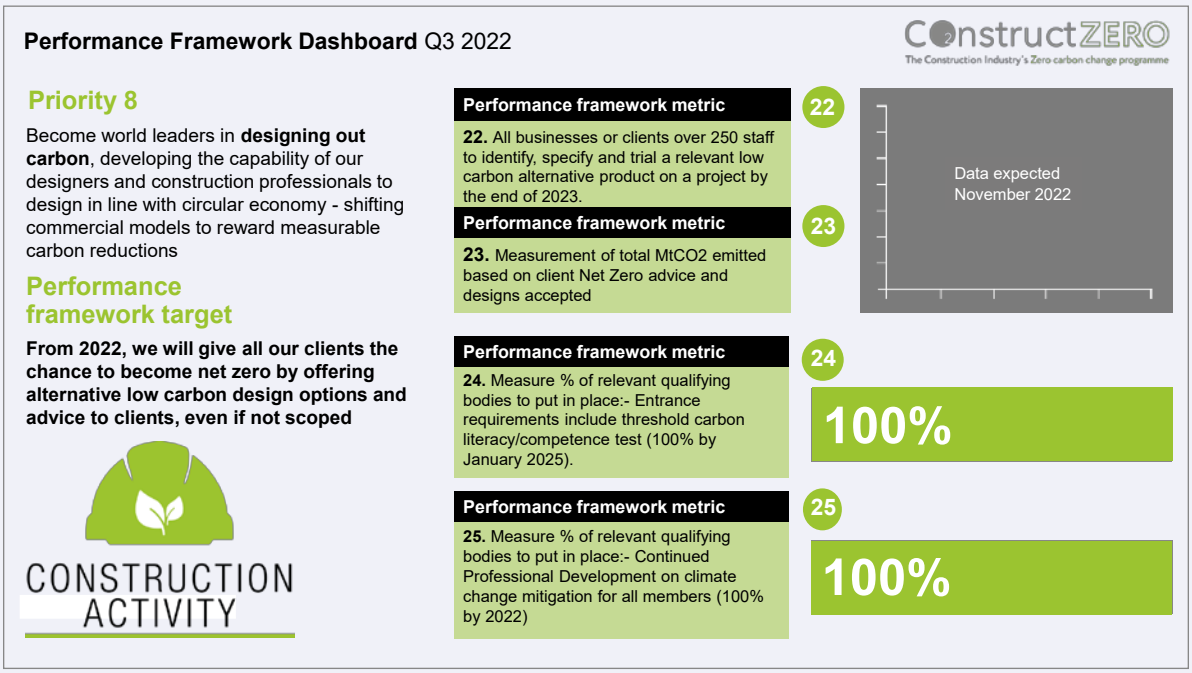


Figure 6
Priority 8 dashboard related to net-zero performance metrics
Source: CLC, Performance Framework Dashboard[29]

manufacturing production processes and distribution. More specifically, the CLC aims to reduce construction product emissions by 66% by 2035 compared with a 2018 baseline. As with the LETI requirements, occupiers adopting net-zero actions and targets need to cross-check CLC ambitions with the *RIBA 2030 Climate Challenge*[19] non-domestic building targets, and the targets published by the UKGBC.

GREEN LEASES

The terms within lease agreements between landlords and tenants can be tailored to help to promote lower energy use and carbon dioxide emissions. These types of lease arrangements are legal instruments generally termed 'green leases'. The first green leases were implemented by the Australian government.[30] They were devised to provide a management framework for shared environmental commitment, placing obligations on a landlord and government tenants to ensure that the environmental impact of buildings is reduced through improved operational performance.

There is no universally recognised definition for green leases, and no set categories for standards.[10, 31] In the UK, the BBP defines a green lease as:

> *a standard form of lease with additional clauses included which provide for the management and improvement of the Environmental Performance of a building by both landlord and occupier(s). Such a document is legally binding, and its provisions remain in place for the duration of the term.*[32]

The BBP has developed two routes to green leasing: a memorandum of understanding between parties with existing tenancy agreements; and inserted clauses that specify mechanisms for collaboration between parties.[33] The clauses aim to meet environmental performance targets for energy and water consumption and the consequential carbon dioxide emissions.

Improving the energy performance of tenanted office buildings is challenging due to the conflicting interests and incentives of landlords and tenants.[34] For example, some leases prohibit energy upgrades that entail changes to the equipment or building's fabric, or require collaboration between the landlord and the tenant(s). Even if the lease allows upgrades, sharing and splitting the cost can be challenging. This is known as a 'split incentive', where tenants benefit from energy efficiency while the landlords bear the cost of improvements.

In 2018, RICS proposed a solution for spreading the cost of major expenditure items over several years by setting up a sinking or reserve fund, rather than charging the entire cost to the current occupiers in the year in which equipment is replaced. In this situation the service charge provision in the lease becomes a critical element that needs special attention by tenants to avoid future disputes with their landlord.[35]

The legally binding elements of a green lease could potentially pose a barrier to attracting tenants and keeping them, especially in cases when the green lease mandates tenants to co-invest with the landlord on sustainable infrastructure.[36] For example, under BREEAM 2011 credits were available for green leases. These were intended to incentivise landlords seeking the highest rating to negotiate green leases with occupiers. However, these credits were subsequently removed from BREEAM 2014, at least partly because tenants were reluctant to accept additional obligations.[10]

ACADEMIC LITERATURE

A significant body of literature has explored the potential for energy savings in commercial office buildings from a technical perspective by employing building performance simulation and other energy consumption modelling methods.[37–45] However, this review focuses on the barriers and challenges, both technical and non-technical, facing tenanted office buildings, or commercial properties more broadly, on the path towards net-zero as identified by several studies to date.[46–48] In summary, these include:

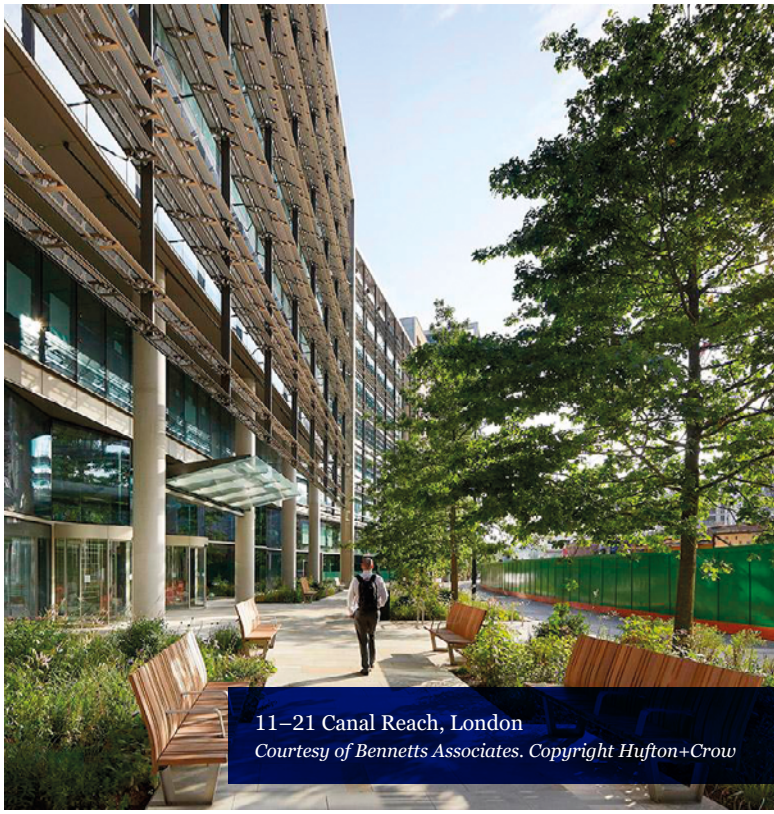
- the heterogeneity of the commercial building stock
- the diverse range of stakeholders involved in the design, provision, maintenance and operation of commercial properties (solicitors, investors, developers, estate agents, advisors, architects and engineers, owners, tenants and facilities managers)
- the complex organisational nature of such stakeholder communities, namely disciplinary fragmentation, siloed decision-making and division of responsibility, and leasehold structures and language.

In the context of an assessment of NABERS Commitment Agreement schemes, and in-use performance targets adopted in the Australian commercial property sector, Cohen et al.[12] evaluated the potential for the UK to introduce similar commitment agreement processes for new office buildings, integrated with the *Soft Landings Framework*.[49] In addition to the barriers related to the division of responsibilities outlined above, the authors identified a number of non-technical barriers specifically applying to the UK office building sector, including:

- a lack of baseline building energy performance monitoring data and real-world feedback
- a lack of energy performance disclosure
- a culture of designing for compliance (as opposed to designing for performance).

Whitney et al.[48] point out that the role of a commercial property (profit generation or provision of public service) is central to stakeholder decision-making, and their roles and responsibilities. Systems thinking is needed to assess the causal feedback loops that can lead to behaviour change in relation to energy management in the sector. Such change can be driven by regulations, voluntary building or operational/management improvements, thus leveraging competitive advantage. These all contribute to what the authors called 'mainstreaming green'.

Through a survey of asset managers of 763 office buildings in the USA, Kontokosta[50] found that ownership type and local market can have a significant impact on energy retrofit decision-making, with privately owned offices less likely to undergo an energy retrofit than corporate-owned office buildings. This was corroborated by the findings of Qiu et al.,[51] who demonstrated that when commercial buildings in New York were owner occupied they were less likely to have a green certification. This indicates that the green building rental premium may be greater in terms of present value than the expected operating cost savings. In addition, the competitive market encourages investor owners to achieve green certification to attract tenants, as also highlighted by Shang et al.[52] Kuivjõgi et al.[53] indicated that commercial property



11–21 Canal Reach, London
Courtesy of Bennetts Associates. Copyright Hufton+Crow

tenants are less motivated to invest due to the low savings in the sum of rental and energy costs. They recommend the introduction of carbon taxes and improved knowledge around energy savings. Bleyl et al.[54] pointed out that the deep energy retrofit (EnerPhit) of office buildings is not a stand-alone business case, as future long-term energy cost savings alone do not typically suffice to convince private sector investors.

Analysing real estate decision-making in Scotland, Leishman et al.[55] reported that the top priorities in occupiers' choice of premises were functionality and accessibility (office size/layout and building/IT system access); previous studies identified a lack of willingness from occupiers' perspective to pay the 'rental premium' potentially associated with energy efficiency features. Lower rents, improved corporate image and perceived improved productivity are potential motivating factors to pay more for such features. According to Mathew et al.,[44] tenant fit-out presents a key opportunity to embed energy efficiency principles within the real estate business cycle, and achieve significant savings in a low-risk, non-disruptive manner.

Faulconbridge et al.[56] assessed the impact of market standards on the design of 10 commercial London offices. They argued that:

> *Market standards … format and act as calculative devices in property markets and result in forms of knowledge diminution that break the relationship between building design and occupiers' practices. Together, these effects result in particular designs being legitimised and valued, and lower energy designs being delegitimised, devalued and pushed to the periphery of the attention of commercial office designers.*

Fuerst et al.[57] also explored the relationship between office building energy efficiency ratings and rental value in the UK, based on the analysis of contract rents and lease terms. They demonstrated that a significant rental premium exists for energy-efficient buildings, which is nevertheless primarily driven by the more recently built 'state-of-the-art' energy-efficient office building stock. A study in the Netherlands found that energy-inefficient commercial buildings achieve lower rental values compared to similar, more energy-efficient buildings. However, this was confounded by other factors influencing market values, such as accessibility to public transport, facilities available in the surrounding area, etc. Kok and Jennen (2012).[58] An investigation into the impacts of the NABERS rating on the value of Australian commercial offices found that, while developers and building owners see asset value as an important driver, the less tangible non-economic benefits of using the NABERS scheme were even more useful when competing for tenants who prefer an efficient building for reputational or staff welfare reasons.[59] Echoing the observations of other researchers about 'mainstreaming green', Faulconbridge et al.[56] pointed out that market standards are closely linked not only to regulatory compliance and benchmarking but also to cultural pressures and social norms.

Galvin and Terry[47] argue that, although regulatory change and landlords' voluntary actions towards energy savings are important, improved energy performance is primarily 'in the hands of the tenant firms'. Interviews were carried out in two London offices that have achieved significant energy savings. They were owned by international firms with a commitment to sustainability. It was observed that the success of these offices relied on a skilled, people-centred, top-down executant approach able to 'sell energy savings', while maintaining a certain degree of flexibility and the ability to learn from failure and readjust.

Although the majority of studies in this area focus on building energy savings and associated carbon emissions reductions, a growing body of literature in recent years has also started exploring the potential impact of such strategies on health and wellbeing. In particular, the impetus to reduce energy consumption in office buildings may result, in some cases, in conflicts with requirements for indoor environmental quality and occupant comfort improvement, the so-called unintended consequences of decarbonisation.[60] McArthur et al.[61] developed a holistic framework of office energy retrofit to assess the co-benefits of improved energy management and green certification for occupant health and wellbeing, pointing out that the latter can lead to even higher economic benefits if the impacts of improved indoor environmental quality on productivity are factored in. Conversely, a study on the relationship between Energy Performance Certificate (EPC) ratings of UK office buildings and occupier survey responses found a statistically significant correlation between occupiers' satisfaction levels and EPC ratings. However, rental value was only associated with occupant satisfaction with facility aesthetics.[62]

A greater, systems-level understanding of 'buildings as communities' is a fundamental step towards achieving energy-use reduction in the UK tenanted commercial property sector according to Axon et al.[46] The mediating (hindering or enabling) role of leases, the associated socio-legal relationships and organisational cultures on energy performance was highlighted by the authors of this study. Taking into consideration the complex socio-technical nature of the issue, Axon et al.[46] argue that interdisciplinary research is required that combines both the physical and social sciences of building energy use to tackle the challenges outlined above.

SUMMARY

A review of the key industrial and institutional guidance documents for net-zero published within the last few years shows a variety of frameworks and performance targets set out for operational and embodied carbon in buildings. The targets set out for operational carbon are generally based on two approaches:

- Top-down methods, whereby the capacity of the national electricity grid for renewable power generation is considered to define carbon limits for different sectors of the economy, including buildings.
- Bottom-up methods, based on building physics and first engineering principles, backed up by some best practice examples, to estimate what is achievable at building level.

The targets set out for embodied carbon are also based on best practice assumptions and bottom-up calculations. However, it should be noted that there is still not enough empirical data available on different building types to verify the veracity of these targets, and this is a challenge, especially in the commercial real estate sector, where the heterogenous nature of buildings and activities involved may require a more tailored approach to performance evaluation and optimisation.

The academic literature shows the socio-technical nature of the challenge and the potential adverse impact of a fragmented industry with several players with different and often conflicting systems of objectives. A systems thinking approach and further collaboration within and across organisational boundaries are required to overcome this challenge and facilitate the transition to net-zero. A key message for building occupiers is that net-zero performance cannot be achieved merely by reliance on technical building systems and smart control. Occupants play an important role. It is essential to clearly define ownership of energy management within an organisation and across its procurement supply chain to define and meet performance targets. ■

INTERVIEWS

INTERVIEW PROCESS

Semi-structured interviews were conducted with building practitioners and occupiers to obtain a better understanding of the readiness of the construction supply chains and building occupiers to achieve net-zero building performance and to identify the gaps. The interviews primarily focused on the following key themes, asking several questions that addressed both operational carbon and embodied carbon:

- net-zero strategies
- net-zero frameworks and performance targets
- achieving net-zero in commercial offices.

We approached BCO members from the Technical Affairs Committee, ESG committee, Occupier Committee and BCO occupier members to arrange interviews. A few interviews were also arranged with building design professionals other than BCO members. In total, 13 interviews were conducted with professionals representing one developer and development manager, four architectural practices, one building services design practice, one asset manager and six occupiers. The occupier organisations taking part in the interviews were large corporations with a portfolio of buildings in the UK and overseas, who were thus more likely to have sustainability objectives and commitments in place. This was a limitation and meant there was no direct representation from smaller occupier organisations. However, the applicability of the issues raised in the interviews to smaller organisation was considered. Furthermore, the design professionals involved in the interviews have extensive experience in dealing with various occupiers, and therefore the challenges facing small building occupiers were considered in the interviews, albeit indirectly. Most interviews were carried out with one representative from each organisation directly involved in the development and implementation of net-zero strategies in their organisation. In some interviews more than one professional from the same organisation attended, which led to a more in-depth discussion and reflections on the organisation's approach to net-zero.

The interview questions and the response and feedback from interviewees also informed the development of the business survey.

INTERVIEW FINDINGS BY TOPIC

NET-ZERO STRATEGIES

All companies participating in the interviews have made commitments to reduce greenhouse gas emissions as part of their ESG strategies. Developers, designers and other professional practices directly involved in construction supply chains increasingly view net-zero building performance as an integral part of their value proposition to their clients. However, for most occupiers, building emissions are only one component, often relatively a modest one, of a much broader range of emissions they must consider. Emissions from buildings constitute one component of their greenhouse gas emissions contributing to Scope 1 and 2 emissions, as defined by the Greenhouse Gas Protocol.[e] A lot of focus was also placed on other contributors to Scope 1 emissions, such as company fleet, and Scope 3 emissions that the organisation is indirectly responsible for up and down its value chain. This was described by a building occupier organisation, a large law firm with several offices in the UK and overseas, as follows:

> *The vast majority of our emissions – and it will be the same for most professional services organisations – are Scope 3 emissions. So those are emissions that are as a result of our activities, but we are not [directly] responsible for services that we buy. So, Scope 3 for us is business, travel, capital, goods, purchase goods and services. That is where the bulk of our emissions are. Less than 10% of our emissions are energy related. 9% of our baseline emissions are as a result of consumption of gas on premises and purchased electricity.*

This distinction is important not only in an organisation's effort to tackle emissions at building level but also in the way building emissions are understood and dealt with at corporate level. For example, building designers usually consider demand-reduction strategies first, followed by energy-efficiency measures, before considering on-site and off-site renewables. However, an organisation not directly involved in building design and management may consider other strategies, such as green power purchase and carbon offsetting, to reduce its greenhouse gas emissions, in addition to any building-related measure that may be deemed feasible but does not necessarily follow this environmental design hierarchy.

The difference between how building professionals approach net-zero and how other organisations, building occupiers in this context, perceive and manage their emissions emerged as a key theme during the interviews and has an impact on the way net-zero performance targets are understood, as explained further on pages 19–20. For example, the above-mentioned law firm has committed to reduce its greenhouse gas emissions by 90% over its baseline 2019 emissions, followed by offsetting any residual emissions to a maximum of 10%. Building energy consumption accounts for 9% of the organisation's baseline emissions, and it has adopted the following key measures to reduce building-related emissions:

- procuring 100% renewable energy across its global estate by 2030
- adopting a smart building programme, whereby an external organisation regularly monitors, via building management systems, the performance of the organisation's buildings and its systems, and provides advice to improve performance
- instigating a demand-side response programme in the organisation's headquarters in London to turn off or slow down the operation of building systems when the electricity grid is under pressure.

[e] Greenhouse Gas Protocol: https://ghgprotocol.org (accessed 15 November 2022).

Priority factor driving net-zero objectives	Priority ranking (score)*			
	Developer/ development manager	Designers	Asset manager	Occupiers
Costs (capital and/or operational)	Highest (1.00)	Medium–high (2.89)	Low (5.00)	Medium–high (3.00)
Achieving green (net-zero) certification	Medium–high (2.67)	Medium–high (3.22)	Low–medium (4.00)	Medium–high (3.00)
Going beyond mandatory requirements for carbon emissions (legislative future-proofing)	Medium–high (3.00)	Medium–high (2.67)	Lowest (6.00)	Medium–high (2.67)
Environmental, social and corporate governance (ESG): external factors (e.g. investor pressure)	Medium–high (2.67)	High (2.11)	Highest (1.00)	High (2.20)
Organisational policy/culture: internal factors	High (2.00)	High (2.11)	Medium–high (3.00)	High (2.00)
Industry/customer demand	Highest (1.00)	Medium–high (2.67)	High (2.00)	Medium–high (3.33)

*Ranking scale: 1, highest priority; 2, high priority; 3, medium–high priority; 4, low–medium priority; 5, low priority; 6, lowest priority.

Table 2
Stakeholders' ranking of the key factors driving net-zero objectives

Table 2 shows the priority rankings the interviewees gave to the factors driving net-zero objectives at building level in their organisations. These factors were identified and slightly adapted for the interviews based on 20 interviews conducted by Collins et al.[63] The previous research investigated the key drivers for sustainable offices as they were ranked by owners and tenants of office buildings in Norway, the USA and the UK. It is notable that, apart from the developer, for whom the cost of achieving net-zero is one of the most important factors (this is understandable for a developer, given the upfront premium cost currently associated with net-zero), other stakeholders did not appear to perceive cost as the main driving factor at a strategic level. Conversely, a company's ESG commitments and external factors such as customer demand, investor pressure and organisational policy and culture played a more important role in an organisation's approach to achieving net-zero building performance. This finding is consistent with the findings of the previous study for the UK in the broader context of sustainability drivers in the commercial real estate sector, as shown in Table 3. However, it should be noted that the interviewee responses were nuanced, and the priority ratings (on a scale of 1–6) were rather close in most cases. This question was also included in the business survey.

Category	Norway	UK	USA
Costs	Low–medium (3.77)	Low (5.00)	Medium–high (3.00)
Green certification	Medium–high (3.11)	Medium–high (2.66)	Low–medium (3.50)
Legislative compliance	Low (4.77)	Low (5.00)	Low (5.25)
Corporate social responsibility (CSR)	Medium–high (3.33)	Low–medium (3.66)	Low–medium (4.00)
Company policy/ culture	High (2.44)	Highest (1.33)	Medium–high (3.00)
Industry/ customer demand	Low–medium (3.55)	Medium–high (3.33)	Medium–high (3.25)

*Ranking scale: 1, highest priority; 2, high priority; 3, medium–high priority; 4, low–medium priority; 5, low priority; 6, lowest priority.
Source: adapted from Collins et al.[63]

Table 3
Stakeholders' ranking of the key factors driving sustainability objectives

NET-ZERO FRAMEWORKS AND PERFORMANCE TARGETS

The UKGBC's framework definition of net-zero[14] and other supporting documents[15–18] were identified by the interviewees, including building occupiers, as the main guidance and reference point for understanding net-zero buildings. LETI guidance documents such as the *LETI Climate Emergency Design Guide*[23] and *LETI Client Guide for Net Zero Carbon Buildings*[25] were also perceived as highly influential in shaping organisations' approach to achieving net-zero. Design for Performance and NABERS UK schemes for base building and tenant space were identified as drivers for change in the commercial office market, although there was a recognition that there is still a lack of empirical data to demonstrate the real impact of these schemes, which have recently been introduced in the UK market.

Most occupier organisations participating in the interviews have started to use Science Based Targets' *SBTi Corporate Net-Zero Standard*[2] to set emissions targets consistent with the 1.5°C global temperature rise scenario. The SBTi initiative was developed in 2015 to help companies set emission-reduction targets in line with climate science and Paris Agreement goals, and led to the development of the SBTi standard in 2021. Few interviewees expressed concerns about the difficulty of linking the SBTi framework to the EUI figures used in building design guides. For example, a building services designer providing strategic consultancy advice to owners and occupiers at the early stages of design stated:

> *A lot of tenants do not work towards LETI targets because in-use energy intensity target means nothing to them. And so quite a lot of tenants are looking at this from a Science Based Targets perspective. They are thinking about it in terms of carbon, not energy intensity, and often the*

conversation is 'Well, can't we just buy some green energy, and it will be solved?' There are no frameworks which are really acting on tenants to encourage them to push the energy side. NABERS could potentially start to do that but, at the moment, it just doesn't really come through in the market.

Figures quoted per GIA are not very helpful for tenants, and there is a lack of strong empirical evidence to define and support EUIs for tenant space. Generally, a lack of clear, detailed and standardised definitions and metrics for net-zero, especially in commercial buildings, is a key challenge raised by designers:

I think the sort of thing that does start to focus the mind is a Science Based Target: 'This is the trajectory you need to be on to 2050, and if you don't do it, tenant, this is you overshooting your trajectory.' How you translate a company-wide Science Based Target into a tenancy is one we have probably not looked at yet.

We've got stuff like CRREM [Carbon Risk Real Estate Monitor]*, for example, which the landlords are buying into, but there's absolutely no way of dividing out those targets between landlords and tenants at the moment. There isn't the sophistication [needed]. Even if we were to say, 'Yes, you should be trying towards energy targets', exactly what should those look like?*

It was also evident that most organisations were more focused on operational carbon, although there is an increasing attention to and interest in embodied carbon expressed by all stakeholders. For example, an occupier stated:

In addition to all the things we're doing from an operational perspective, we're also starting to quantify embodied carbon for our larger projects … It's more difficult to do it retrospectively for things that have already been built, but we are rolling out a process for the kind of upcoming refurbishments and fit-outs to start quantifying it on a high level, so we know what the impact is.

Building designers also acknowledged that evaluating the embodied carbon of some material and equipment is particularly challenging and that the industry requires some time to get there, as explained, for example, by a building services designer:

I think the bigger challenge around embodied carbon is that most chillers or heat pumps have really complex supply chains with lots of components with lots of hard-to-measure bits of carbon, and at the moment we're only, I think, really just taking a flyer at it.

ACHIEVING NET-ZERO IN COMMERCIAL OFFICES

The challenge of achieving net-zero performance in commercial offices was discussed in the interviews representing different scenarios.

Managing existing buildings

There was a consensus that the relationship and collaboration between building owner and occupier(s) is essential to achieve performance targets for both the base building and tenant spaces. However, current leases often do not cover such performance targets. The memorandums of understanding that complement lease agreements and green leases also lack specifics such as performance targets, a clear definition of responsibilities with respect to these targets, and corresponding incentive and penalty clauses. Lack of verified performance targets, especially for tenant spaces with variety of functional requirements and corresponding loads, is a major challenge.

There is a requirement for robust benchmarks and performance baselines to define reasonable and achievable targets. The NABERS UK scheme might be able to fill this gap in due course, if there is a feedback loop to help define appropriate performance benchmarks for different activity types.

Another theme that emerged from the interviews was the role of occupier advisors and managing agents in understanding and communicating sustainability objectives between occupiers and owners. It was generally believed that there are serious gaps in this area.

Two ongoing initiatives instigated by the BBP that can help address these challenges, at least to some extent, were discussed in interviews:

- The BBP *Green Lease Toolkit*,[32] originally released in 2013, is being revised to be more prescriptive around setting limits for energy performance in-use and embodied carbon, as well as data sharing.
- The Managing Agents Partnership, which currently comprises ten members that manage over 29,000 commercial properties, aims to provide greater clarity, transparency and standardisation around sustainability services that managing agents should provide.

Finally, a key challenge flagged up in the interviews was the effect of hybrid working and lower utilisation of office space since the COVID-19 pandemic, as explained by an occupier:

The drive to hybrid working is a game changer in the space requirements that most occupiers now need. The colleague experience when you're in the office needs to be very compelling to give workers an advantage, or an alternative to working from home. That doesn't necessarily need lots of carbon input or carbon activity. To get good utilisation in your office, you need to deliver and manage a great [facility].

[Currently] *over seven days, we're only going full power three days, and then we have got utilisation factors. So, we're still building buildings in the same way and supporting colleagues in the same way as we did 20 years ago for way less utilisation.*

This trend will have implications for an organisation's greenhouse gas emissions and how these emissions are evaluated for hybrid working. Management of underutilised office space also requires a lot of attention to building services controls and effective demand-controlled strategies to avoid wasting energy.

Retrofits

The intricacies of lease agreements, such as non-co-terminus leases in multi tenancies, can cause problems in funding energy-efficiency measures, as the interviewee representing the asset management company explained:

> *If a building is being upgraded, which will result in a reduction in operational costs, then the cost of the upgrade should be borne at least in part by the service charge or by the occupier of the building, because they are ultimately the ones deriving the benefit from that project. But there's a bit of a dilemma there, because not all occupiers are prepared to pay if they leave during the pay-out period. Would you? Should they get a rebate or whatever it might be?*

As for technical barriers, factors cited as barriers against deep retrofits were access to the occupier areas of a building where retrofit measures can be intrusive, and uncertainties about the existing façades and structure.

Most occupiers who took part in interviews have already done or planned for lighter interventions, such as installing LED lights, replacing gas-fired boilers with heat pumps and improving system controls.

Deep retrofit at scale, however, remains a key challenge in this sector, and may benefit from approaches such as off-site construction and careful phasing of intervention measures. It is also important to consider the balance between potential operational savings and the excess in embodied carbon, and to plan for appropriate interventions on a pathway to net-zero, as explained by a designer:

> *The biggest problem we have at the moment is that we can get to net-zero carbon* [operationally]*, but you have to change the façade … for buildings that aren't as old where you've got another 15–20 years life in the façade, there's not much you can do about that. So, you can go on the trajectory to net-zero carbon and then, when the façade needs upgrading, you'll do that bit then.*

Fit-outs

A key theme that emerged in discussions with designers and occupiers was the environmental impact of removing and altering developer/owner installations and fittings (ripping out Cat A fit-out) for tenant fit-out (Cat B). It was argued, by a few interviewees, that a shell and core building delivered by the developer/owner may be a better solution to leave the fit-out completely to tenants, although the developer interviewee indicated that not all tenants, especially small organisations, are equipped to provide Cat A services, and that ripping out of Cat A fit-out does not happen very often in practice:

> *The rule of thumb based on people looking at some of the Licenses to Alter is they lose about 10% of the Cat A. If you could make it attractive, durable and more difficult to mess about with, the odds are that the 10% shrinks still further.*

As for building services and equipment used in fit-outs, the lack of verified information about embodied carbon is clearly a key issue that building occupiers are facing. They often struggle to define a baseline for their current operation. They also find it difficult to source Environmental Product Declarations (EPDs) for the new items, especially for items imported from overseas (outside Europe). Strong views were expressed by a few designers about the need to set out mandatory requirements for the disclosure of embodied carbon. For example, an architect stated:

> *Companies (manufacturers) should be mandated to provide detailed information about the products they sell; EPDs. They don't and they aren't, and that's the problem. You know, we're all specifying, and people blindly scrambling to try and understand what's in the stuff we're specifying. It's not easy because a lot of [suppliers] don't sign up to it.*

The problem of a lack of information about embodied carbon was echoed by several occupiers. For example:

> *The products are being specified [without knowing] what embodied carbon value would actually be, which is something that we haven't done to date, but I think as this is getting pushed up the agenda, it will become more relevant, and it will become part of the specification and decision-making process.*

One of the interviewees, representing an organisation that had commissioned a study on embodied carbon of office furniture, explained the challenge of evaluating embodied carbon even when a product is sourced from a UK manufacturer:

> *For the last five or six years we had a policy of concentrating on buying furniture from UK manufacturers. However, UK manufacturers import products and components from outside the EU.*
>
> *We can't influence that. For example, if you have an office chair, it has a piston inside it, and there are only two manufacturers of those pistons in the whole of mainland Europe.*

It was clear from the interviews that building professionals and occupiers believe a lot more needs to be done across the procurement supply chains in the UK and globally to respond to the climate emergency. It is important to instigate this change by asking the right questions and demanding carbon figures. Some large organisations are also investing in their supply chains to fund innovative ideas that can help produce more environmentally friendly office furniture. ■

DESCRIPTION OF THE SURVEY PROCESS AND SAMPLE

An on-line survey was created to obtain feedback from clients, occupiers, design professionals and allied professions on current activities and expectations for achieving net-zero carbon in the office market. The survey was promoted by the BCO, CIBSE, LETI and BBP.

The survey obtained 102 responses. The responses covered a wide range of professional roles (Figure 7), locations (Figure 8) and company sizes (Figure 9). Inevitably, the survey responses were London-centric and predominantly from larger enterprises, either primarily serving the office market in London or companies with regional satellites.

Appendix A provides an analysis of survey scores by size of organisation to determine whether industry views of net-zero differed by size of organisation. Overall, the professional views expressed in the survey were largely consistent across all sizes of organisation.

Despite the primary objective of obtaining insights on net-zero from developers, office owner-occupiers and tenants, the survey responses were dominated by the building design professions (Figure 7). This is thought to be largely due to office occupiers being independent and dispersed entities. They are neither a grouping nor represented by a body or institution, and therefore cannot be reached as a specific community. For these reasons, the one-to-one interviews reported in the preceding section should be read in conjunction with the survey findings in order to understand net-zero trends in occupiers of offices.

In short, the results of the on-line survey largely chime with the interview findings. This is not surprising, as occupiers of office space tend to rely heavily on construction industry advisors, whether those advisors be design professionals, project managers, sustainability consultants or managing agents.

Note that the 'other' category in Figure 7 (7 total responses) includes job titles such as workplace design consultant, development and asset managers, and client advisors.

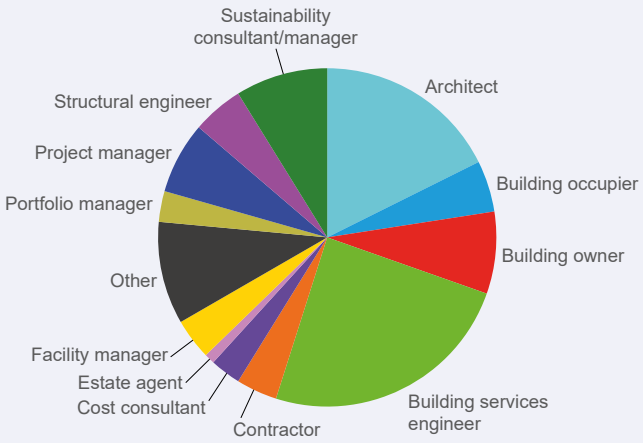


Figure 7
Breakdown of the on-line survey by profession. Architects and engineers account for half of all survey responses.

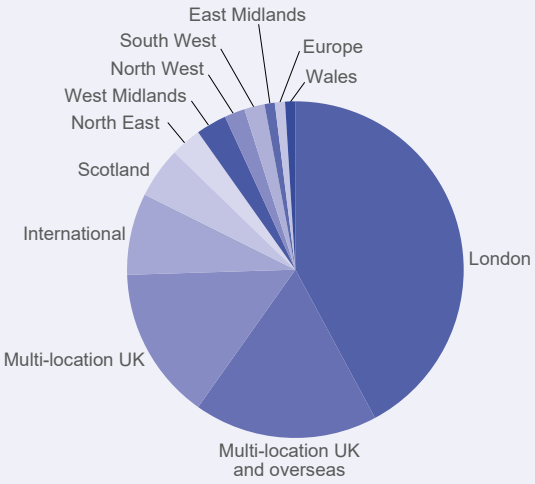


Figure 8
Breakdown of the on-line survey by respondent location. 43% of the responses were from London-based individuals.

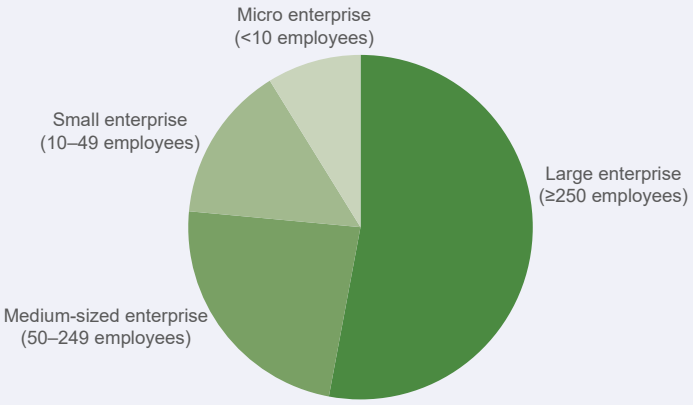


Figure 9
Breakdown of the on-line survey by company size. Over 76% of responses were from large or medium-sized organisations.

SURVEY FINDINGS BY TOPIC

DRIVERS FOR AND BARRIERS AGAINST ACHIEVING NET-ZERO CARBON IN BUILDINGS

There were few open text-based questions asking the survey respondents to identify key drivers for and barriers against achieving net-zero carbon in buildings. Generally, it appears that the pursuit of net-zero is primarily driven by the companies' ESG objectives and increasing expectation from their customers (and, ultimately, the public) for them to respond to the climate emergency, which resonates with the observations made in the reviewed literature about social and cultural pressures in relation to sustainability in the commercial property sector. Another external factor is increasing pressure from funders and investors. The climate-related financial disclosure frameworks such as the Global Real Estate Sustainability Benchmark (GRESB), and carbon risk evaluators such as the Carbon Risk Real Estate Monitor (CRREM) tool, which helps identify and mitigate the risk of stranded real estate assets, is also pushing building owners and designers to achieve further improvements.

The energy crisis that began in 2022 is another incentive that may focus minds on energy and bring forward capital investment in retrofitting buildings to improve efficiency. There is, however, an acknowledgment that this trend has not yet been fully translated into tangible results. A few respondents expressed concerns about 'greenwash' and the gap between aspirations and actual deliverables. There is also a question of scale, and whether the niche trend observed (mainly among big players and 'blue chip' clients) will reach the critical mass required to make a real impact. Most respondents strongly believe that a more serious commitment to net-zero from the government, in terms of both legislation and financial incentives, is required to facilitate the transition to net-zero at scale.

Table 4 provides a summary of net-zero drivers and barriers identified by the survey respondents for the commercial office sector.

	Driver/barrier category			
	Policy/initiative	Financial	Technical	Asset management
Drivers	Climate emergency and corporate initiatives such as SBTi (Science Based Targets initiative)[2] UKGBC Framework and LETI design guides NABERS UK and Design for Performance RIBA 2030,[19] MEP 2040,[64] SE2050[65] commitments Minimum Energy Efficiency Standards (MEES) for existing buildings (facilitator) Building Regulations for new buildings (facilitator)	Savings in the bottom line, especially in the context of the current energy crisis Financial disclosure frameworks such as the global ESG benchmark for real assets (GRESB)[66] Increasing customer demand and investor pressure Climate emergency and the risk of stranded assets	Low-carbon electricity grid Phasing out of fossil fuels (replace boilers with heat pumps) Potential of smart sensors, demand response and digital twins to improve performance Increasing attention to embodied carbon, EPDs and circular economy principles	Increasing alignment of owner/occupier ESG objectives in the context of the climate emergency Green leases with specific requirements and a clear definition of responsibilities Increasing attention to fit-outs and opportunities to reduce environmental impact
Barriers	Lack of specific net-zero building policy and mandatory requirements from the UK government to date	Capital cost required and commercial viability No financial incentive provided by the government (grants, subsidies, etc.) Investors' 'short-term' view Scalability, especially for existing buildings	Clear and standard definition of net-zero Technical know-how across supply chains and lack of data Access for retrofit and the uncertainties associated with existing façades Tendency to rebuild rather than retrofit Lack of EPDs, especially for imported material (outside Europe) and building services	Knowledge gaps among owners, agents, occupiers and facilities managers Disjointed objectives between owners and occupiers Inflexible leases Retrofit phasing Greater focus on aesthetics rather than performance

Table 4
Key drivers for and barriers against achieving net-zero buildings identified in the survey

OPERATIONAL NET-ZERO CARBON TARGETS

Respondents were asked to score the degree to which they thought commitments to net-zero operational carbon targets were being achieved. They were asked to consider what was happening in their own organisation and what they thought was happening in the wider building sector. The distribution of the responses is shown in Figures 10 and 11. Note the five-point response scale, the response sample sizes (which may differ across questions), and the mean value of the combined scoring. Variance in the data is also shown.[f]

Note that the total 102 responses in each histogram breaks down to more modest numbers per profession (of which there are 13, including 'other'). Judgements about the scoring of individual professions will be less robust than conclusions based on the combined scores. Nonetheless, the breakdown in scores offers some insights.

It can be seen from Figure 10 that a majority of respondents tend towards the view that their own organisation is achieving net-zero commitments, at least to some extent. Around 14% believe their organisation is achieving commitments to the fullest extent. Engineer respondents were more bullish about this than architects, building owners and sustainability consultants, possibly because they feel more able to directly influence net-zero decisions. The few facilities managers in the survey expressed the opposite view.

Figure 11 shows the survey results for respondents' views on net-zero operational commitments in the building sector. The response distribution is different to that in Figure 10. Respondents are far less convinced that the building sector is achieving net-zero commitments. The mean value (2.71) is below the scale midpoint (3). Around 38% of building owners, architects and engineers evidently believe more needs to be done. Statistical tests show that the response distribution in Figure 11 is significantly different at higher than 95% confidence.[g] Note that the lower variance in Figure 11 suggests a greater level of agreement among respondents. In essence, people think their own company is doing quite well, but that the construction industry is not.

Survey respondents were asked a supplementary question about the extent to which operational energy use is being managed and optimised in existing commercial offices. The results are shown in Figure 12. The professions differ little in their perceptions, with a roughly equal distribution among those who say energy is being managed well or poorly. A slightly greater number of respondents err towards negative views, but over 70% of respondents say energy is being managed at least to some extent. Presented with such feedback it is tempting to generalise, but the reality is that energy management depends largely on the local context. One can certainly conclude from the survey distribution of scores that there is considerable room for improvement.

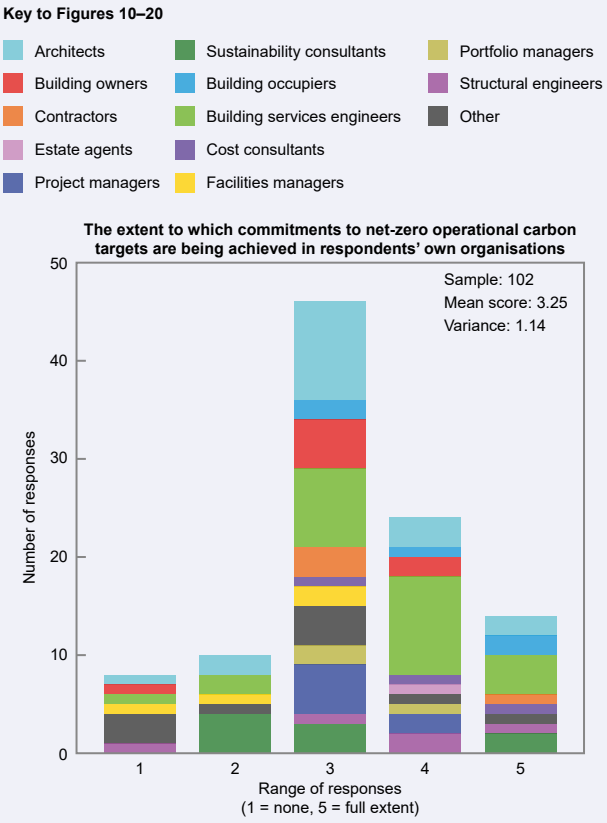


Figure 10
The extent to which commitments to net-zero operational carbon targets are being achieved in respondents' own organisations.

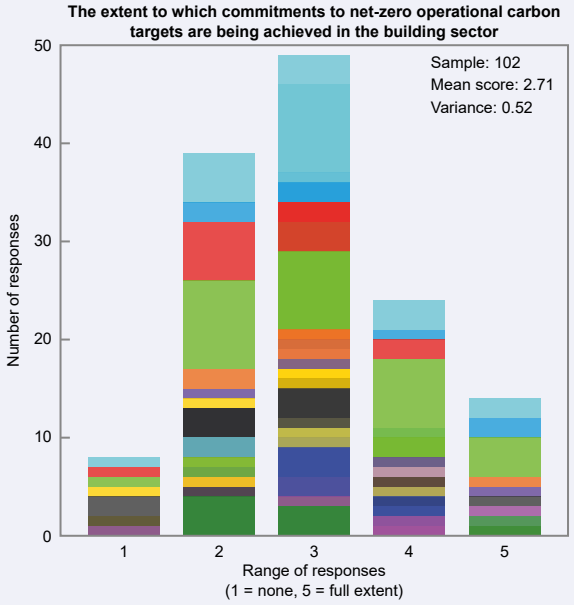


Figure 11
The extent to which commitments to net-zero operational carbon targets are being achieved in the building sector

[f] Variance is a useful descriptive statistic for the dispersion of data around a mean value (the average). Given the narrow response scale of 1–5, differences in variance will be small. A number around 0.5 can be taken as a relatively small variance, and a number >1.5 as a relatively higher variance. The shape of the histogram also provides a visual cue: whether the responses are spread across the scale, cluster around the scale mid-point (i.e. 3) or are biased towards either end of the scale.

[g] Given that respondents answered both questions, it is possible to conduct what is known as a 'matched pair' test for statistical significance, i.e. comparing each respondent's scoring for both questions using the Wilcoxon matched-pairs signed-ranks test. The result indicates that the scores in Figure 11 were statistically different to those in Figure 10 at a p value of <0.0001. A p value below 0.05 is statistically significant at 95% confidence, and a p value below 0.0001 is statistically significant at 99% confidence. As a check, the same result was obtained using the Mann–Whitney U test for non-parametric data, and also when applying a simpler standard paired-samples t-test.

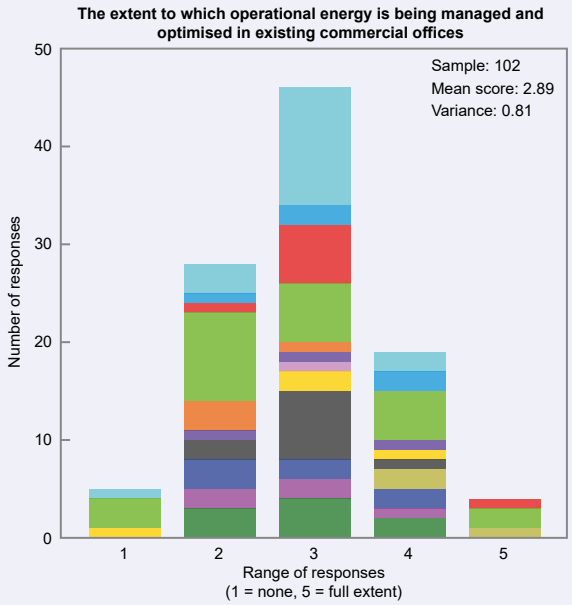


Figure 12
The extent to which operational energy is managed and optimised in existing commercial offices.

EMBODIED NET-ZERO CARBON TARGETS

Respondents were asked to score the degree to which they thought commitments to net-zero embodied carbon targets were being achieved. As with operational net-zero carbon commitments, respondents were asked to consider what was happening in their own organisation and what they thought was happening in the wider building sector. The distribution of the responses is shown in the histograms in Figures 13 and 14.

Around 25 fewer responses were achieved for the embodied carbon questions relating to a respondent's own organisation, suggesting a lack of knowledge or doubt about their company's activities. This reinforces the issues outlined in the interview section about the lack of robust data and uncertainties related to embodied carbon. However, all 102 survey respondents expressed a view about the building sector's embodied carbon commitment.

Respondents were asked to consider three main areas of office development where embodied carbon is generally concentrated: the shell and core, services fit-outs, and furniture, fixtures and fittings.

Figure 13 shows respondents' views of their own company's commitment to embodied zero-carbon measures. Although the distributions are not statistically different, there appears to be relatively greater confidence that embodied measures are being achieved in shell and core projects compared with fit-outs. Architects and services engineers in particular are less confident about net-zero commitments in fit-outs.

There is a greater spread (and thus variance) of responses to reducing the embodied carbon content in fixtures and fittings. The range of responses is possibly influenced by what respondents know is happening in individual cases. The combined responses shown in Figure 13 may therefore possess less explanatory power than the individual responses. Some organisations may be doing it well, others evidently not.

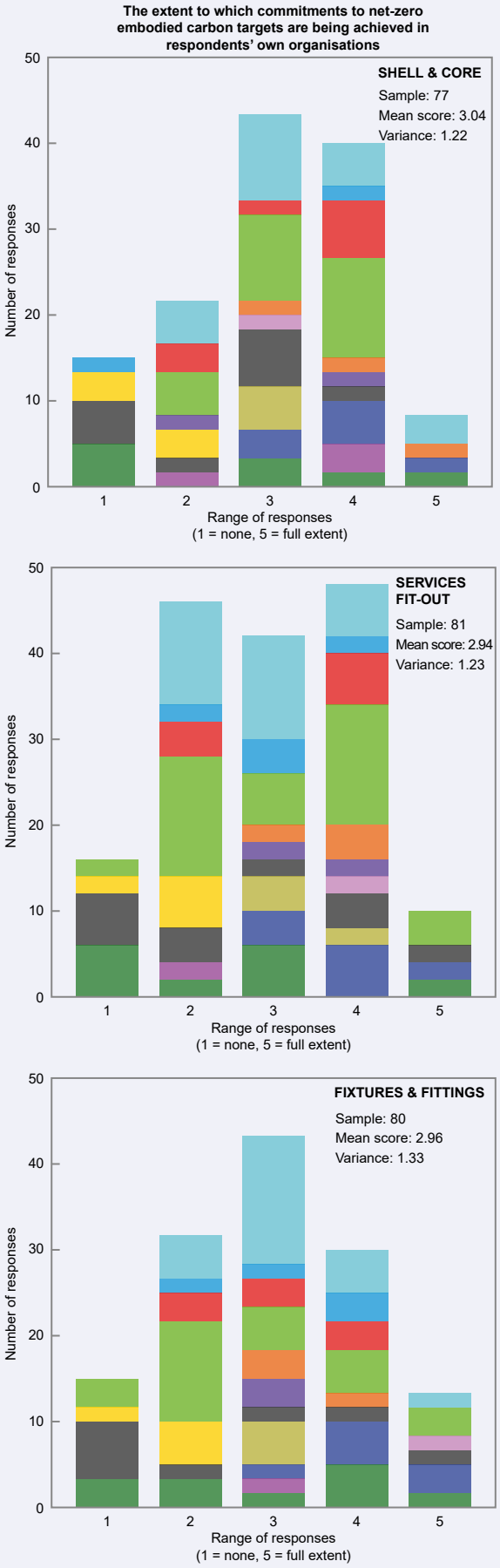


Figure 13
Respondents' views on embodied net-zero commitments in their own organisations as they apply to shell and core, services fit-outs, and office furniture, fixtures and fittings.

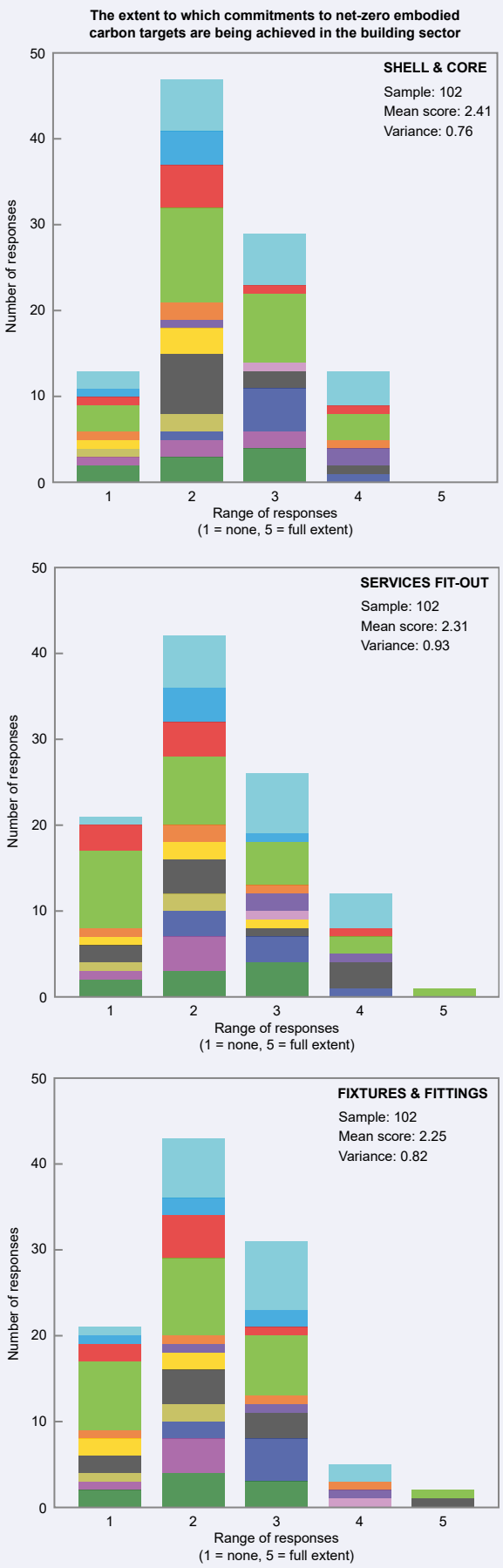


Figure 14
Respondents' views on embodied net-zero commitments in the building sector as they apply to shell and core, services fit-outs, and office furniture, fixtures and fittings.

Figure 14 shows the results of the same question applied to the building sector. All 102 survey respondents answered this question. As with the responses to questions on operational net-zero, respondents are relatively less confident about net-zero commitments in the wider building sector. The same statistical tests for significant difference were applied to the survey samples in Figures 13 and 14. The tests generated exactly the same result: Respondents expressed statistically lower confidence in the building sector's ability to hit net-zero commitments in shell and core, services fit-outs, and furniture, fixtures and fittings compared with what they thought their own organisation was achieving.

Project managers appeared to give more positive scores on this question than facilities managers. The survey results suggest that the commitment to net-zero embodied carbon thought by project managers to be achievable (or which has been achieved) is different to that thought achievable by those charged with managing buildings and tenancies. It is possible that building managers have a more sober perspective compared with the enthusiasm and ambitions of those advising clients and managing their projects. Another possibility is that facilities managers (at least those who responded to the survey) are simply less aware of or less knowledgeable about net-zero commitments than project managers working at the sharp end of procurement.

Caution should be applied when interpreting the scores given by project managers and facilities managers. In both cases the response samples are small and may not be representative of the wider professions. Furthermore, surveys are largely expressions of opinion rather than proof of experience.

Survey respondents were asked a subsidiary question on net-zero embodied carbon: 'To what extent are embodied carbon targets considered in retrofitting existing commercial offices?' The responses are shown in Figure 15. There is a relatively higher variance in responses, with a bias towards the lower end of the response scale. Building owners and project managers tend to be more positive than building

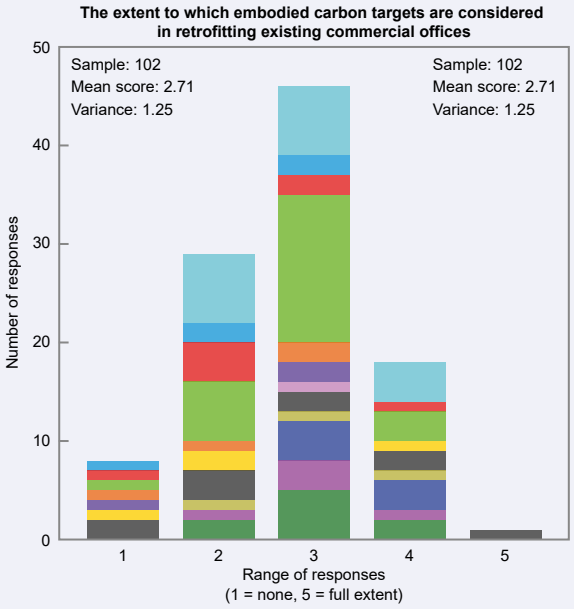


Figure 15
Survey respondents' views on the extent to which embodied carbon targets are considered in retrofitting existing commercial offices.

services engineers, the latter being biased towards a more negative perspective on embodied carbon targets in retrofits, perhaps because less is known about materials in engineering components and there is less control over their carbon content compared with construction materials. Architects appear split over the issue, largely giving a score of 2 or 4. Facilities managers are less positive, along with sustainability consultants. While both respondents are few in number, the latter should, theoretically, have a greater grasp of the issues. Given the wide spread of responses it clearly depends on who you ask. Evidently there is considerable doubt and, equally, considerable room for improvement.

EMBODIED CARBON TARGETS FOR FIT-OUTS

Survey respondents were asked their views on the extent to which embodied carbon targets are being considered in the fit-out of existing commercial offices. The results are shown in Figure 16. All 102 respondents answered the question.

The scores exhibit a bias towards the low end of the scale, with an average score of 2.44. Well over half of all respondents scored the question 1 or 2. There is some variance in scoring, but the spread is not wide enough to avoid the conclusion that embodied carbon is largely not being considered effectively in fit-outs, a conclusion that is backed up by interviews to a large extent. Even project managers who responded positively to other questions about embodied carbon did not demur from the views of other professionals. The majority of the sustainability consultants responding to the survey were also gave less positive scores on this question.

GUIDANCE ON NET-ZERO CARBON

Respondents to the survey were asked to rank the importance of a raft of guidance relating to net-zero carbon interventions, target setting and certification. Figure 17 shows how the professional categories ranked the influence of various guides and tools. The ranked importance is shown in a clockwise rotation. Note that the survey asked about influence. The voting does not reflect actual adoption of any of the schemes shown.

There is general consensus among the professions about which standards and guidance documents are most relevant, as evidenced by the uniformity of the concentric voting in Figure 17. Guidance and targets from the UKGBC was ranked the highest (UKGBC membership is composed of the large client and supply chain corporates), followed by recent guidance issued by professional bodies such as the LETI network and RIBA. Both have set challenging targets for net-zero carbon and have produced influential guidance.

NABERS UK also ranked highly among survey respondents. NABERS UK, aimed at the energy certification of commercial offices, has been heavily promoted by the BBP, with the scheme certified by the BRE. Despite its newness, NABERS UK has achieved a high level of visibility if not actual buy-in at scale in the office market.

The commercial environmental certification schemes Building Research Establishment Environmental Assessment Method (BREEAM) and Leadership in Energy and Environmental Design (LEED), a North American product, are not net-zero carbon schemes *per se*, and therefore cannot be expected to occupy prime positions in respondents' minds. The relatively

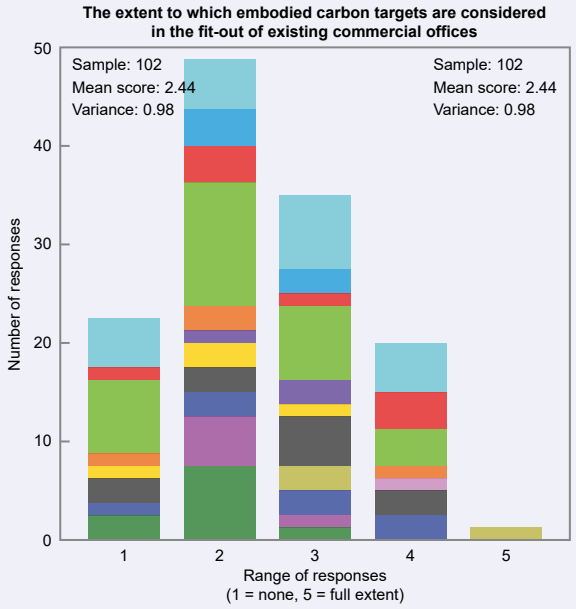


Figure 16
Survey respondents' views on the extent to which embodied carbon targets are considered in the fit-out of existing commercial offices.

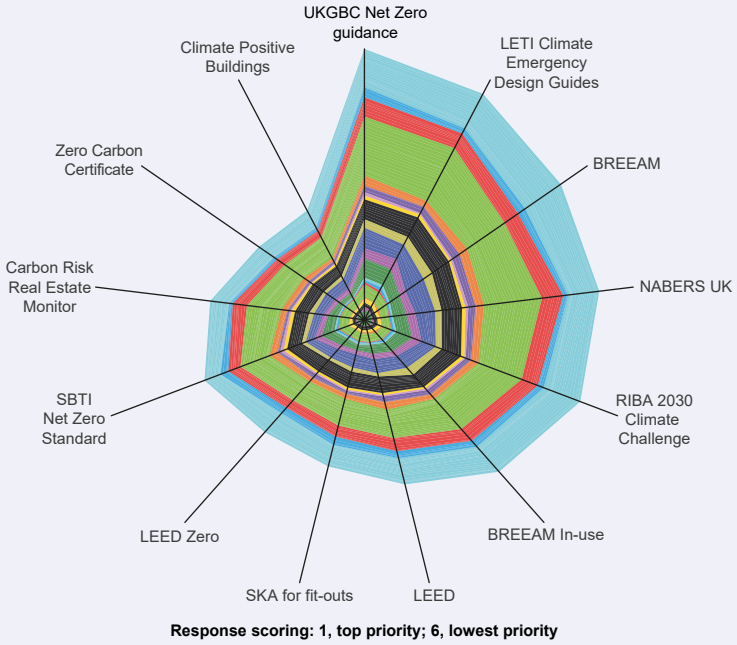


Figure 17
Survey respondents' ranking of the various sources of guidance for net-zero carbon frameworks, standards and certification schemes.

lower scoring for BREEAM In-Use compared with the BREEAM design tool is nonetheless notable. It suggests that users of BREEAM are more interested in certification in design and relatively less interested in operational performance certification.

In the view of the report's authors, this is consistent with the dogged reluctance of the construction industry and building owners to undertake post-occupancy evaluation (POE). Both groups are resisting voluntary declarations of outturn

energy consumption (and, by extension, a building's actual carbon budget, both embodied and operational). That said, acceptance of POE is slowly growing, largely due to initiatives such as the RIBA Plan for Use[67] (RIBA's interpretation of Soft Landings), recent changes to the RIBA's Stirling Prize to include operational climate data, the CIBSE performance awards, and the promotion of POE by LETI, UKGBC and BBP. Furthermore, in November 2021 the Architects Registration Board (ARB) made POE a mandatory sustainability competence requirement.[68] Nonetheless, resistance to POE persists, driven largely by a perception of additional costs (which are usually far less than the accumulated savings) and designers' concerns about potential insurance risks if they are unfairly blamed for problems uncovered in buildings (expressed by an architectural practice in the interviews).

A relatively low score was given to the RICS retrofit certification scheme, SKA. Although SKA is not a net-zero carbon assessment tool *per se*, its relative ranking is a surprise given the growing importance of refurbishing buildings to reduce carbon penalties as opposed to building new. The relatively low ranking suggests that further development, and possibly better promotion, is needed for SKA to gain greater importance as an assessment method for retrofits.

FACTORS INFLUENCING NET-ZERO OBJECTIVES

Survey respondents were asked to rank the priority of key factors in the context of net-zero when choosing to develop, refit or occupy a building, similar to the question asked in the interviews. Figure 18 illustrates the average scores given by each profession, with scoring on a 1–6 scale.

As with Figure 17, the rankings reflect consensus among the professions on the relative importance of the six topics. All topics were ranked as high (if not top) priority. Net-zero certification was ranked highest, followed closely by the other topics. The (relatively) lowest score was for going beyond mandatory requirements. What this might suggest is that, while office clients and their supply chains are responsive to certification, if there is no mandatory requirement they are relatively less motivated to voluntarily raise the bar on their low carbon aspirations. Put another way, it may be a case of 'If people want it, we'll do it, but not before'.[h]

THE ROLE OF GREEN LEASES

Survey respondents were asked to express their views on the role of green leases in promoting or otherwise supporting net-zero carbon aspirations in commercial offices. Figure 19 illustrates the average scores given by each profession, with scoring on a 1–5 scale.

As can be seen in the scoring, green leases elicited a positive response from all 102 survey respondents, with an average score of 3.68. This suggests (and is consistent with the messaging on certification in Figure 18) that green leases may play a persuasive role in the adoption of net-zero targets. Facilities managers were relatively less enthusiastic, but as elsewhere in the survey they represent a small percentage

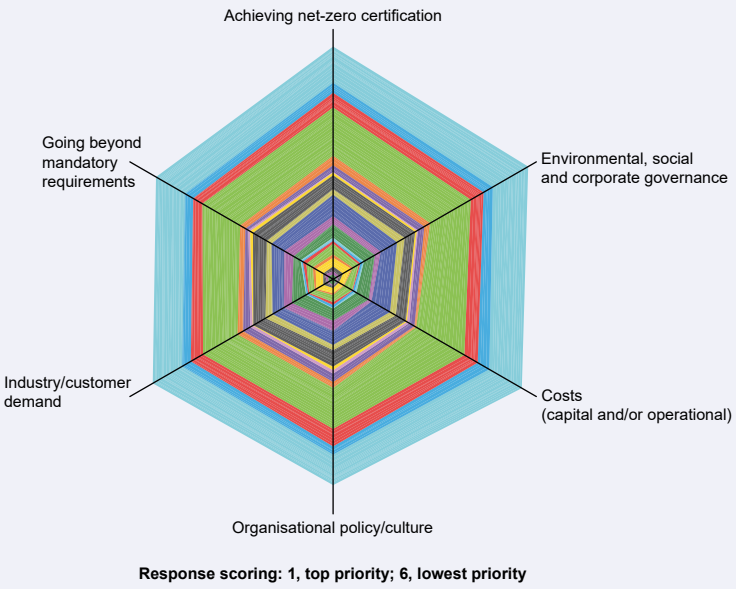


Figure 18
Survey respondents' ranking of factors influencing application of net-zero activities.

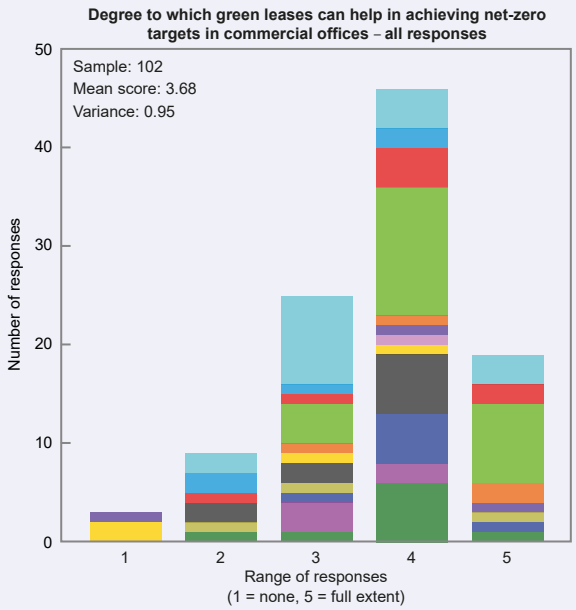


Figure 19
Survey respondents' ranking of green leases in supporting net-zero carbon aims and ambitions.

[h] Readers of this report will note an absence of central government guidance, tools or requirements for net-zero buildings. Virtually all the net-zero guidance used in the office market is generated by institutions or industry. Readers wanting to know more about central government initiatives could read the June 2022 report *Progress in Reducing Emissions* by the Parliament Climate Change Committee.[69]

of all survey responders. Building services engineers were particularly positive, whereas architects were slightly less so. Building owners were largely positive, while the few occupiers in the survey were slightly less enthusiastic.

As before, it is risky to make definitive statements when the survey sample is small. Overall, however, green leases were thought to be a good thing. In their answer to text-based questions many respondents thought the current green lease agreements must be improved, which is consistent with the message emerging from interviews. For example:

> [Green leases] *are not the default option for new leases and are not always 'green' enough.*

> [There is] *still some hesitation to adopt unproven clauses, particularly when there's no certain demonstrable impact on value.*

> *Green leases need to get more prescriptive, setting limits for embodied carbon and performance in use, complemented by carbon trading/penalties at the asset level.*

ALIGNMENT OF ENVIRONMENTAL, SOCIAL AND GOVERNANCE (ESG) FACTORS WITH NET-ZERO CARBON

Survey respondents were asked to express their views on the alignment of ESG factors with net-zero carbon ambitions. Figure 20 illustrates the average scores given by each profession.

The mean score of 2.76, below the scale midpoint of 3, suggests room for improvement in terms of alignment. The variance in the survey responses is relatively low, which indicates a degree of consensus among the various professions responding to the survey. As with other issues, project managers tend towards a more positive perspective, while building services engineers (along with architects and facilities managers) are less positive.

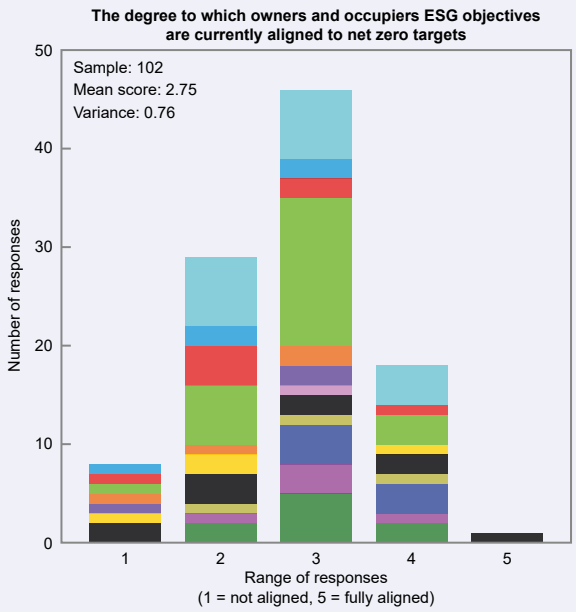


Figure 20
Survey respondents' views of ESG alignment with net-zero carbon aspirations.

Respondents were asked to comment on what changes they thought were required to better align owners' and occupiers' ESG objectives to achieve net-zero targets. Improved green leases, pre-lets and longer leases, with more say over refurbishments for tenants and more transparency, were identified as improvement measures. Generally, there was a consensus that clear and standard definitions (and enforcing them) would help. Several respondents also highlighted the role of education and further collaboration for better alignment of the objectives. ■

RECOMMENDATIONS

The case studies in Appendix B represent the design targets and measures used in new-build offices. The main problem, however, is achieving net-zero in existing offices. This section provides an overview of the key challenges identified and a few improvement measures for existing buildings, retrofit projects and fit-outs. The recommendations are based on the literature review, interviews, business survey comments and the authors' experience of building performance evaluations of office buildings.

EXISTING BUILDINGS

A key challenge identified in both the interviews and the business survey is a lack of verified net-zero targets for the EUI of different types of offices, especially tenant space.

Although the UKGBC has issued interim and Paris-proof energy targets for tenant office space per NLA, these targets currently do not differentiate between different types of office and intensity of operation. This can make it difficult for building users to evaluate their current performance and improvement opportunities to get to net-zero operational performance.

Another challenge is the existing metering strategies that do not allow an effective disaggregation of energy use between landlord and occupier(s) areas, a persistent problem across the built environment. Although this chronic problem is being addressed by the NABERS UK scheme, the scheme itself is new and, in practice, applies only to high-end office buildings. It will take some years before enough evidence is gathered to know whether the problem is being solved by voluntary certification. Outside of NABERS UK, dysfunctional metering remains a problem in the vast majority of existing UK office buildings, many occupiers of which are attempting to adopt net-zero targets without knowing when and where their power is being consumed.

It is helpful to view the UKGBC's or any similar EUI values as guidelines rather than as deterministic targets, before working out what is feasible given the actual building context. A simple energy monitoring and targeting (M&T) programme can yield significant savings in most new and existing offices that may be underperforming against either design expectations (the oft-quoted 'performance gap') or against prevailing best practice energy benchmarks for offices. Savings can often be made at low or zero cost.

The following measures can help building users improve the operational energy performance of their buildings and find a tailored pathway to net-zero:

- Clearly define energy ownership within the occupying organisation as part of the ESG strategy.
- Agree on a framework for collaboration with the landlord and other building occupiers. It is vital to agree on performance targets, these being progressive if appropriate. Even if this is not legally possible due to uncertainties, it is important to ensure the agreement promotes data sharing and transparency.

Here Now Phase 1, Thames Valley Park Drive, Reading
Courtesy Hawkins\Brown

- Review the existing metering strategy for the building and attempt a reconciliation of energy sub-meter readings with the main meters. Resolve disparities to an acceptable level of accuracy (e.g. ±5%).
- Instigate an energy M&T programme defining the baseline year, net-zero guideline values and benchmarks available for offices. Identify the improvement opportunities for operational energy use through the M&T programme. Note that the UKGBC net-zero EUIs can be adjusted for extended operation if necessary, using the DEC methodology (for the whole building) or NABERS UK (for landlord/tenant space).
- Review annual energy performance regularly at different levels of disaggregation (e.g. total electricity use, heating, cooling, lighting energy, small power) to an appropriate level of additional granularity (e.g. hourly, daily, monthly). Review against the intensity of use and hours of occupation to identify improvement opportunities.
- Review the existing performance against net-zero operational targets regularly and determine the necessary interventions to approach these targets by further incremental improvements and retrofit measures. It is also important to evaluate the cost and the embodied carbon of intervention measures to avoid unintended consequences.

RETROFITS

Deep retrofit of office buildings, including measures that involve façade systems, is a particular challenge in commercial offices. This is due to technical uncertainties and the disruptive nature of such interventions in a commercial environment. Furthermore, it is important to strike the right balance between operational and embodied carbon when improving building façades.

The funding of retrofit measures in multi-tenant buildings is also a financial challenge that needs to be tackled. There is currently considerable doubt (and often dispute) between landlords and leaseholders over the division of funding responsibility for net-zero improvements, particularly for short-term leases.

The following measures and trends can support retrofit projects:

- Follow the UKGBC (2022) framework for delivering net-zero through commercial retrofits.
- Identify a tailored net-zero pathway for operational and embodied carbon for a building (including tenanted space), considering the useful life of the building façade and plant equipment, potential operational savings and the embodied carbon of the suggested interventions.
- Define a collective mechanism for funding improvement interventions between the landlord and the occupier(s), taking into account upfront funding through the service charge and/or a funding contribution commensurate with the benefits achieved. The mechanism must be clearly defined and legally binding.
- Consider careful phasing and use of prefabricated components to minimise on-site interventions in refurbishments, particularly where façade systems are involved. Such a strategy can also contribute to a circular economy through 'design for disassembly' of prefabricated components. Upgrading existing fabric components, however, should often take place on-site to avoid delays and minimise transportation emissions.
- Advances in building information modelling make it possible to link the digital twin of a building to a material passport[i] database created through platforms such as Madaster,[j] an expanding online registry for materials and products that provides information about embodied carbon and circularity. This is especially helpful in deep retrofits, where there is often an extensive list of materials. The project budget must cover the development and ongoing management of the digital twin.
- Plan for monitoring and performance verification to evaluate the real effects of the retrofit after handover (after all fit-out works, any phased occupation and resolution of defects including sub-meter reconciliation).

Note that verification of net-zero performance achievements may require the definitions of 'practical completion' and 'outstanding defects' to be worded more appropriately to the shared expectations.

FIT-OUTS

The material waste in ripping out Cat A fit-out in favour of a bespoke Cat B fit-out by tenants was highlighted in several interviews and survey comments. Another key challenge identified was the uncertainties around the embodied carbon of material, building services systems and office furniture.

The following measures and trends can support environmentally friendly fit-outs:

- Pre-let and long lease agreements – these typically involve large occupier organisations that wish to completely craft the space to suit their needs, and would be happy with a shell and core building to start.
- Cat A or Cat A+ (plug and play) fit-outs for shorter and more flexible tenancies – given the market trend after the COVID-19 pandemic, it is envisaged that most office spaces will benefit from these fit-outs.
- Prioritising the use of locally sourced material with lower embodied carbon and verifiable EPDs.
- Asking building services system suppliers for an estimation of the embodied carbon of their systems (preferably requiring the adoption of the CIBSE TM65 methodology, *Embodied Carbon in Building Services*[1]).
- Considering the use of platforms such as Globechain[k] to offer and source stripped-out materials and systems.
- Considering the use of recycled, reused and further recyclable office furniture – inform workers and clients about the environmental benefits.

THE WORKPLACE POST-PANDEMIC

The trend of underutilisation of office space after the COVID-19 pandemic was a concern raised in the interviews. Post-pandemic changes in office utilisation[4] justify analysis of the savings possible from rationalising space and introducing demand-control strategies for energy-consuming systems. Changes to zone control strategies for systems such as ventilation and lighting may be required to ensure net-zero performance targets are not compromised by wasteful operation.

NET-ZERO GUIDANCE AND STANDARD

A recurring theme in both the interviews and the business survey was the lack of clear guidance, especially from the government, a standard definition and approach to net-zero, and verifiable performance data. The UKGBC framework definition of net-zero and its guidance documents, introduced in this report, are currently the main point of reference for stakeholders. At the time of writing, the Department for Business, Energy & Industrial Strategy (BEIS) has commissioned an independent review of the government's approach to delivering its net-zero target.[l] This may pave the way for clearer guidance and strategy from the government for the building sector in due course. An ongoing industry-led initiative to develop a net-zero carbon buildings standard for the UK could also help provide clear and consistent methodology along with real-world data to show how net-zero performance could be achieved in different building types.[m] ■

[i] A material passport is an electronic set of data that describes the characteristics of materials stock in products, providing information about their composition, which give them value for recovery or reuse.[70]

[j] Madaster: https://madaster.com (accessed 15 November 2022).

[k] Globechain: https://globechain.com (accessed 15 November 2022).

[l] BEIS, Net Zero Review: Call for Evidence: https://www.gov.uk/government/consultations/review-of-net-zero-call-for-evidence/net-zero-review-call-for-evidence (accessed 15 November 2022).

[m] UK Net Zero Carbon Buildings Standard: https://www.nzcbuildings.co.uk (accessed 15 November 2022).

CONCLUSIONS

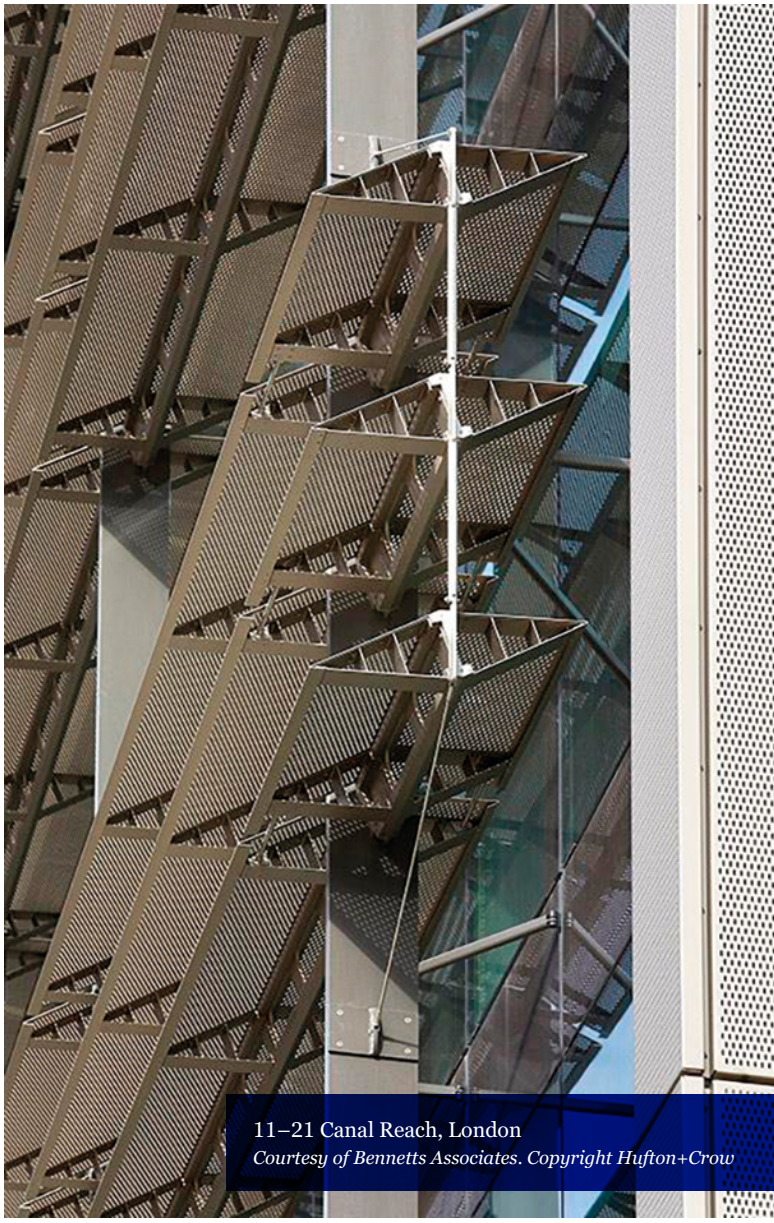
This study reviewed the performance frameworks and targets set out for net-zero performance in the commercial real estate sector. It also engaged with several building professionals and occupiers through semi-structured interviews and a business survey to understand their views about achieving net-zero performance in the workplace.

The interviews flagged up different approaches to net-zero at the organisational and building levels, and several challenges that need to be addressed to meet operational and embodied targets. Two overarching themes emerged from the interviews:

- Robust benchmarks and empirical data are required for net-zero commercial offices.
- Mandatory requirements and incentives from the government are essential to support the current market trends and ensure that a critical mass is achieved to facilitate the transition to net-zero.

The business survey echoed these findings in several ways. The respondents were generally positive about their organisational commitments and efforts made to achieve net-zero. However, only around 12% took the view that commitments to net-zero operational carbon targets are being achieved in the building sector, and 38% thought more needs to be done. The feedback received for embodied carbon also shows more than 60% of respondents believe more needs to be done to meet embodied carbon commitments for building shell and core, services fit-outs, and fixtures and fittings.

The survey shows that stakeholders have embraced the UKGBC framework definition for net-zero and LETI design guides. They are generally supportive of the initiatives such as the NABERS rating schemes for base building and tenant space. The real impact of these new schemes on the market needs to be evaluated in due course. There is also a strong demand for standardised and consistent definitions and targets for net-zero. The industry-led initiative to develop a net-zero carbon buildings standard for the UK could help provide clear and consistent methodology to support organisations in meeting their net-zero objectives. ■



11–21 Canal Reach, London
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REFERENCES

1. Chartered Institution of Building Services Engineers (CIBSE) (2021) *Embodied Carbon in Building Services: A Calculation Methodology*. CIBSE TM65. Available at: https://www.cibse.org/knowledge-research/knowledge-portal/embodied-carbon-in-building-services-a-calculation-methodology-tm65 (accessed 15 November 2022).

2. Science Based Targets (2021) *SBTi Corporate Net-Zero Standard*, Version 1.0. Available at: https://sciencebasedtargets.org/resources/files/Net-Zero-Standard.pdf (accessed 15 November 2022).

3. Building Research Establishment (BRE) (2021) *What is NABERS UK?* Available at: www.bregroup.com/nabers-uk/nabers-uk-about (accessed 15 November 2022).

4. BCO (2022) *The Future of UK Office Densities*. Available at: https://www.bco.org.uk/Research/Publications/The_Future_of_UK_Office_Densities.aspx (accessed 15 November 2022).

5. BEIS (2016) *Building Energy Efficiency Survey: Office sector, 2014–15*. BEES Sector Report Offices FINAL. Available at: https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees (accessed 15 November 2022).

6. Better Buildings Partnership (BBP) (2020) *Real Estate Environmental Benchmark: 2019 Energy Snapshot*. Available at: www.betterbuildingspartnership.co.uk/sites/default/files/media/attachment/BBP_REEB%202019%20Energy%20Snapshot.pdf (accessed 15 November 2022).

7. Better Buildings Partnership (BBP) (2020) *BBP Climate Commitment*. Available at: https://www.betterbuildingspartnership.co.uk/member-climate-change-commitment (accessed 15 November 2022).

8. Better Buildings Partnership (BBP) (2020) *BBP Spearheads Launch of New Energy Rating Scheme for UK Offices*. Available at: www.betterbuildingspartnership.co.uk/bbp-spearheads-launch-new-energy-rating-scheme-uk-offices (accessed 15 November 2022).

9. Bannister P (2012) *NABERS: Lessons from 12 Years of Performance Based Ratings in Australia*. Available at: https://www.semanticscholar.org/paper/NABERS%3A-Lessons-from-12-Years-of-Performance-Based-Bannister/8f65e9a56fe37ea8f3430329d9c4fd6f9b5ce384 (accessed 15 November 2022).

10. Janda K, Rotmann S, Bulut M and Lennander S (2017) Advances in green leases and green leasing: Evidence from Sweden, Australia, and the UK. Paper presented at: *European Council for an Energy Efficiency Economy Summer Study, Tolon, Hyeres, France*. Available at: https://www.researchgate.net/publication/317719942_Advances_in_green_leases_and_green_leasing_Evidence_from_Sweden_Australia_and_the_UK (accessed 15 November 2022).

11. Carbon Trust (2011) *Making Buildings Work*. Available at: www.usablebuildings.co.uk/UsableBuildings/Unprotected/LowCarbonBPP/CommissioningLowCarbonBuildings.pdf (accessed 15 November 2022).

12. Cohen R, Austin B, Bannister P, Bordass B and Bunn R (2017) How the commitment to disclose in-use performance can transform energy outcomes for new buildings. *Building Services Engineering Research and Technology* **38**(6): 711–727. Available at: https://doi.org/10.1177/0143624417711343 (accessed 15 November 2022).

13. Building Research Establishment (BRE) (2022) *Design for Performance*. Available at: https://bregroup.com/products/nabers-uk/nabers-uk-products/nabers-design-for-performance (accessed 15 November 2022).

14. UK Green Building Council (UKGBC) (2019) *Net Zero Carbon Buildings: A Framework Definition*. Available at: https://www.ukgbc.org/ukgbc-work/net-zero-carbon-buildings-a-framework-definition (accessed 15 November 2022).

15. UK Green Building Council (UKGBC) (2017). *Embodied Carbon: Developing a Client Brief*. Available at: https://www.ukgbc.org/ukgbc-work/embodied-carbon-practical-guidance (accessed 15 November 2022).

16. UK Green Building Council (UKGBC) (2020) *Building the Case for Net Zero: A Feasibility Study into the Design, Delivery and Cost of New Net Zero Carbon Buildings*. Available at: https://www.ukgbc.org/ukgbc-work/building-the-case-for-net-zero (accessed 15 November 2022).

17. UK Green Building Council (UKGBC) (2022) *Delivering Net Zero: Key Considerations for Commercial Retrofit*. Available at: https://www.ukgbc.org/ukgbc-work/commercial-retrofit-key-considerations (accessed 15 November 2022).

18. UK Green Building Council (UKGBC) (2020) *Energy Performance Targets for Net Zero Carbon Offices: Technical Report and Summary of Consultation Responses*. Available at: https://www.ukgbc.org/ukgbc-work/net-zero-carbon-energy-performance-targets-for-offices (accessed 15 November 2022).

19. Royal Institute of British Architects (RIBA) (2021) *RIBA 2030 Climate Challenge*, Version 2. Available at: file:///C:/Users/julie/Downloads/RIBA-2030-Climate-Challenge.pdf (accessed 15 November 2022).

20. Greater London Authority (GLA) (2022) *Analysis of a Net Zero 2030 Target for Greater London*. Available at: https://www.london.gov.uk/sites/default/files/nz2030_element_energy.pdf (accessed 15 November 2022).

21. Greater London Authority (GLA) (2021) *The London Plan*. Available at: www.london.gov.uk/what-we-do/planning/london-plan/new-london-plan/london-plan-2021 (accessed 15 November 2022).

22. Greater London Authority (GLA) (2021) *'Be Seen' Energy Monitoring Guidance*. Available at: www.london.gov.uk/what-we-do/planning/implementing-london-plan/london-plan-guidance/be-seen-energy-monitoring-guidance (accessed 15 November 2022).

23. London Energy Transformation Initiative (LETI) (2020) *LETI Climate Emergency Design Guide*. Available at: https://www.leti.uk/cedg (accessed 15 November 2022).

24. London Energy Transformation Initiative (LETI) (2020) *LETI Embodied Carbon Primer*. Available at: www.leti.london/ecp (accessed 15 November 2022).

25. London Energy Transformation Initiative (LETI) (2020) *LETI Client Guide for Net Zero Carbon Buildings*. Available at: https://www.leti.uk/ecp (accessed 15 November 2022).

26. Royal Institute of Chartered Surveyors (RICS) *Whole Life Carbon Assessment for the Built Environment*. Available at: https://www.rics.org/uk/upholding-professional-standards/sector-standards/building-surveying/whole-life-carbon-assessment-for-the-built-environment (accessed 15 November 2022).

27. CIBSE and LETI (2022) *Net Zero FAQs. What Does Net Zero Mean?* Available at: https://www.cibse.org/media/rwrboqd3/cibse-leti-faq-rev1.pdf (accessed 15 November 2022).

28. Construction Leadership Council (CLC) (2021) *Performance Framework*. Available at: https://www.constructionleadershipcouncil.co.uk/constructzero/performance-framework (accessed 15 November 2022).

29. Construction Leadership Council (CLC) (2021) *Performance Framework Dashboard Q3 2022*. Available at: https://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2022/10/CZ-Performance-Framework-Dashboard-Q3-2022-final-18_10_22.pdf (accessed 15 November 2022).

30. Woodford L (2007) The green lease schedule. Paper presented at: *eceee 2007 Summer Study on Energy Efficiency: Saving Energy – Just do it!* Available at: https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2007/Panel_3/3.343 (accessed 15 November 2022).

31. Rameezdeen R, Zuo J and Stevens J (2017) Practices, drivers and barriers of implementing green leases: lessons from South Australia. *Journal of Corporate Real Estate* **19**(1): 36–52. Available at: https://doi.org/10.1108/JCRE-04-2016-0018 (accessed 15 November 2022).

32. Better Buildings Partnership (BBP) (2013) *Green Lease Toolkit*. Available at: https://www.betterbuildingspartnership.co.uk/sites/default/files/media/attachment/bbp-gltk-2013_0.pdf (accessed 15 November 2022).

33. Granell R, Wallom D, Janda K, Patrick J and Bright S (2017) Quantifying the impact of green leasing on energy use in a retail portfolio: limits to big data analytics. Paper presented at: *eceee 2017 Summer Study on Energy Efficiency: Consumption, Efficiency and Limits*. Available at: https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2017/8-monitoring-and-evaluation-building-confidence-and-enhancing-practices/quantifying-the-impact-of-green-leasing-on-energy-use-in-a-retail-portfolio-limits-to-big-data-analytics (accessed 15 November 2022).

34. Department of Energy & Climate Change (2015) *Private Rented Sector Energy Efficiency Regulations (Non-Domestic)*. Available at: https://www.gov.uk/government/consultations/private-rented-sector-energy-efficiency-regulations-non-domestic (accessed 15 November 2022).

35. Edwards C and Krendel P (2018) *Institutional Leases in the 21st Century*. Available at: https://doi.org/10.4324/9781315040738 (accessed 15 November 2022).

36. Bright S and Dixie H (2014) Evidence of green leases in England and Wales. *International Journal of Law in the Built Environment* **6**(1/2): 6–20. Available at: https://doi.org/10.1108/ijlbe-07-2013-0027 (accessed 15 November 2022).

37. Hillebrand G, Arends G, Streblow R, Madlener R and Müller D (2014) Development and design of a retrofit matrix for office buildings. *Energy and Buildings* **70**: 516–522. Available at: https://doi.org/10.1016/j.enbuild.2013.10.029 (accessed 15 November 2022).

38. Parkinson A and Guthrie P (2014) Evaluating the energy performance of buildings within a value at risk framework with demonstration on UK offices. *Applied Energy* **133**, 40–55. Available at: https://doi.org/10.1016/j.apenergy.2014.07.074 (accessed 15 November 2022).

39. Surmann M and Hirsch J (2016) Energy efficiency: behavioural effects of occupants and the role of refurbishment for European office buildings. *Pacific Rim Property Research Journal* **22**(1), 77–100. Available at: https://doi.org/10.1080/14445921.2016.1168565 (accessed 15 November 2022).

40. Yoon YR and Moon HJ (2018) Energy consumption model with energy use factors of tenants in commercial buildings using Gaussian process regression. *Energy and Buildings* **168**: 215–224. Available at: https://doi.org/10.1016/j.enbuild.2018.03.042 (accessed 15 November 2022).

41. Abdelalim A, O'Brien W and Gilani S (2019) A probabilistic approach toward achieving net-zero energy buildings using a stochastic office tenant model. *Science and Technology for the Built Environment* **25**(6), 743–752. Available at: https://doi.org/10.1080/23744731.2019.1598137 (accessed 15 November 2022).

42. Oto Y, Masuda T, Akashi Y and Lim J (2019) Prediction of energy saving policies effects reflecting decision making process of office building owners and tenants. *IOP Conference Series: Earth and Environmental Science* **238**(1): 2–8. Available at: https://doi.org/10.1088/1755-1315/238/1/012034 (accessed 15 November 2022).

43. Papadopoulos S, Kontokosta CE, Vlachokostas A and Azar E (2019) Rethinking HVAC temperature setpoints in commercial buildings: the potential for zero-cost energy savings and comfort improvement in different climates. *Building and Environment* **155**: 350–359. Available at: https://doi.org/10.1016/j.buildenv.2019.03.062 (accessed 15 November 2022).

44. Mathew P, Regnier C, Shackelford J and Walter T (2020) Energy efficiency package for tenant fit-out: laboratory testing and validation of energy savings and indoor environmental quality. *Energies* **13**(20): 14–16. Available at: https://doi.org/10.3390/en13205311 (accessed 15 November 2022).

45. Duran Ö and Lomas KJ (2021) Retrofitting post-war office buildings: interventions for energy efficiency, improved comfort, productivity and cost reduction. *Journal of Building Engineering* **42**: 102746. Available at: https://doi.org/10.1016/j.jobe.2021.102746 (accessed 15 November 2022).

46. Axon CJ, Bright SJ, Dixon TJ, Janda KB and Kolokotroni M (2012) Building communities: reducing energy use in tenanted commercial property. *Building Research and Information* **40**(4): 461–472. Available at: https://doi.org/10.1080/09613218.2012.680701 (accessed 15 November 2022).

47. Galvin R and Terry N (2016) Selling energy savings in the United Kingdom: a case study of top-down pro-environmental behaviour change in commercial office buildings. *Energy Research and Social Science* **11**: 155–163. Available at: https://doi.org/10.1016/j.erss.2015.10.001 (accessed 15 November 2022).

48. Whitney S, Dreyer BC and Riemer M (2020) Motivations, barriers and leverage points: exploring pathways for energy consumption reduction in Canadian commercial office buildings. *Energy Research and Social Science*, **70**: 101687. Available at: https://doi.org/10.1016/j.erss.2020.101687 (accessed 15 November 2022).

49. Agha-Hossein M (2018) *Soft Landings Framework 2018: Six Phases for Better Buildings*. BG 54/2018. Available at: https://www.bsria.com/uk/product/QnPd6n/soft_landings_framework_2018_bg_542018_a15d25e1 (accessed 15 November 2022).

50. Kontokosta CE (2016) Modeling the energy retrofit decision in commercial office buildings. *Energy and Buildings* **131**: 1–20. Available at: https://doi.org/10.1016/j.enbuild.2016.08.062 (accessed 15 November 2022).

51. Qiu Y, Su X and Wang YD (2017) Factors influencing commercial buildings to obtain green certificates. *Applied Economics* **49**(20): 1937–1949. Available at: https://doi.org/10.1080/00036846.2016.1229434 (accessed 15 November 2022).

52. Shang L, Lee HW, Dermisi S and Choe Y (2020) Impact of energy benchmarking and disclosure policy on office buildings. *Journal of Cleaner Production* **250**. Available at: https://doi.org/10.1016/j.jclepro.2019.119500 (accessed 15 November 2022).

53. Kuivjõgi H, Uutar A, Kuusk K, Thalfeldt M and Kurnitski J (2021). Market based renovation solutions in non-residential buildings – Why commercial buildings are not renovated to NZEB. *Energy and Buildings* **248**: 1–13. Available at: https://doi.org/10.1016/j.enbuild.2021.111169 (accessed 15 November 2022).

54. Bleyl JW, Bareit M, Casas MA, Chatterjee S, Coolen J, Hulshoff A, et al. (2019) Office building deep energy retrofit: life cycle cost benefit analyses using cash flow analysis and multiple benefits on project level. *Energy Efficiency* **12**(1): 261–279. Available at: https://doi.org/10.1007/s12053-018-9707-8 (accessed 15 November 2022).

55. Leishman C, Orr A and Pellegrini-Masini G (2012) The impact of carbon emission reducing design features on office occupiers' choice of premises. *Urban Studies* **49**(11): 2419–2437. Available at: https://doi.org/10.1177/0042098011427189 (accessed 15 November 2022).

56. Faulconbridge J, Cass N and Connaughton J (2018) How market standards affect building design: the case of low energy design in commercial offices. *Environment and Planning A* **50**(3): 627–650. Available at: https://doi.org/10.1177/0308518X17752681 (accessed 15 November 2022).

57. Fuerst F, Van De Wetering J and Wyatt P (2013) Is intrinsic energy efficiency reflected in the pricing of office leases? *Building Research and Information* **41**(4): 373–383. Available at: https://doi.org/10.1080/09613218.2013.780229 (accessed 15 November 2022).

58. Kok N and Jennen M (2012) The impact of energy labels and accessibility on office rents. *Energy Policy* **46**: 489–497. Available at: https://doi.org/10.1016/j.enpol.2012.04.015 (accessed 15 November 2022).

59. Mallaburn P, Azhari R, Fawcett T and Topouzi M (2021) Australian non-domestic buildings policy as an international exemplar. *Buildings and Cities* **2**(1): 318–335. Available at: https://doi.org/10.5334/bc.114 (accessed 15 November 2022).

60. Shrubsole C, Macmillan A, Davies M and May N (2014) 100 Unintended consequences of policies to improve the energy efficiency of the UK housing stock. *Indoor and Built Environment* **23**(3): 340–352. Available at: https://doi.org/10.1177/1420326X14524586 (accessed 15 November 2022).

61. McArthur JJ, Jofeh C and Aguilar AM (2015) Improving occupant wellness in commercial office buildings through energy conservation retrofits. *Buildings* **5**(4): 1171–1186. Available at: https://doi.org/10.3390/buildings5041171 (accessed 15 November 2022).

62. Parkinson A, De Jong R, Cooke A and Guthrie P (2013) Energy performance certification as a signal of workplace quality. *Energy Policy* 62: 1493–1505. Available at: https://doi.org/10.1016/j.enpol.2013.07.043 (accessed 15 November 2022).

63. Collins D, Junghans A and Haugen T (2018) Green leasing in commercial real estate. The drivers and barriers for owners and tenants of sustainable office buildings. *Journal of Corporate Real Estate* **20**(4): 244–259. Available at: https:// 10.1108/JCRE-01-2017-0003 (accessed 15 November 2022).

64. MEP (2022) *The MEP 2040 Challenge*. Available at: https://www.mep2040.org (accessed 15 November 2022).

65. Structural Engineering Institute (2022) *SE 2050. Committing to Net Zero*. Available at: https://se2050.org (accessed 15 November 2022).

66. GRESB (2022) *The Global ESG Benchmark for Real Assets*. Available at: https://www.gresb.com/nl-en/about-us (accessed 15 November 2022).

67. RIBA (2021) *RIBA Plan for Use Guide*. Available at: file:///C:/Users/julie/Downloads/Plan%20for%20Use%20Guide%202021.pdf (accessed 15 November 2022).

68. Architects Registration Board (ARB) (2021) *Competence Guidelines: Sustainability*. Available at: https://www.arb.org.uk (accessed 15 November 2022).

69. Climate Change Committee (2022) *Progress in Reducing Emissions*. Available at: www.theccc.org.uk/wp-content/uploads/2022/06/Progress-in-reducing-emissions-2022-Report-to-Parliament.pdf (accessed 15 November 2022).

70. Buildings As Material Banks Consortium (BAMB) (2021) *Enabling a Circular Building Industry*. Available at: https://www.bamb2020.eu (accessed 15 November 2022).

APPENDIX A
ANALYSIS OF SURVEY SCORES BY SIZE OF ORGANISATION

In order to determine whether industry views of net-zero differed by size of organisation, the survey sample of 102 respondents was simply split between micro and small enterprises of fewer than 250 employees and medium-sized and large enterprises of above 250 employees.

A micro-organisation of fewer than 10 staff may have a considerably different perspective from an enterprise with 249 employees. Similarly, an international company with many thousands of staff worldwide will have a different perspective from a UK domestic company of just over 250 employees. Justified on that basis, the survey sample could be separated to a great degree of granularity (as with the charts separating responses by profession in the main report). However, the researchers believe greater correlation between responses and professional orientation was more likely compared with responses that are sorted by fine categories of company size.

Furthermore, as all survey responses are those of individuals, their views do not necessarily reflect a corporate perspective. Hence a simple separation of the survey sample using a threshold of 250 staff was deemed less likely to generate spurious statistics and lead to misleading conclusions (particularly given the relatively small proportion of respondents from small and micro-enterprises, as shown in Figure 2 of the main report).

The following charts show data in percentages rather than by number of responses, again as befitting the simple categorisation. The cumulative distributions are nonetheless virtually identical to the charts separating responses by profession. For consistency the sequence of charts follows that on pages 24–29.

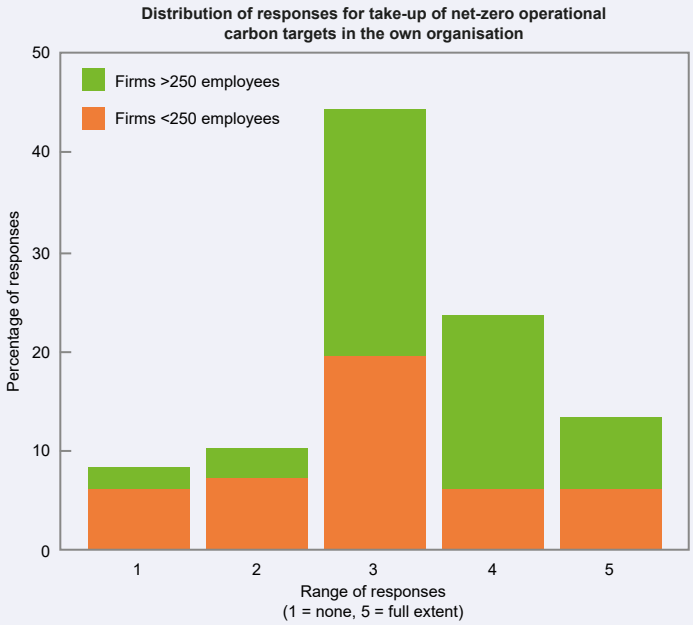

Figure A.1
Distribution of responses for take-up of net-zero operational carbon targets in own organisation.

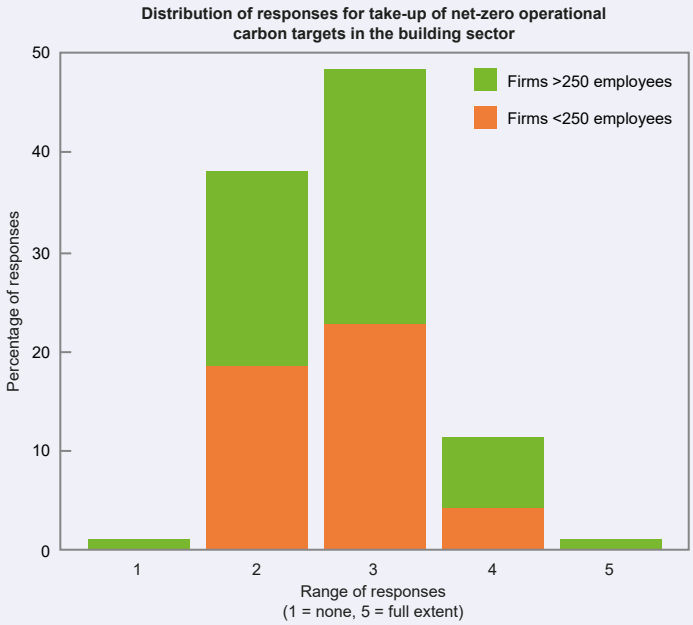

Figure A.2
Distribution of responses for take up of net-zero operational carbon targets in the building sector.

OPERATIONAL NET-ZERO CARBON TARGETS

Respondents were asked to score the degree to which they thought commitments to net-zero operational carbon targets were being achieved. Respondents were asked to consider what was happening in their own organisation (Figure A.1) and what they thought was happening in the wider building sector (Figure A.2). Respondents' views broadly concur, irrespective of the size of employer.

In simple terms it might be said that respondents in large organisations have a more positive perspective on the take-up of operational net-zero carbon targets in their own company than do those in smaller companies, who expressed a greater range of opinion. Part of the reason may be the professional perspectives discussed elsewhere in this report, but it could also be the case that larger organisations have a greater stake in net-zero outcomes (e.g. developers, clients and owner occupiers on the industrial demand side). Their views may, therefore, be

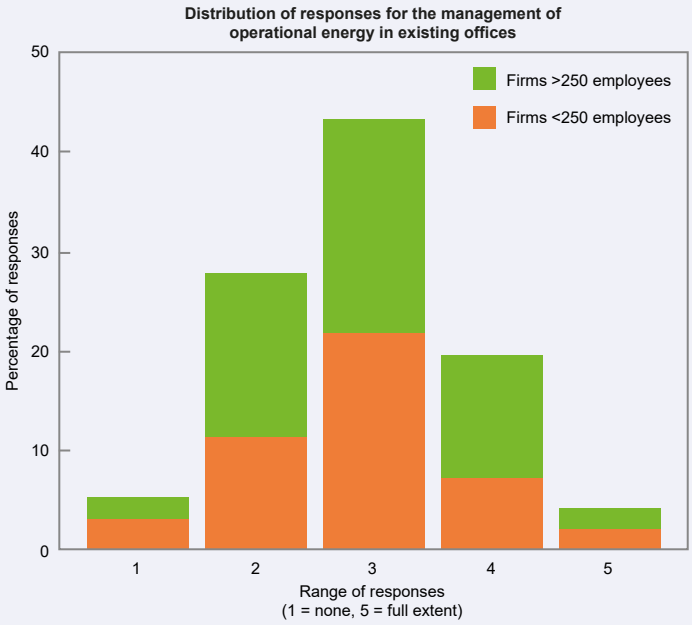

Figure A.3
Distribution of responses for the management of operational energy in existing offices.

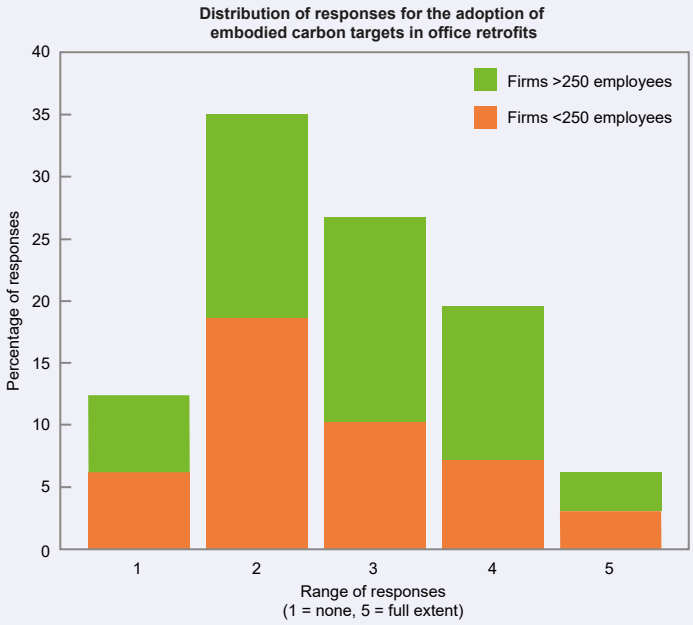

Figure A.4
Distribution of responses for the adoption of embodied carbon targets in office retrofits.

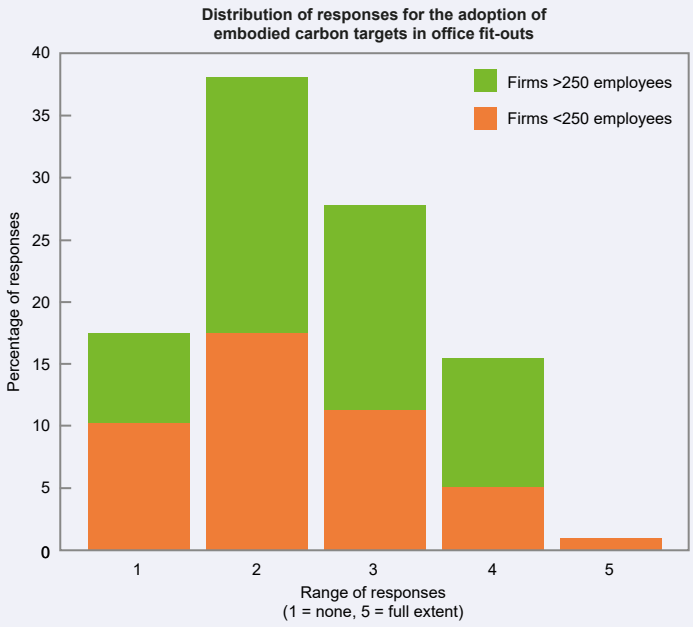

Figure A.5
Distribution of responses for the adoption of embodied carbon targets in office fit-outs.

relatively more sanguine compared with views from smaller companies, which are more likely to be selling services into that market. This may be the reason why there is less distinction with respect to what is thought to be happening in the industry broadly (Figure A.2).

Survey respondents were asked a subsidiary question about the extent to which operational energy use is being managed and optimised in existing commercial offices (Figure A.3). The percentages of responses are largely the same – there is broad agreement irrespective of the size of enterprise. This is consistent with the results from the professions' perspectives given on pages 22–29. Some believe management of operational energy is being done well, others badly. The normality of the distribution offers little comfort: there is considerable room for improvement given that the immediate context is net-zero carbon dioxide emissions not simply the more efficient use of energy.

Survey respondents were asked to what extent embodied carbon targets are being considered in retrofitting existing commercial offices. The responses are shown in Figure A.4. As with Figure A.3, the responses are consistent irrespective of the size of respondents' host organisations: a distinct bias in perception that less is being achieved with embodied carbon targets in office retrofits. The pattern of responses for the adoption of embodied carbon targets in fit-outs (Figure A.5) mirrors the perceptions for retrofit shown in Figure A.4: there is broad agreement among organisations of all sizes that considerably more needs to be done to achieve net-zero in both office retrofit and subsequent fit-out.

Figure A.6 illustrates perceptions by organisational size for the role of green leases in achieving net-zero aspirations. Again, there is general consensus that the greening of leases – in whatever way that might be achieved – may support net-zero aspirations. Given the more negative scoring for embodied carbon for retrofits and fit-outs in Figures A.4 and A.5, it may be concluded that green leases may be at least one mechanism for exerting greater leverage over the carbon intensity of materials used in office design and fit-out. This finding feeds into the debate about green leases in the main body of the report (and to the role of ESG commitments discussed below).

Respondents were asked about the alignment of ESG objectives and net-zero aspirations. Figure A.7 shows how responses differ by size of organisation. There is little difference, save for a slight negative skew in the opinions of respondents from smaller organisations. As discussed in the main report, there is room for improvement to better align ESG commitments and net-zero objectives. The consensus of professional views discussed in the main report is largely consistent across all sizes of organisation. Essentially, a lot more work is required to endow ESG commitments with greater leverage, for example with employees, shareholders, corporate investors and the general public. ■

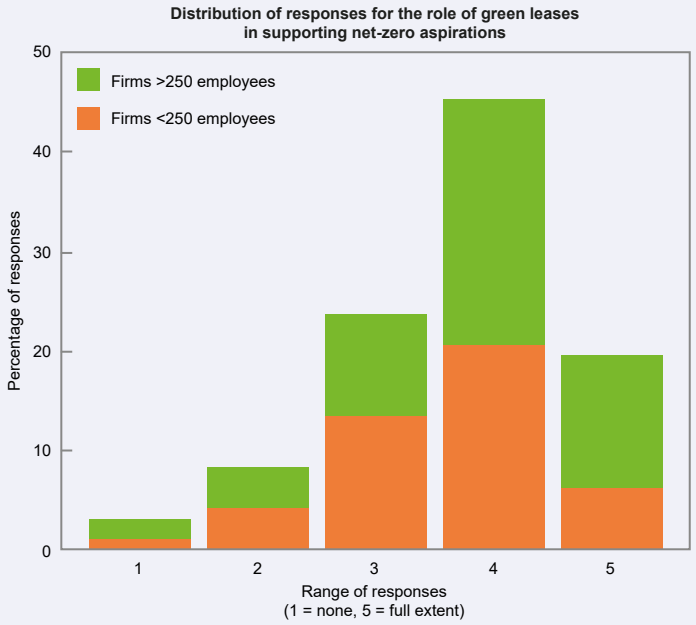

Figure A.6
Distribution of responses for the role of green leases in supporting net-zero aspirations.

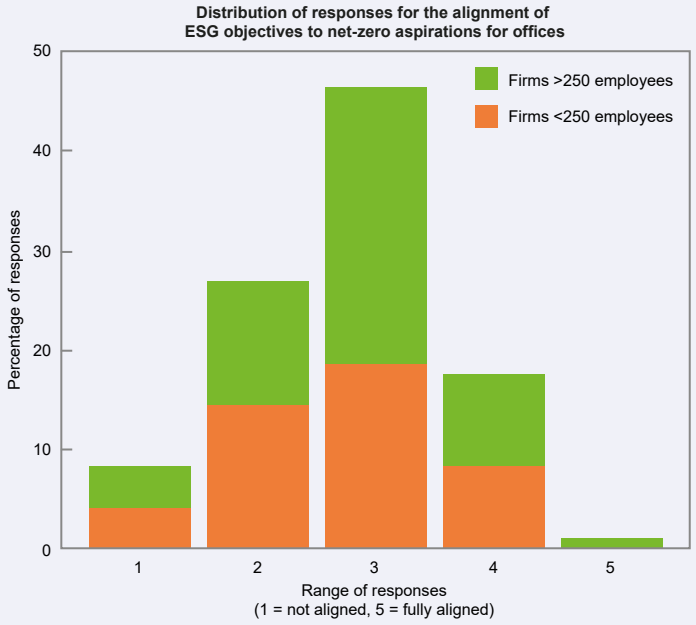

Figure A.7
Distribution of responses for the alignment of ESG objectives with net-zero aspirations for offices.

APPENDIX B
NET-ZERO CARBON CASE STUDIES

CASE STUDY 1

PROJECT SUMMARY

The sustainability vision for the Royal Street Masterplan project includes an overarching target to achieve net-zero embodied and operational carbon outcomes in line with the UKGBC guidance without compromising performance across any aspect of the commercial, residential and external works. The masterplan has set phased targets. At RIBA Stage 2 all plots have been assessed against the same targets, but the later phase of development will strive for higher targets.

The sustainability vision includes targets relating to biodiversity, resilience, the circular economy, air quality, social value and integration of the public realm. The project is targeting BREEAM Outstanding, WELL V2 Core Gold, NABERS 5* and Wired Platinum. Over the course of the masterplan design and construction, new technologies and innovations may become available to help further reduce embodied carbon.

Project name: Royal Street Masterplan

Location: Lambeth, London

Building use or typology: Speculative offices and residential homes

Project value: Not disclosed

Status: Design (RIBA Stage 2)

Area: 126,286 m² (NIA)

Category: New build

Client: Guy's & St Thomas' Foundation

Developer: Stanhope PLC

Professional design team members:

Architects: AHMM, Henley Halebrown, Piercy & Co, COBE + Morris & Co, Fielden Fowles and East

MEP designer: Arup

Cost consultant: Alinea

Main contractor: To be appointed

Courtesy of Stanhope plc

NET-ZERO BRIEF

The project set a sustainability vision during RIBA Stages 1 and 2. The vision includes an overarching target to achieve net-zero embodied and operational carbon outcomes. The targets are in line with the UKGBC guidance without compromising performance across any aspect of the scheme including commercial, residential and external works. The masterplan has set phased targets. Although all plots were assessed against the same targets at RIBA Stage 2, the later phase of development will strive for higher targets. The proposed development achieves an overall reduction in regulated carbon dioxide emissions of 41% (beyond the Greater London Authority's minimum 35% threshold via on-site measures).

Net-zero brief defined at what RIBA Stage? RIBA 1 and 2

Net-zero target set by: Stanhope in collaboration with the design team

Operational energy and carbon targets

Energy use

- Regulated electricity: 33.0 kWh/m² per year
- Unregulated electricity: 81.3 kWh/m² per year

Fossil gas: 0 kWh/m² per year

On-site renewables: 0.57 kWh/m² per year

Total: 114.3 kWh/m² per year

The all-electric servicing strategy relies on heat pumps to take advantage of future grid decarbonisation, with the aim of future-proofing the site. Photovoltaic panels will provide additional on-site energy.

For the offices, commissioning will be undertaken and monitoring will be done post-completion to ensure systems are operating as expected and in accordance with NABERS.

Operational carbon

- *Commercial*: NABERS 5* with a route to 6* (aligned with tenants when on board)
- *Residential*: Aligned with Passivhaus (60 kWh/m^2 per year)
- *Operational carbon dioxide emissions*: 16.7 $kgCO_2/m^2$

Carbon factors used

- *Electricity*: 0.233
- *Fossil gas*: 0.210

Detailed energy modelling was carried out at Stage 2, including NABERS for the commercial plots and the use of the Passivhaus Planning Package (PHPP) for the residential plots. The results of the PHPP modelling at Stage 2 indicated that the building's primary energy demand will be above the Passivhaus Standard. Measures have been identified for the design team to implement during detailed design, such as additional envelope insulation and external shading.

The results of the NABERS modelling at Stage 2 indicated that the target of 5* would be achievable (a modelled result of 5.5*). A scenario was also modelled assuming a low-carbon LETI-aligned tenant, and this indicated a possible route to 6*.

The design team will explore a wider comfort range, reducing ventilation to back-of-house areas, and further efficiencies for landlord lighting during detailed and technical design.

Embodied carbon (site-wide totals)

- Commercial: 575 $kgCO_2/m^2$ (A1–5*), 800 $kgCO_2/m^2$ (A–C*)
- Residential: 500 $kgCO_2/m^2$ (A1–5*, 800 $kgCO_2/m^2$ (A–C*)

Aligned with LETI B–C, with an aspiration for Phase 2 to meet LETI A.

A Stage 2 whole-life carbon assessment was carried out using One Click LCA in accordance with the RICS Professional Statement *Whole Life Carbon Assessment for the Built Environment*[26] and BS EN 15978:2011. Several workshops and discussions took place with the client and design team to minimise embodied carbon as much as possible in the Stage 2 design. Double-skinned/closed-cavity façades have been proposed on elevations exposed to high solar gains. Other passive measures include exposed thermal mass to reduce peak cooling loads. Active measures include a proposed smart building system using sensors to use services effectively to match demand. A 21% reduction in regulated carbon dioxide emissions is projected through lean measures.

Specific measures included:

- consolidated basement to reduce excavation and new construction
- reuse of in situ superstructure on Plots E and F
- potential reuse of granite cladding from Plot E in the new cladding
- hybrid concrete/cross-laminated timber frame potential including high-ground-granulated blast-furnace slag replacement.

Further measures have been identified to incorporate at Stage 3, including:

- removing suspended metal raft ceilings, or specifying a low-carbon alternative
- identifying and specifying a low-carbon raised access-floor panel
- continual optimisation of the structural design to reduce material consumption.

Low-carbon material specifications will be adopted throughout procurement.

Anticipated benefits

By undertaking enhanced operational energy modelling for NABERS and targeting a high rating (5*), the intent is that there will be operational benefits for the building operators/tenants.

Although plots have been considered against the same targets at Stage 2, more stretching targets have been set for Phase 2 of the development.

Lessons learned from the net-zero process

All members of the design team were heavily involved in discussions around embodied and operational carbon during Stage 2. Such involvement is key to a project achieving its goals. The operational energy modelling process was complex as it included compliance modelling as well as detailed NABERS and Passivhaus modelling. A key lesson learned was that starting this process earlier in Stage 2 would have allowed more time for discussion and iterations. This will be picked up in RIBA Stage 3.

* Whole life-cycle carbon, i.e. including maintenance, repair, use, replacement and final disposal at end of life, over a period of 60 years, in line with BS EN 15978:2011.

CASE STUDY 2

PROJECT SUMMARY*

The project team for the New Bailey office project are aiming to reduce the upfront embodied carbon of the scheme to 784 $kgCO_2e/m^2$, slightly above the LETI Intensity target of 600 $kgCO_2e/m^2$. Further reductions will be investigated at the next design stage. The operational energy target is a 40% reduction over industry standard best practice performance. At 70 kWh/m^2 per year the initial design was above the 2030 net-zero carbon operational energy intensity for the whole building. However, the potential scenario is close to the landlord's energy use target of 35 kWh/m^2 per year. Following the Stage 3 assessment, a pathway to meeting the target has been produced for development. The design key to this will be further reducing the landlord's intensity, thereby giving tenants a bigger budget to work within.

Project name: New Bailey, Plot A3

Location: Salford, Manchester

Building use or typology: Speculative office

Project value: £45 million

Status at time of writing: RIBA Stage 4

Area: 16,098 m^2 GIA

Category: New build

Client: English Cities Fund

Developer: Muse Developments

Professional design team members: Make Architects, Cundall

Main contractor: Bowmer + Kirkland

NET-ZERO BRIEF

Net-zero brief defined at what RIBA Stage? RIBA Stage 1

Net-zero target set by: Client

Operational energy and carbon targets: No breakdown available

A detailed operational energy performance assessment of the Stage 3 design was carried out using the BBP's Design for Performance standard. As a result of the Stage 3 Design for Performance assessment, three scenarios were assessed: a high-end scenario which reflects the Stage 3 design (also referred to as the 'baseline scenario'); a mid-range scenario with improved controls and setback (circulation and reception); and a potential scenario involving improved controls and setback (circulation and reception), enhanced pipework insulation and improved after-hours controls to reduce heat losses.

Copyright MAKE Architects

Embodied carbon

Embodied carbon target: 750 $kgCO_2/m^2$

The Whole Life-Cycle Embodied Carbon Assessment (WLCA) was carried out in accordance with BS EN15978:2011 (Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method), and the RICS Professional Statement *Whole Life Carbon Assessment for the Built Environment*.[26]

Lessons learned from the net-zero process

To effectively address whole-life carbon throughout the continuation of the design process, the project team recognises that it will be important to undertake whole-life carbon assessment beyond RIBA Stage 4 and during construction. Data on the carbon footprint of materials will be assessed during procurement, and the data will be publicly disclosed and reported to the RICS embodied carbon database.

Early engagement of the design team with the contractor will be crucial. At Stage 4, Design for Performance workshops will be arranged with the contractor to regularly review the design and investigate opportunities to further reduce the current operational energy use. Progress against the project target will be tracked.

* Further information can be found at: https://www.ukgbc.org/solutions/plot-a3-new-bailey (accessed 15 November 2022).

CASE STUDY 3

PROJECT SUMMARY*

Paradise is a new six-storey office building in Lambeth. It will provide a low-carbon building for businesses that want their premises to represent their sustainability credentials, but still need to be in central London and cannot afford to build their own building.

The initial sustainability targets were around BREEAM Outstanding, WELL Platinum and WIRED scores, reflecting the London office market in 2018. However, as the design progressed, the opportunity for a zero-carbon building became apparent, with the sequestered carbon offsetting the embodied and operational carbon over a defined period. The brief evolved based on pivoting the design towards a mass-timber solution, and the key performance target became to meet or outperform the RIBA 2030 Climate Challenge targets.

The building has an extensive timber superstructure, with glulam columns and cross-laminated timber floor slabs, which are significantly lower carbon than concrete or steel alternatives. The ceramic tile façade has comparatively high upfront embodied carbon, but it will comfortably last over 100 years in the harsh environment next to a railway line. At the end of their life, the tiles can be demounted and reused on another building. Other façade materials were rejected due to concerns over durability and the complexity of cleaning in the constrained site.

The design has sought to maximise the use of timber and to achieve the lowest possible whole-life carbon figure while meeting the requirements of emerging Structural Timber Association guidance on mass timber laminated fibre board and requirements in terms of fire-fighting. The building has been assessed following the RICS Professional Statement and following BS EN 15978:2011, for a life-cycle of 60 years.

The building does not use fossil fuels, with air-source heat pumps providing the heating and cooling throughout. This will benefit from the increasing decarbonisation of the national grid to eventually become effectively zero carbon in operation.

The dense site provided limited space for photovoltaic (PV) panels on the roof, but the system has been sized to maximise generation from the limited space. It is anticipated that all the energy generated by the PV system will be utilised by the building, maximising the benefits for the occupants.

Passive design measures of high insulation, low infiltration rates and optimised glazing ratios have been incorporated to reduce the underlying energy use of the building, providing the best start for the future occupants.

Openable windows provide fresh air in the shoulder seasons, providing free ventilation and increased occupant satisfaction. Carbon dioxide detectors within the office spaces also facilitate demand-controlled ventilation when required.

Project name: 30–34 Old Paradise Street

Location: Lambeth, London

Building use or typology: Speculative office

Project value: Not disclosed

Status at time of writing: Design completed

Area: 7437 m² (GIA), 5627 m² (NIA)

Category: New build

Courtesy of Bywater Properties. Copyright Paradise11 Ltd

Client: Bywater

Developer: Bywater Properties

Professional design team members: FCBStudios (Architect), Webb Yates (Structural designer), Wallace Whittle (MEP designer), CHP (Quantity Surveyor), Quartz (Project manager)

Main contractor: Gilbert Ash

NET-ZERO BRIEF

Net-zero brief defined at what RIBA Stage? RIBA Stage 2

Net-zero target set by: Client with design team

Operational energy and carbon targets

Electricity: 115 kWh/m² per year (based on GIA)

Natural gas: 0 kWh/m² per year

Renewable onsite: 5 kWh/m² per year (based on GIA)

Operational carbon emissions: 14.8 $kgCO_2/m^2$ per year (based on GIA)

Carbon factor used for electricity: 0.127 (based on 2024 National Grid Future Energy Scenario)

* Further information can be found at: https://paradise11.co.uk (accessed 15 November 2022).

Embodied carbon target

Upfront, A1–5: 443 kgCO_2e/m² (based on GIA)

Life-cycle embodied, A1–B4, C1–4: 543 kgCO_2e/m² (based on GIA)

Lessons learned from the net-zero process

Embodied carbon figures are highly dependent on the detail. Changes to incorporate increased fire safety requirements have significantly pushed up the overall figures, which were difficult to predict at the outset of the project.

The impact of MEP systems on embodied carbon has become far better understood since the inception of this project (in 2018), in particular the publication of CIBSE TM65, and should be considered from the outset. The MEP systems and refrigerant are predicted to emit 1,910 t CO_2e, more than the substructure and superstructure combined. ■

ABOUT THE AUTHORS

Rayan Azhari BSc MSc MRes MPhil is a Senior Sustainability Consultant at Verco. Before working at Verco, Rayan worked on his PhD focusing on understanding the operational energy in non-domestic buildings and occupant activity using a comprehensive model called 3DStock. Rayan has also published a few peer-reviewed journal papers.

Rayan has over ten years of experience in the architecture, data analysis, sustainability and energy fields across commercial and academic sectors. He is fluent in SQL and R, and has experience in developing data analysis approaches to inform the rating of commercial and industrial buildings based on the operational energy use for the Department for Business, Energy and Industrial Strategy (BEIS).

Previously, Rayan worked with the Better Buildings Partnership (BBP) to deliver the Real Estate Environmental Benchmark project, which included presenting energy and carbon trajectories compared to UKGBC and CRREM targets and net-zero carbon trajectories and pathways to 2050.

Roderic Bunn BA (hons) EngD has a track record in researching the performance of non-domestic buildings, from their energy and carbon dioxide emissions to measuring the comfort and satisfaction of their occupants.

Roderic lectures widely on the role of human behaviour in building performance, and advises building owners and building design teams on ways to ensure design ambitions can be achieved in reality. He is also a lecturer in post-occupancy evaluation for the UCL IEDE MSc programme Environmental Design and Engineering. He is known for co-authoring the definitive industry guidance on Soft Landings, The Soft Landings Framework, and many subsequent supporting guides on Soft Landings. Dr Bunn co-authored CIBSE TM61:2020 *Operational Performance of Buildings*, and authored CIBSE TM62:2020 *Operational Performance: Surveying Occupant Satisfaction*.

Between 1995 and 2001, Dr Bunn led the ground-breaking PROBE building performance evaluation research project. This project was instrumental in devising what have become industry-standard methods of measuring occupant satisfaction and energy consumption. He subsequently worked on the Carbon Trust's Low Carbon Buildings Performance programme (2011), and was lead evaluator for InnovateUK's Building Performance Evaluation (2011–2015) and Invest in Innovative Refurbishment (2013–2015) programmes.

Esfand Burman BSc MSc EngD CEng MCIBSE is an Associate Professor at the UCL Institute for Environmental Design and Engineering, a Chartered Engineer, and a corporate member of the Chartered Institute of Building Services Engineers (CIBSE).

Esfand has a strong track record in building performance evaluations, and was involved in the Innovate UK BPE programme, leading the field work in in several offices and educational buildings. He also contributed to the development of CarbonBuzz and the metadata analysis of the operational performance data collated on this platform.

Esfand's research in the area of building performance evaluation also includes the EPSRC funded Total Operational Performance of Low Carbon Buildings (TOP), a major research programme that, in addition to several academic publications, led to the publication of CIBSE Technical Memoranda TM61-64. Esfand was an editor of these series and a principal author of CIBSE TM61:2021 *Operational Performance of Buildings* and TM63:2020 *Operational Performance: Building Performance Modelling*. Esfand has produced over 80 peer-reviewed publications.

He was the academic supervisor for a Knowledge Transfer Partnership (KTP) with the architectural practice Allford Hall Monaghan Morris (AHMM) on 'Achieving Net Zero Carbon in High Density, Mixed Use, Commercial Developments', which involved engagement with key stakeholders and technical studies to identify the optimal pathways to net-zero in the UK commercial office sector.

He currently teaches on UCL built environment MSc and MEng courses, specifically BENV0031: Efficient Building Services Systems, and BARC0167: Environmentally Responsible Building Systems. Prior to his academic life, Esfand practiced as a building services design engineer at Hurley Palmer Flatt and as a low carbon energy assessor for commercial buildings at Arcadis UK.

Anna Mavrogianni MArch MSc PhD PGCert FHEA is a Professor of Sustainable, Healthy and Equitable Built Environment at the Institute for Environmental Design and Engineering (IEDE), at the Bartlett, University College London (UCL).

Anna trained as an architect specialising in building physics and environmental design at the School of Architecture at the National Technical University of Athens and the Bartlett, UCL, and has several years of experience in architectural design and environmental consultancy.

She is an expert in indoor environmental quality, building energy retrofit and climate change adaptation of the built environment, focusing on heat vulnerability and air quality at the building and urban scale. She leads interdisciplinary research in building performance used by policymakers to evaluate impacts of energy efficiency in the context of net-zero targets, urban growth and climate change on energy use, carbon emissions, health and wellbeing. She was the Principal Investigator of the EPSRC-funded project Advancing School Performance: Indoor Environmental Quality, Resilience and Educational Outcomes (ASPIRE), and leads the Work Package on Projections of Temperature Change and Impacts in UK Housing as part of the Climate Services for a Net-Zero Resilient World (CS-N0W) project commissioned by BEIS.

She has produced over 120 peer-reviewed publications and has contributed to policy reports, including the UK Government's 2017 Climate Change Risk Assessment. She is a Co-Secretary of the International Building Performance Simulation Association-England (IBPSA-England), a member of the CIBSE Knowledge Management Committee, and an Associate Editor of the *Energy and Buildings* journal.

Since its launch in 2017, Anna has been acting as the Deputy Director of the MSc in Health, Wellbeing and Sustainable Buildings. She is the Module Lead for BENV0055: Integrated Building Design for Health, Comfort and Wellbeing and BENV0029: Natural and Mechanical Ventilation of Buildings. ■

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