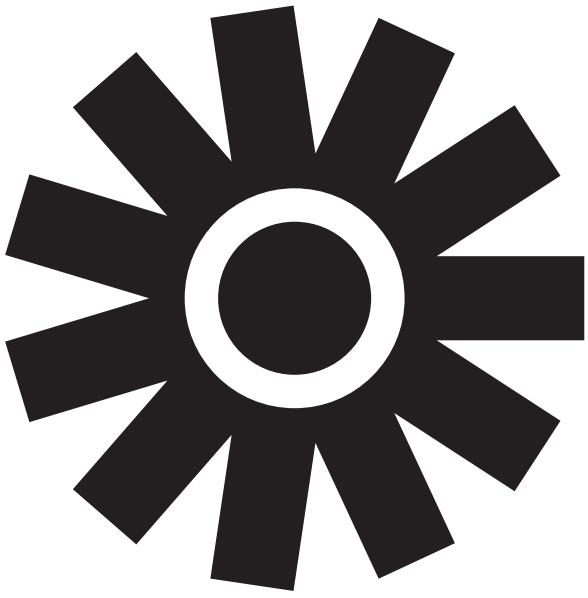
Low-carbon Homes: *Housing construction for the green transition*

AUTHOR Dr Ruth Lang

FUTURE OBSERVATORY



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EXECUTIVE SUMMARY

The UK has a housing shortage, for which the Government consistently cites the need for 300,000 homes to be built each year.[1] Yet since the construction sector accounts for 11% of the UK's carbon emissions, building on the required scale, using standard methods and high-carbon materials, would undermine the country's ambitions to achieve net zero carbon by 2050. Whilst initiatives are already being adopted to reduce the carbon emitted in the operation of these buildings, there is also an urgent need to shift the housebuilding industry away from a reliance on the 'business as usual' model of procurement, and to instead use alternative construction materials which have lower embodied carbon, such as timber, stone and bio-based materials. Although the construction sector is committed to meeting net zero targets, barriers to adopting the necessary strategies to achieve this still exist.

This report compiles surveyed experiences from construction industry professionals, designers, policy makers and researchers, to better understand how the systemic changes necessary might be catalysed. This process has revealed the nature of the issues hindering wide-scale adoption of low-carbon construction, including:

→ A lack of standardised data regarding embodied carbon from which to set benchmarks for its reduction.
→ A lack of incentives to develop the supply chain networks and workforce required for low-carbon construction, which is currently reliant on private funding. This is due to a combined perceived lack of market demand, and the lack of consistent targets being set for reduction by national government or local authorities.
→ Higher costs for low-carbon materials, which are currently provided on a smaller scale than their high-carbon alternatives.
→ A backlog in the provision of insurance, detailing information, building codes and warranties for non-standard construction.

The final section of this report sets out a national roadmap for delivering

1 'Fact Sheet 1. The need for homes.' Updated 16 January 2024. Available at: https://www.gov.uk/government/publications/new-homes-fact-sheet-1-the-need-for-homes/fact-sheet-1-the-need-for-homes.

projects to meet these targets. This will require supply chains, technical knowledge and market demand to be developed. As part of this journey, there is also a need to set incrementally decreasing carbon targets in planning requirements, design codes, regulations and standards, covering the use of renewable materials and the reduction of carbon in construction to provoke the necessary changes in the sector.[2] To do so requires political will and continuity for delivery.[3]

2 The Levelling Up and Regeneration Bill will introduce National Development Management Policies enacted via Section 38/6 offering a mechanism for introducing low-carbon strategies – such as the GLA policy SI/7 for Reducing Waste and Supporting the Circular Economy (requiring 95% reuse, recycling or recovery) – on a national scale rather than at that of the Local Plan.

3 This is exacerbated by different local authorities setting different standards, leading to developers/contractors having to alter their approaches depending on location, hindering the expertise and economies of scale which could be developed.

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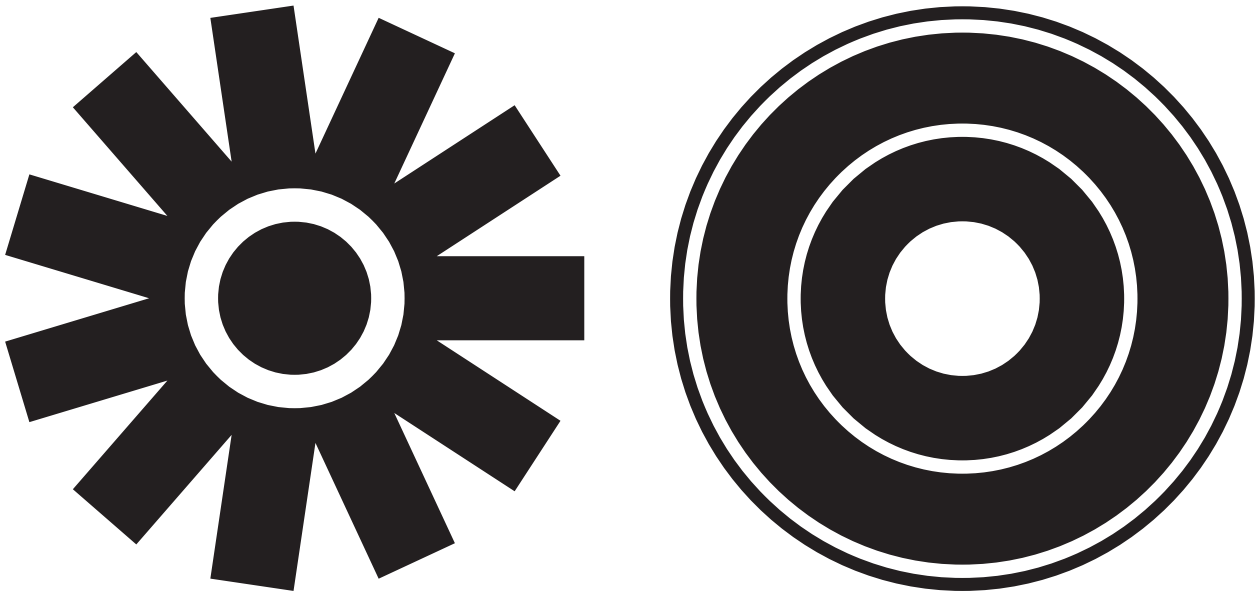
INTRODUCTION
Why reduce embodied carbon in housing construction?



In December 2023 the UK Government reiterated the intention to reach net zero carbon emissions by 2050 under terms of the 2008 Climate Act.[1] With this target in place, it is essential that strategies are defined in order to ensure this can be delivered.

The design and delivery of buildings in the UK plays a significant role in this ambition. Currently, the UK Green Building Council (UKGBC) estimates that the built environment sector is responsible for 25% of the total carbon emissions in the UK.[2] In analysing the first update of the UK Net Zero Whole Life Carbon Roadmap, however, UKGBC identified that the UK is already falling behind the trajectory required to deliver this aim, and have estimated that the rate of decarbonisation needs to double.[3] The Government recognises this, acknowledging that "we must intensify our efforts and eliminate virtually all emissions arising from the built environment if we are to meet our legally binding target of net zero emissions by 2050."[4]

Yet while initiatives to reduce carbon emissions in the operation of buildings have been set out in policies relating to the forthcoming Future Homes Standard (due to come into force in 2025) and for Whole Life Carbon Assessments, the Government acknowledges that "there is no Government policy requiring the assessment or control of embodied carbon emissions from buildings" – any mitigation of embodied carbon is currently undertaken purely on a voluntary basis.[5] This focus on reducing

1 'Net Zero Government Initiative: UK Roadmap to Net Zero Government Emissions'. Available at: https://assets.publishing.service.gov.uk/media/6569cb331104cf000dfa7352/net-zero-government-emissions-roadmap.pdf.

2 UKGBC, 'Climate Change Mitigation'. Available at: https://ukgbc.org/our-work/climate-change-mitigation/.

3 Building Design, 'Built environment needs to decarbonise twice as fast to meet 2025 target, UKGBC says' Available at: https://www.bdonline.co.uk/news/built-environment-needs-to-decarbonise-twice-as-fast-to-meet-2025-target-ukgbc-says/5126737.article.

4 Third report, 'Building to net zero: costing carbon in construction: Government Response to the Committee's First Report'. Available at: https://publications.parliament.uk/pa/cm5803/cmselect/cmenvaud/643/report.html. This figure is 39% globally. The World Green Building Council estimate that "all new buildings, infrastructure and renovations will have at least 40% less embodied carbon" by 2030. Available at: https://worldgbc.org/advancing-net-zero/embodied-carbon/.

5 Such policies build upon the Government's own research into delivering low embodied carbon housing: Department for Business, Energy and Industrial Strategy. 'Building for 2050 Low Cost, Low Carbon Homes. BEIS Research Paper Number 2022/031', November 2022. Available at: https://assets.publishing.service.gov.uk/media/6388cfb7d3bf7f3289092f42/Building_for_2050_Low_cost_low_carbon_homes.pdf. Paragraph 69, Third report, 'Building to net zero: costing carbon in construction: Government Response

operational carbon is distracting from the need to regulate embodied carbon, for which no legislative targets are currently set. This lack of regulation presents an enormous issue in meeting net zero, since embodied carbon – the carbon which is generated in the extraction, production, transportation and application of construction materials – contributes 11% of the carbon footprint globally. Limiting embodied carbon impacts the full supply chain of procurement, including the manufacture, transportation and installation of materials, and can often be considered too complex to address. Yet it is essential that we reduce this upfront carbon emission in conjunction with the long-term gains of neutrality in operation, where the sector's carbon reduction initiatives are currently focused. While operational savings can only be achieved after twenty years of a building's operation, there is no way to rectify the damage being done as a result of the upfront embodied carbon emissions being made now, which have an immediate impact on our environment.[6]

Parallel to this, the UK is facing a housing shortage crisis. The Conservative manifesto of 2019 set an agenda to deliver a minimum of 300,000 new homes per year to address this, which was reiterated by Michael Gove, Secretary of State, at the Department for Levelling Up, Housing and Communities (DLUHC), in October 2022.[7] This commitment has a consequential impact upon our future carbon budget, since, based on data from the Office for National Statistics (ONS), public and private housing construction combined represented 25.46% of the UK's construction output in 2022.[8] Despite calls to explore the means by which non-building initiatives could address the current housing shortfall within carbon

to the Committee's First Report'. As above.

6 "The embodied carbon associated with the construction of a typical new building can be equivalent to 20 years' worth of its operational carbon emissions". Andrew Leiper, 2023. 'Retrofit or new build? Net Zero Carbon Guide'. Available at: https://www.netzerocarbonguide.co.uk/guide/early-decisions/retrofit-or-new-build/summary. This also substantiates the argument for the 'retrofit first' strategy for existing buildings, as the current thinking that demolition of old building stock and replacement with more efficient buildings saves carbon in the longer term will not be accepted.

7 'Tackling the under-supply of housing in England' Available at: https://commonslibrary.parliament.uk/research-briefings/cbp-7671/. This objective has not yet been met, as – according to architect Luke Tozer – other barriers to housing delivery in general include: "construction inflation, high cost of borrowing, policy inflation (fire/climate emergency), local authority funding commitment on statutory obligations for temporary accommodation, insufficient grant funding and a [lack of] government [appetite to deliver] affordable housing." Architects' Journal, 'Weston Williamson and Pitman Tozer schemes shelved by council over costs'. Available at: https://www.architectsjournal.co.uk/news/weston-williamson-and-pitman-tozer-schemes-shelved-by-council-over-costs.

8 ONS 'Datasets related to Construction industry' Available at: https://www.ons.gov.uk/businessindustryandtrade/constructionindustry.

limitations, the Government remains committed to the goal of new housing construction. Embodied carbon in the housebuilding sector is therefore set to take up a significant proportion of the national carbon budget as we move towards the 2050 deadline. While we must ensure that the population's current housing needs are catered for, it is essential that we do not lose sight of the imperatives for carbon reduction which would have a negative impact on the future global population. Without a major effort to reduce the embodied carbon in housing construction, the goal of achieving net zero in 2050 will prove unattainable.[9]

THE CURRENT CONTEXT OF THE HOUSEBUILDING SECTOR

Housebuilding delivery is currently characterised by a tension between an overwhelming demand for the product currently produced, and an urgent need to update the material and labour resources which produce it. The 2016 Farmer review identified the lack of preparedness of the construction sector in confronting future challenges, of which the climate emergency could be categorised as one.[10] This has been exacerbated by the construction skills shortage due to the sector's ageing demographic, and compounded by the effects of Brexit, which has left the sector poorly equipped for the green transition.[11]

Although the intention for reducing embodied carbon is in evidence across the construction sector, a lack of urgency prevails throughout – much work still needs to be done to persuade decision makers and management that change in order to confront the climate emergency is necessary, before the consequential adaptations can begin to be made.[12] Even when internal strategies have already been developed, these are not yet being delivered with sufficient efficiency or effectiveness.[13]

9 "The building of new homes under a business as usual scenario, coupled with current trends on making existing homes more efficient, would mean the housing system would use up 104% of the country's cumulative carbon budget by 2050." Phoebe Weston, 'England's Housing Strategy Would Blow Entire Carbon Budget, Says Study'. *The Guardian*, 22 August 2022. Available at: https://www.theguardian.com/environment/2022/aug/23/englands-housing-strategy-would-blow-entire-carbon-budget-says-study.

10 This report highlighted the impact of "dysfunctional training, a lack of innovation and collaboration, and non-existent research and development". Available at: https://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2016/10/Farmer-Review.pdf.

11 Insight as to how this has come about was collated by Oliver Wainwright at *The Guardian*. Available at: https://www.theguardian.com/lifeandstyle/2023/oct/21/cracked-tiles-wonky-gutters-leaning-walls-why-are-britains-new-houses-so-rubbish.

12 A road map for change has previously been outlined by LETI. Available at: https://www.leti.uk/netzero.

13 It was noted in the roundtables that the private sector is currently leading local authorities in this regard, which is often attributed to ESG data drivers.

The high market demand for residential schemes relative to other building typologies, and the current lack of housing supply, means that issues relating to carbon reduction are lagging behind in the housing sector in comparison to the commercial sector, where customer and funding demands are driving change.[14] There is a concern that setting carbon limits for the delivery of housing would incite housing providers to push back on the viability of housing developments, which are a key priority for local authorities to deliver.

Much of the rationale for not adopting low-carbon construction is also attributed to a lack of market demand.[15] In comparison to operational carbon reduction, which helps occupants save money in running their homes, the health and generational impact benefits of using low-carbon materials are less tangible for residents, and are therefore less likely to gain market enthusiasm given their current higher financial premium. Coupled with the potential cost for ongoing maintenance in the case of novel building products this can dissuade a homebuyer from investing in a property built in that manner.[16] This is exacerbated by a nervousness regarding the combustibility of non-standard bio-based materials, and the subsequent risk of not being able to secure a mortgage on the property but is also impacted by the standardisation of products covered by warranties such as that provided by NHBC.

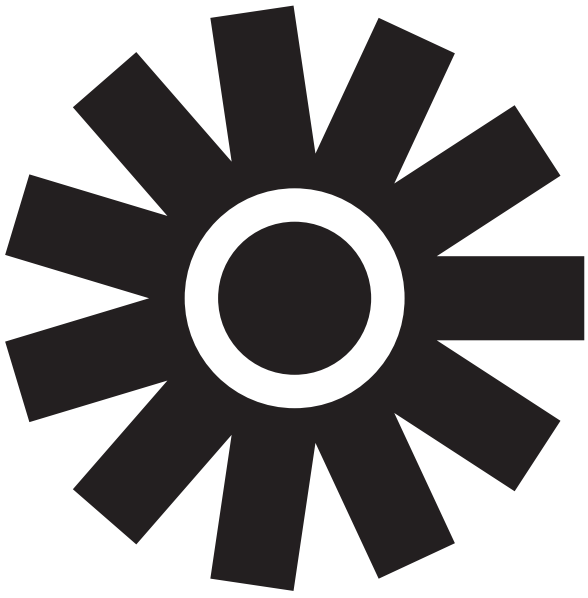
In lieu of carbon limits being set out in the Building Regulations, the agency for eliciting embodied carbon reduction adopts two complementary and intertwined forms: via local authorities setting embodied carbon restrictions within the local development plan for which they will grant permission for construction, or via CEOs of development and construction firms in response to monetary and market incentives. However, the benchmark limitations on embodied carbon cannot yet be set without the certainty that housing could be delivered within such parameters due to the urgent need for housing, and the necessary changes are unlikely to be made in the construction sector without having set targets which need to be met. Hence, there is a catch-22 scenario between setting carbon targets and creating supply chains.

14 Investors are increasingly requiring ECG data for new construction schemes, which demands carbon consumption is minimised in order to safeguard the investment in the future.

15 However, sales predictions are not based on surveying of house buyers, but upon precedent of sales in the area, which in turn is based upon previous forms of construction. Yet moving away from measuring housing scheme values based on these studies creates uncertainty for sales expectations.

16 Nor does this provide any trade off in ‘value’ for mortgage providers.

1
Report aims



There is no shortage of low-carbon construction techniques that could counteract the carbon impact of the housebuilding industry. But these are not being adopted at any significant scale, and certainly not on the scale required to meet the UK Government's objectives of becoming net zero carbon by 2050. Despite the many advances in orchestrating the delivery of low embodied carbon housing, significant barriers to these initiatives remain.

The research undertaken as part of Future Observatory's Low-Carbon Housing project seeks to identify these barriers, and to highlight the ways in which such initiatives can gain greater traction, and positively impact governmental targets. This report will explore the current barriers to reducing carbon in the housebuilding sector calling upon a wide range of stakeholders throughout the procurement process – accross the conception, design and construction of housing schemes, as well as their funding and perception by the house buying public.

In parallel to the Government's report, 'Building to net zero: costing carbon in construction', which considers the interrelated themes of assessment, supply, procurement, retrofit and education, this research explores the overlaps between these themes, and the gaps which arise in the application of such strategies to the housing sector.[1] By examining the experience of implementing embodied carbon reduction strategies in real terms, it sets out the opportunities for adapting the frameworks of housing delivery to enable these to have greater impact, and identifies the stakeholders with the necessary agency to catalyse change. It will explore the potential for innovations in policy, procurement, design and education, and recommend strategic interventions to help the Government meet its objectives.

THE ROLE OF FUTURE OBSERVATORY

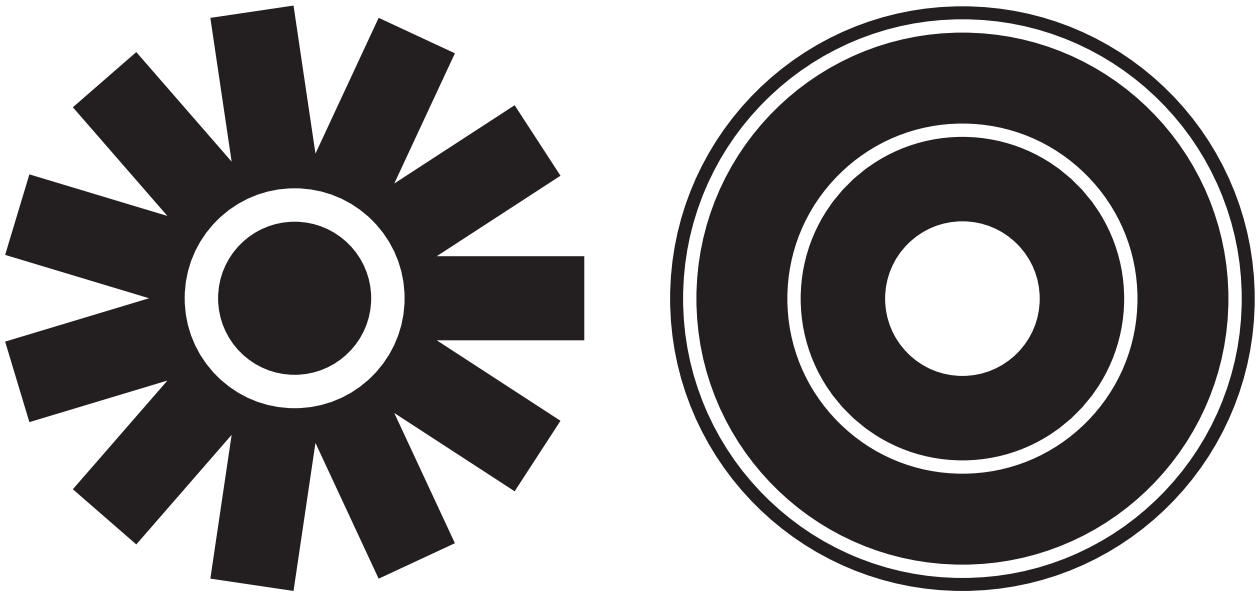
Future Observatory occupies a strategic position straddling academic research, industry application and public engagement. Acting as both a coordinating hub for a nationwide research programme, and a research department within the Design Museum, Future Observatory curates exhibitions, programmes events and funds and publishes new research, all with the aim of championing new design thinking on environmental issues. Being placed within a cultural institution enables Future Observatory to bring cutting-edge design research to broad audiences, making it accessible and engaging, and enabling this research to have a greater impact.

A green transition for the construction sector requires coordinated transformation across design, procurement, policy, tech innovation, material development, education and funding. Future Observatory's goal is to bring together these otherwise siloed perspectives, not only to draw

1 House of Commons Environmental Audit Committee, 'Building to Net Zero: Costing Carbon in Construction', 26 May 2022. Available at: https://committees.parliament.uk/publications/22427/documents/165446/default/.

out the gaps and barriers that exist in the current context, but also to identify where design research and innovation can help overcome them. Future Observatory thus serves as a connector, engaging a broad range of stakeholders with whom to catalyse the necessary changes.

2
Methods



We adopted a three-part process in this report that enabled us to learn from the experience of stakeholders across political policy, design practice, research and industry.

1. A desktop survey of the current context of low embodied carbon construction was undertaken from November 2022 onwards, collating reports, papers and articles regarding initiatives for low-carbon construction in the UK and overseas, and the associated (or proposed) governmental policies.

The insight from this initial study was used to identify key UK-based architectural practices, researchers and construction sector stakeholders developing low embodied carbon construction strategies. From this, a series of twenty studio visits was arranged to interview representatives across all stages of a housing scheme's development; from conception to funding to design, and from legislative control to construction to sales. These interviews identified the points of friction which exist in the current context, presenting barriers to greater adoption of low-carbon housing construction.

2. While there is discernible willingness across the sector to achieve net zero carbon by 2050, the lack of impetus for shifting to low-carbon construction strategies is often attributed to other stakeholders' inability to change the system, with each stakeholder blaming another. This research seeks to overcome this siloed approach, and explore these points of friction to ascertain where the barriers currently lie, and what leverage is available for change in the future. To do so, Future Observatory hosted three roundtables between September and October 2023, which brought together 26 stakeholders with expertise on low-carbon material use. We selected participants who had undertaken research surrounding nascent initiatives to increase uptake, who have experience of implementing such initiatives in industry, or who were policy makers at local or national level. These sessions provided the opportunity for gaining deeper insight into the points of friction at work, in order to generate a more direct engagement between the parties involved and, as a result, to collaboratively identify routes forward.

→ The first roundtable brought together stakeholders across the procurement process of housing projects. Through discussing their applied experience of reducing embodied carbon, we were able to explore the current gaps and obstructions that exist in housing delivery.

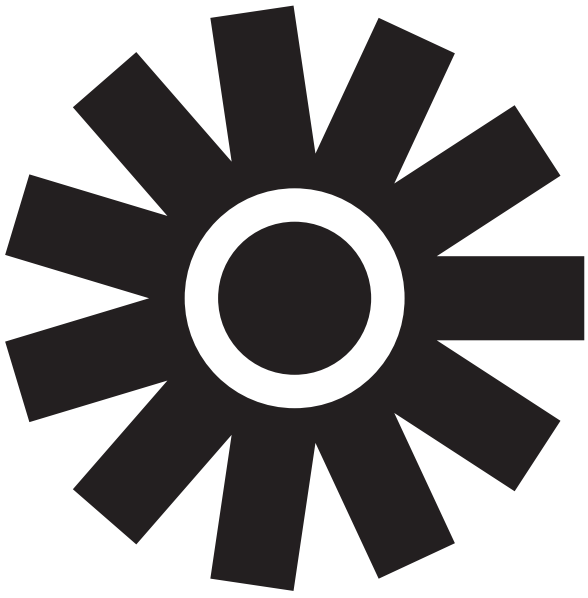
→ The second roundtable brought together parties spanning academia, policy and industry, who have developed nascent embodied carbon reduction strategies for construction, to consider how these parallel strategies might overlap and intersect. Participants shared their research into the opportunities for strategic intervention, including the use of full lifecycle carbon assessments, reducing carbon in supply chains through material reuse and local sourcing, and the potential

introduction of material passports.

→ The final roundtable took a wider view to consider the changes necessary to bring these carbon reduction initiatives to fruition. Our invited stakeholders were selected for holding agency which is both top-down and bottom-up, to explore the potential role of policy change, employment opportunities and commissioned research in achieving net zero. We questioned what interventions are required to successfully elicit changes in the housing construction sector, to identify potential future research projects, and to consider recommendations for policy change.

3. The final part of this phase of research synthesised the desktop studies, interviews and roundtables into a suite of proposed strategic interventions. These offer applied strategies for lowering embodied carbon in housing construction, through the development of public exhibitions and events, the commission of future research, the generation of financial investment and in making recommendations for policy change.

3
Key barriers identified



Mapping the housing construction eco-system

At each stage, what are the most impactful barriers and opportunities for adopting low-carbon materials and construction?

▲ BENCHMARKING ✚ POLICY
■ EDUCATION ● SUPPLY CHAIN

0 Business justification

Opportunities

✚ Demonstrate **incentives/benefits for buyers** (better running costs, better value) to up demand

Local government can promote low-carbon in housing delivery **requirements**

Encourage **early engagement** with low carbon opportunities to avoid later barriers

■ **Risk aversion** by all stakeholders, worsened by low awareness of low-carbon opportunities and impact

Developers unconvinced by **financial viability** and market demand for low-carbon construction

▲ Architects lack **data** on carbon impact and product performance to help steer a low-carbon strategy

■ Investors often unconvinced or unaware of low-carbon sureity and benefits

1 Brief

Opportunities

✚ **Taxation incentives** can affect **choice of materials** here due to **budgeting** principles

▲ Quantity surveyors need accurate data to adapt **time/cost estimates** for low-carbon materials

● Developers need certainty on **time, cost, supply chain** and **skills** for delivery

● Warranty providers need to give assurance for proposed materials now, before they impact **STAGE 4**

■ Estate agents have **preconceptions** of **market demand** for low-carbon materials

▲ **Non-standardised carbon counting** creates discrepancies between assessments of different strategies

2 Concept

Opportunities

Low-carbon strategies to be embedded through **KPIs/ESG goals** for low carbon

Developers are wary of the potential **time/cost** impact of the availability of **warranties** and **skilled workers** for using non-standard products

3 Developed design

Opportunities

▲ Planning control need to set and assess **Net Zero** targets

■ **Biomaterials** have carbon negative impact, but require detailing in accordance with **fire safety standards**

Planners lack resourcing to enforce **material passport** conditions and check carbon assumptions

▲ **Non-standardised carbon counting** means carbon sequestering is not taken into account

Government

Opportunities to support low-carbon housing

Zero carbon incentives (e.g. tax breaks, planning goals) can drive supply chain improvements

National support for certifying materials can ease time/cost of testing and providing warranties

Adopting a large-scale public procurement strategy could reduce low-carbon cost

Circular economy initiatives need local authority support for development/integration

7 Building in use

Opportunities

✚ Policies can incentivise **circularity** following demolition

▲ Initiatives required to **celebrate projects** on **carbon consumption** basis

▲ **Data** after completion is lacking to inform **whole-life carbon costing** and future developments

6 Handover

■▲ Building control struggles to verify **compliance** of low-carbon materials/methods, requiring warranties and data

5 Construction

■ Workforce faces a **skills gap** in low-carbon construction, requiring **time/cost impact of training**

Lack of **investment** in **local materials**, which are therefore sourced **overseas** despite a **larger carbon footprint**

■ Architects need **confidence** that materials have been applied correctly

4 Technical design

Warranties are required now for non-standard materials but processes needed to start at **STAGE 1**

● Material certifiers face a **testing backlog**, need data to mitigate **perceived risks**

Rigid existing standards restrict opportunities to use non-standard materials

● Material suppliers face **economies of scale** issues for low-carbon materials

▲ **BREEAM** is insufficient for demonstrating impact of low-carbon materials

● Developers face **time/cost** impacts if materials lack availability and **certification**

FIGURE 1 The barriers and opportunities for carbon reduction in housing procurement

There are a range of adopted and nascent construction materials with low embodied carbon that are available for housebuilding construction. These include the use of mass timber construction, bio-based materials such as cladding, insulation and structural elements made of straw, timber and hemp, as well as those made of clay, stone, earth or recycled materials (such as processed construction waste). Barriers to the use of these materials are present in current legislation frameworks which prohibit bio-based materials, a lack of skills and knowledge regarding their manufacture and application, and a general lack of market demand for low-carbon alternatives, all of which combine to make low-carbon construction seem a riskier option to pursue than its carbon-intensive alternative. However, there is a far greater risk in not taking the opportunities for carbon reduction which are available to us now, as climate change will have an enormous negative impact on our homes, our wellbeing and our economy. Figure 1 shows how these issues play out within the procurement of a housing scheme, demonstrating the barriers – and opportunities – encountered at each stage of the RIBA Plan of Work.[1] These identify four key themes, relating to a lack of cross-sector education, policy barriers, a lack of data benchmarking and the need for a low-carbon supply chain to be built.

EDUCATION

A LACK OF EDUCATION AROUND THE RISKS AND APPLICATIONS FOR USING LOW-CARBON MATERIALS

There is currently a widespread misconception that low-carbon materials are more costly, more difficult to use, require more maintenance, and are unsafe or have lower performance in use. The reluctance to use bio-based materials in housing projects – especially for social housing – stems from a perceived increased fire risk. These perceived risks have been amplified following the Grenfell Tower tragedy, despite such materials not being involved in the context of the fire. In contrast, carbon intensive materials such as standard brick are often used in housing schemes as there is a preconception that planning officers will feel more comfortable in giving planning consent.[2]

1 This is a rough framework which sets out the general expectations of each of the contributory parties to a building scheme, for which subsequent variations have been developed to adapt to initiatives for promoting Passivhaus design, Design for Manufacture and Assembly (DfMA) and inclusive design, among others. For the sake of simplicity, the standard framework has been employed here. The outline document is available at: https://www.architecture.com/knowledge-and-resources/resources-landing-page/riba-plan-of-work.

2 From a planning perspective this is not always the case, as other targets in the Local Plan regarding carbon reduction are also being discharged, though these do not have the same leverage for enforcement as national-level policy.

A WORKFORCE SKILLS GAP

Low-carbon materials need to be integrated from the outset of the design of a housing scheme, to ensure that the sourcing of the materials and the appropriate workforce to implement them is reflected in the cost plan, the project programme, and the detailed design strategy. Therefore, an awareness of opportunities for carbon savings needs to be shared throughout the whole consultant team for a housing scheme's delivery if the full impact of adopting low-carbon construction strategies is to be capitalised upon, in order to de-risk the cost/time impacts as the project develops. It is imperative that the architect/developer who is setting the strategic objectives for a housing scheme's delivery has access to information on the benefits and parameters for using low-carbon materials from the outset.[3] Such awareness and collaboration is required on the part of the whole team, including clients, contractors, quantity surveyors, architects, project managers, and engineers, as well as insurers and warranty providers who contribute to the project development. According to industry experience, without this integrated alignment early on in a project, subsequent reversion to 'business as usual' approaches is more likely, according to industry experience. At present, it is felt there is no distinct leader in the sector providing support for developing this knowledge, so many professions are taking on the costs of doing so individually, leading to this research being developed in a piecemeal and uncoordinated manner.

Coupled with this, there is perceived to be a lack of green jobs and service providers in the construction sector. Carbon-intensive materials such as concrete and steel are familiar in application requirements, and readily available for purchase (thereby reducing lead-in times), and there is a lack of contractors with the skills and proven experience to use low-carbon construction methods such as new bio-based material products. As a result, a low-carbon construction strategy using these materials is perceived as a more risky approach. This is hindering contractors' confidence in employing carbon reduction strategies in their schemes, due to their uncertainty in being able to deliver on these aims.

POLICY

GAPS IN LEGISLATIVE FRAMEWORKS

One of the key strategies for reducing embodied carbon in construction materials is to use bio-based materials, made of plants and other naturally occurring materials. Yet current legislation – and in particular the provisions of the new Building Safety Act – is having a negative impact on project teams' willingness to use these materials, due to their potential untested combustibility. The inherent variability of natural materials such

3 Without the due knowledge of the impact of specifying non-standard materials, these designers risk compromising their Professional Indemnity Insurance.

as stone, timber and bio-based materials, and their associated tolerances and contingencies, is also at odds with the prescriptive legislative parameters currently in place, exercised through Building Control.[4] The new Building Safety Act prohibits the use of combustible materials within housing facades. Project teams fear the possibility of project delays from having to redesign and re-specify materials within their schemes in order to pass Building Control, or to ensure that the restrictions within their insurance requirements are adhered to. These materials are often excluded from the outset for being deemed too high a risk to find ways they can be safely employed. Whilst fire and life safety considerations are imperative, current regulation for the use of bio-based materials is felt to be too rigid, and privileges carbon-consuming construction.

PLANNING DEPARTMENTS HAVE MINIMAL AGENCY TO ENFORCE POLICY TARGETS

Planning Authorities and Building Control are often identified as two possible mechanisms through which embodied carbon could be monitored, and its reduction incentivised. Yet since there are no targets enshrined in planning policy, unless the carbon consumption is linked to detailed material design – for example, by moving away from traditional fired brick to bio-based or recycled materials – there is little leverage for planners to insist on lower carbon materials within the current approvals framework.[5]

In lieu of regulation through Building Control processes, the possibility of assessing embodied carbon data by planning departments is also hindered by a resource gap for planning teams – in terms of time, expertise and staffing – to be able to assess. The default accepted standards of BREEAM, EPCs and compliance with Building Regulations used by local authorities are ineffective in addressing embodied carbon consumption. Currently, if the planners are left in any doubt as to the scheme's compliance due to lack of information provided, this is given as grounds for refusal. Therefore, support to suppliers for developing suites

4 This is also the case for reused materials, which vary in sourcing. It is therefore essential to ascertain what aspects of the specification need to be set, and where any leniency for variation lies, to optimise the potential impact for reuse. Where there is uncertainty in performance, engineers and designers tend to over-specify materials to ensure they will be compliant, which has a subsequent impact on the carbon and material consumption of a project.

5 London Plan Policy SI 2 sets out the requirement for WLC emissions assessment, and has been adopted by the GLA. However, at a local scale, current planning policy in Camden was written in 2017, whereas the guidance relating to carbon consumption is written in 2021, so is more ambitious but carries less weight. There is also a question as to whether the greatest impact lies in changing the approach adopted by the many small-scale housebuilding schemes built in the UK, or in changing a few large developments. Defining the intended audience will affect the audience and stakeholder participants involved – a two scale approach may be required for greatest impact.

of clear, appropriate and benchmarkable information – including samples, data and visuals – which aligns with the planners aims would be beneficial to both the applicants and the assessors. However, the additional workload of undertaking carbon analysis of proposed schemes is often deemed too onerous for design practices and local authorities, which are under-resourced, or do not yet possess the specialist expertise required to do so as such skills have previously been missing from the training of the workforce. This raises the question as to whether such processes can be brought 'in house', to ensure alignment of assessment but which would be prohibitive in terms of the resources required, or whether specialist consultancies need to be engaged to take on this work – of which too few are currently available.

BENCHMARKING

NON-ALIGNMENT OF CALCULATION AND ASSESSMENT STANDARDS

Coherent and easily applied systems for calculating the embodied carbon of materials are much needed, so this data can be measured and responded to accordingly. Different calculation tools and benchmarking standards used by different sectors (such as engineers, architects and surveyors) provide different information, which was confusing for those undertaking the calculations and understanding a project's impact, as well as those who need to assess the suitability of a given project (such as planners, project managers and investors).[6] At present, carbon sequestration – whereby materials absorb carbon over their lifespan, and so can become carbon negative over time – cannot be taken into account unless commitments to the product's end of life are accounted for in the design calculations. As a result, materials which would improve the Whole Life Carbon Assessment (WLCA) of a scheme are not yet encouraged to be used.

SUPPLY CHAINS

THE LACK OF CERTIFICATION, INSURANCE AND WARRANTIES FOR THE SUPPLY CHAIN

Risk aversion in the sector is proving a significant hurdle to adopting low-carbon constructions. The current system of certification is set up on the pretence of the previous construction approach, of using new 'virgin' extractive materials which have been systemically produced, often using carbon intensive methods. Due to the innovation involved in developing and producing new low-carbon materials, there are no specific standards the resulting products can adhere to.[7] There is a need to proactively

6 Measuring by volume rather than weight was also noted as an anomaly.

7 For example, Webb Yates point out that there is currently no BSI code for reinforced stone, hindering insurance and warranties being put in place for its use as a replacement for reinforced concrete or steel. Carmody Groarke have undertaken much research in relation to Eurocode 6 EN 1996-4 'Design

develop building codes and standards – which are usually only initiated where demand already exists – to help overcome this uncertainty which is prohibiting use.

The use of these alternative, low-carbon materials in housing construction is currently held back by the lack of testing facilities available in the UK, and the resulting backlog for certification which would help build confidence in their use. Although it once formed part of the suite of services by the Civil Service, the Building Research Establishment was privatised in 1997 and has since been criticised for being driven by commercial pressures and interests.[8] As a result, the UK is lacking the resources required to undertake the scale of testing required to bolster uptake of non-standard, low-carbon constructions. The need for testing has been exacerbated in regard to the requirements for construction over 18m under the requirements of the Building Safety Act 2022, for which compliance with combustibility limits is essential. Without the assurances this provides to contractors, developers, funders and residents, such materials are not going to gain the greater application required, as there is no defined strategy for who should adopt the associated risks for their use.[9]

NO APPETITE TO BUILD SUPPLY CHAINS

Supply chains for low-carbon materials have not been developed with the enthusiasm and investment required, which, in turn, lessens confidence in the possibility of their supply. There are currently up-front cost premiums associated with the use of low-carbon materials, as these are not yet industry standards. Building networks of both material and labour supply can help develop cost equality and increase surety of supply between low-carbon materials and comparable higher carbon construction strategies. However, there are development costs associated with product innovation and certification required for products to enter the sector, which are currently borne by the material developers and contractors. At present, these additional costs of low-carbon construction demand a certain environmental altruism. Given the current policy roll backs regarding climate and environmental targets, there is less impetus for manufacturers to undertake the necessary changes required for the green transition. The question arises as to how the costs for the necessary testing and approval required for these be moved 'upstream' to encourage greater growth, by

of Sustainable Masonry Structures' in relation to their Gent Waste Brick, which would otherwise be categorised under the requirements of EN 772-2 'Calcium silicate blocks' or Eurocode 6 EN 1996-2 for 'Design of Masonry Structures', both of which privilege the use of virgin materials. CE marks require high volumes of production before these can be awarded.

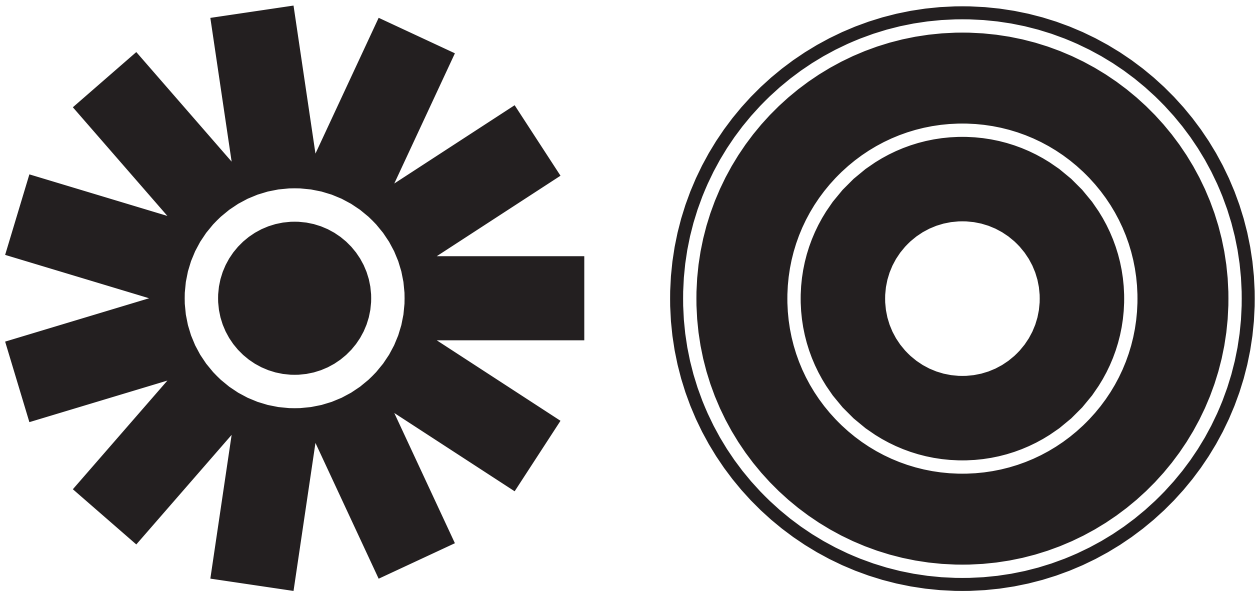
8 'FBU calls for Grenfell building safety body to be nationalised.' Available at: https://www.fbu.org.uk/news/2022/05/13/fbu-calls-grenfell-building-safety-body-be-nationalised.

9 Whilst the Belgian Union for Technical Approval in Construction provides assessment, approval and certification of construction products in Europe, we have no comparable support in the UK as yet.

shifting this cost to those who benefit from the economic uplift of housing development.[10]

10 As has been experienced in the supply of modular construction and MMC initiatives, it must be noted that simple subsidies of product costs do not help address the issue, as resilient supply chains and demand must be developed if this strategy is to have longevity. Housing Today, 'Government "can't subsidise MMC forever" warns housing minister.' Available at: https://www.housingtoday.co.uk/government-cant-subsidise-mmc-forever-warns-housing-minister/5126827.article.

4
Strategies for carbon reduction in the UK



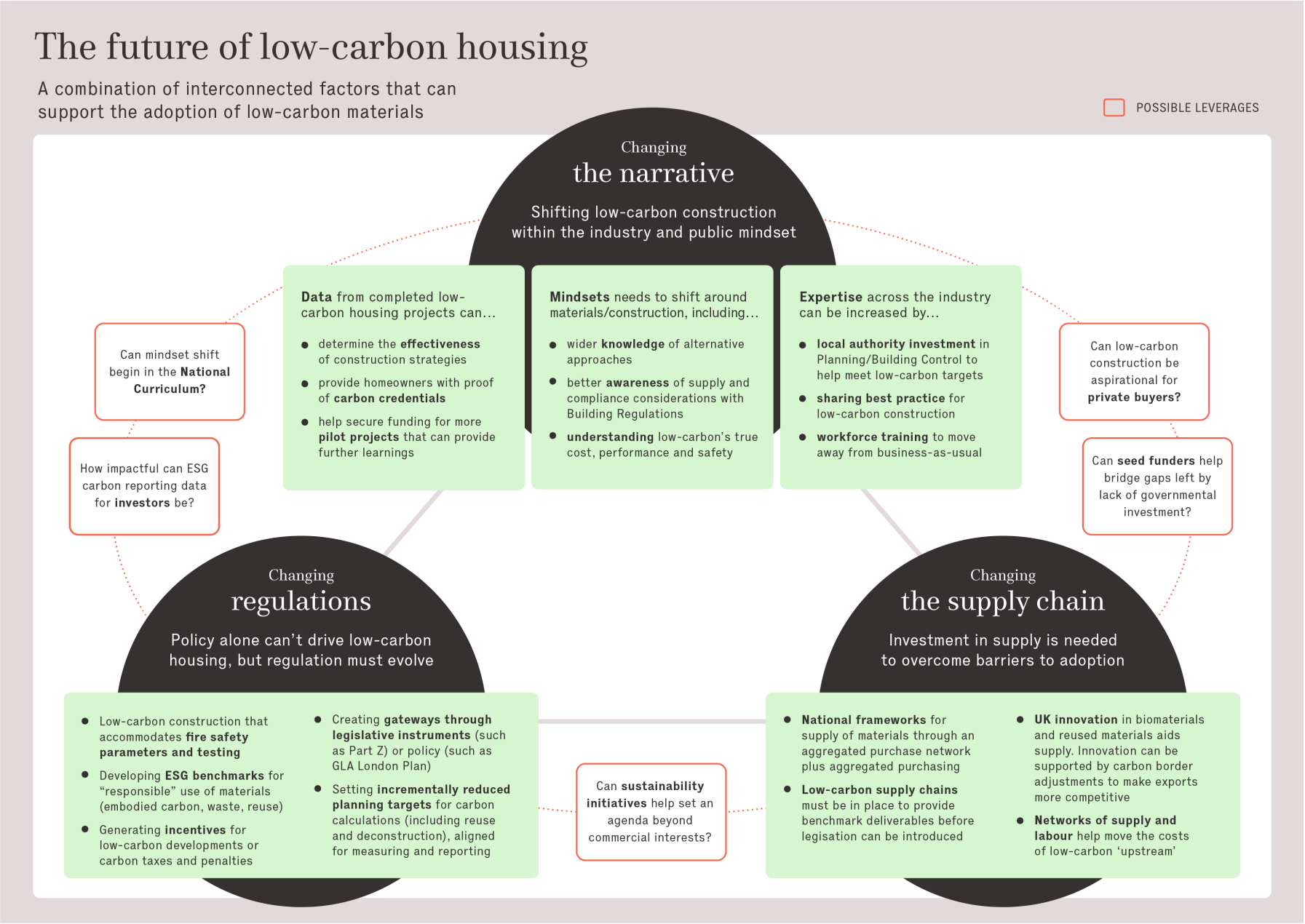


FIGURE 2 **How the three strategic points for change – to the narrative, regulations and within supply chains – are interlinked**

Within this ecosystem of housing delivery, there are already many innovations which can help leverage the change required for the green transition. However, the means by which these can be applied has often been explored in isolation. This research instead explores the changes required by different stakeholders as part of a strategically collaborative development process. The resulting approach highlights three key points of intervention: to change public awareness of low-carbon construction[1]; the strengthening of construction supply chains; and the development of policies for setting targets and incentives for carbon reduction.[2]

As shown in Figure 2 the interventions required to increase uptake of low-carbon construction strategies, which will be outlined in this section are inherently interrelated, and will each need to be implemented if low embodied carbon materials are to have the required positive impact on the nation's carbon budget.

CHANGING REGULATIONS

SPECIFIC TARGETS AND TIMESCALES FOR CARBON REDUCTION MUST BE SET

Whilst the ambition to reach the target of net zero by 2050 is constant, the more granular benchmarks for delivering these aims are ever shifting. However, a system for the clear, incremental decrease of carbon emission targets towards net zero (such as that undertaken in the Netherlands) needs to be established, to help bolster industry confidence that they are meeting comparable sector-wide targets without investing in technologies that will not be rewarded.[3] Rather than waiting for new national policies to be

1 'The public' includes education for the house buying market – such as through television and social influencers – but could also be instigated by changes within the National Curriculum. LETI and ACAN have stepped in to push this in lieu of a governmental agenda. This guidance is available at https://www.leti.uk/ecp and https://www.architectscan.org/embodiedcarbon respectively.

2 This final point regarding setting policy targets requires the benchmarking of current data, which was identified in the previous section as a key barrier for embodied carbon reduction.

3 The UK government has set targets for "Contracting authorities…with the trajectory of reducing UK emissions by 68% by 2030, 78% by 2035, and achieving net zero carbon by 2050." Promoting Net Zero Carbon and Sustainability in Construction, Guidance Note September 2022. Available at: https://assets.publishing.service.gov.uk/media/631222898fa8f54234c6a508/20220901-Carbon-Net-Zero-Guidance-Note.pdf. However, how these are applied on a more granular level to the construction sector has not yet been explicitly set out. Instead, the onus under PPN 06/21 is for providers to adopt the obligation to set out how these targets will be achieved. As a result, stakeholders are currently concerned about potentially overdelivering in comparison to their competitors, and therefore losing their commercial

written and adopted, interim policies which raise the immediate ambition for carbon reduction need to be developed. This can be achieved on a local authority scale by augmenting and exceeding existing accepted policies, in order to address fast-moving climate change.[4]

NEW STANDARDS AND CERTIFICATIONS FOR LOW-CARBON MATERIALS ARE NEEDED

Fire safety legislation parameters currently prioritise traditional construction and virgin materials, and will need to be augmented with processes which consider how low-carbon construction materials can be used without compromising overall safety objectives.

Coupled with this, guidance and best practice examples for designers, clients and regulatory bodies as to how these material approaches can be successfully accommodated within the constraints of Building Control are much needed. The adoption of the proposed Part Z would add imperatives for seeking ways of reducing embodied carbon as part of this. However, there is a question as to who should invest in the development (and adopt the risks) of such guidance: the state, the material producer or the construction sector at point of use?[5]

SUPPORT IS REQUIRED FOR PLANNING DEPARTMENTS IN SETTING AND ASSESSING APPROPRIATE CARBON LIMITS FOR SCHEMES

The introduction of planning policy limiting carbon is considered a key intervention for eliciting systemic change in the construction sector.[6] To achieve this, planning departments need to be involved at the concept stage of housing schemes, to ensure that carbon limits for any project – along with the numbers of units being delivered – are appropriately set to combat both the housing crisis and the climate emergency concurrently.[7] Greater

advantage.

4 Local Plans under the National Planning Policy Framework (NPPF) are implemented every five years, and cover a period of 15 years.

5 Such a strategy sanctioning use also carries ongoing potential risk of being held responsible if these fail, which thus creates a reluctance to be adopted.

6 However, there is also a lack of detailed design resolution possible at planning stage, and subsequent deviations from limits may creep into the design progresses over the tender/construction phases – this is particularly evident in Design and Build procurement, which seeks to capitalise on finding efficiencies in delivery. As a result, limitations for future changes to the submitted scheme need to be integral to the permissions granted. It should be noted that the GLA has developed support for Whole Life Carbon Assessments at a local level, as part of the London Plan. Similar initiatives could be adopted on a national scale. GLA, 'Whole Life-Cycle Carbon Assessments guidance'. Available at: https://www.london.gov.uk/programmes-strategies/planning/implementing-london-plan/london-plan-guidance/whole-life-cycle-carbon-assessments-guidance.

7 Anna Bardos at Max Fordham illustrates the positive impact of early low-carbon strategies, and how these can best be integrated. Architecture Today

investment in these resources is necessary in order to help support the transition of the sector across all scales – from individual houses to larger residential blocks and estates. This will help provide a more nuanced and robust approach to the aims for minimising environmental harm set in the Local Plan, which are often argued down or overlooked in the design process.[8] The use of low-carbon materials, and the lesser impact (in terms of noise, pollutants and reduced time for construction) that these have on surrounding residents, may be employed as an incentive for supporting low-carbon construction at planning stage, particularly in dense urban neighbourhoods.

Alternatively, to help take the pressure off the already overstretched planning resources, regulations and standards which are reportable to statutory authorities – such as Building Control – could serve as alternative approaches to creating gateways at planning stage, using the proposed Part Z and UK Net Zero Carbon Building Standard (UKNZCBS) for ensuring compliance.[9] Given its alignment with the incoming European Standards for sustainability in construction, it is hoped that the new RICS standards for Whole Life Carbon Assessment (WLCA) for the built environment could provide a unified alternative benchmarking strategy which addresses concerns in establishing parity between assessments, but would need to be applied and assessed in practice before this route was adopted.[10]

'The Value of Low-Carbon Design', 27 September 2023. Available at: https://architecturetoday.co.uk/the-value-of-low-carbon-design-webinar/.

8 Schemes which fall under Permitted Development rights would not pass through such checks, so other forms of regulation would be required to ensure that these do not adopt high carbon construction strategies.

9 EPDs – Environmental Product Declarations – hold potential for assessing a product's performance in terms of its environmental and human health impact, but the current EPC does not. There are limitations to operational carbon as set out in Part L, but no embodied carbon parameters have yet been set. The Part Z campaign proposes how this would be addressed through regulation of Whole Life Carbon and embodied carbon emissions as part of the Building Regulations. This is available at: https://part-z.uk/proposal. The UKNZCBS is a science-based standard for assessing both embodied and operational carbon across all typologies, including new and existing buildings, based on research into current practices. This has been developed in a manner which would not be applied as a Building Standard or governmental policy due to concerns over uptake. Available at: https://www.nzcbuildings.co.uk/.

10 This was launched on 19 September 2023, and amended in November 2023. Details are available at: https://www.rics.org/profession-standards/rics-standards-and-guidance/sector-standards/construction-standards/whole-life-carbon-assessment.

CHANGING THE SUPPLY CHAINS

MORE FACILITIES FOR TESTING AND CERTIFICATION OF LOW-CARBON MATERIALS ARE REQUIRED

It is imperative that materials – whether low embodied carbon or reused – are able to meet performance standards. There is thus a pressing need for a national fire testing programme to support the provision of warranties, certification and insurance for new applications and materials, and to demonstrate how safe these are to all stakeholders in the development.[11] The testing and certification of low-carbon materials, and the creation of Environmental Product Declarations, is an essential component in increasing their acceptance in the construction sector. Given the current backlog of testing facilities, National government support is required to fund the creation of new certification hubs. The Building Safety Regulator could adopt responsibility for testing products, and disseminate the findings.[12]

LOW-CARBON MATERIALS NEED TO BECOME COST EFFICIENT

If market demand can be increased then issues of affordability will be diminished. In lieu of robust supply chains being built, which would generate economies of scale, there are currently additional costs incurred by developers for adopting low-carbon construction strategies, which are a prohibiting factor for their uptake in the sector. There is therefore an opportunity to consider what financial incentives can be introduced to create incentive for adopting low-carbon construction. This could be as a support or a penalty: potential strategies include linking the capacity for profit (in terms of financial viability calculations) to the delivered carbon savings, either through regulation, council tax banding or land value tax. Tax incentives for using lower carbon products,[13] or taxes for high carbon

11 A national fire testing service does not necessarily have to be a government *run* service, but is needed on a national scale, since when these are undertaken by private companies for their own schemes or projects, this information is seen as being commercially valuable and therefore isn't shared. In communicating the results of such tests, it would be beneficial to define what the safe use of bio-based material products might be, as well as what health benefits they might also bring, to encourage greater uptake.

12 There is a concern that commercial considerations would prevent such testing being published, although there is an economy in collaboratively sharing the research into identifying successful strategies for construction and detailing which would fulfil the compliance requirements.

13 This can help address the upfront cost comparison disparity between timber and steel/concrete, effectively 'costing in' the carbon impact. However, this is currently complicated by emissions trading processes, and the question of how the carbon impact can be included for products imported from overseas. One possible strategy is to adopt the policy of the Austrian Government, which pays developers per kilogram of timber in buildings – yet this can only be effective if coupled with controls on carbon

consuming materials could also be introduced at a national or local level, such as through the GLA.[14] Any calculated shortfalls in compliance could also be translated into equitable payments to Local Authority to help mitigate the impact of carbon emissions.[15]

FURTHER MATERIAL RESEARCH AND INNOVATION MUST BE UNDERTAKEN

The current housing market is experiencing high demand and low supply, with such issues exacerbated in London in comparison to the rest of the UK.[16] Given this context, and the desire to reduce the carbon impact of transportation, it will be necessary to develop regional responses which will have regional benefits (particularly for employment). Further research is required into the opportunities for developing material supply chains on a regional basis, exploring the networks of existing natural and reuse resources, and processing opportunities, to ascertain what direct actions are required in terms of workforce development for each area.[17]

There is an enormous opportunity for UK product development to lead innovation in low-carbon product development, manufacturing and

emissions. Removing the current zero-rated tax incentive for new build construction over refurbishment would also incentivise carbon reduction strategies.

14 At a product scale, carbon border adjustment mechanisms such as the EU's CBAM tool could also be introduced to make export of low-carbon materials more competitive than their carbon consuming equivalents, and thus increase their market.

15 This could be akin to the current arrangement for S106 payments. However, it was noted that the capacity to mitigate the impact of the carbon emissions is minimal once the emissions have been made during the construction process, and that these effects are not necessarily felt in the same locale where the tax income would be generated, due to off-site extraction and production.

16 This also creates a disparity in whether housing is primarily delivered as low rise or high rise construction, which changes the construction approach and the implication for the Building Regulations and materials this entails. There is also an issue that even social housing is being delivered by the for-profit private sector, which has an inherent agenda to drive down overall costs of construction (leading to a preference for higher carbon materials). Instead, if this was developed by the local authority itself, the construction could be seen as an opportunity for long-term investment in sustainable public infrastructure - and which could also generate opportunities for SME green transition jobs in the community at the same time.

17 An audit of materials available – such as that previously undertaken by Material Cultures and Arup in North East – could be undertaken to identify new opportunities for materials sourcing. Material Cultures 'Circular Biobased Construction in the North East and Yorkshire.' Available at: https://www.ynylep.com/Portals/0/adam/Stories/dZPBWh5Fz0mcAqqNaH1neA/Body/211015_MC2105_NEY_REPORT_FINAL_ISSUE_SPREADS_COMPRESSED-1.pdf.

supply, as a collaboration between researchers and industry. To move the requirement for this to be funded directly by developers/clients, and instead have public bodies and manufacturers adopt the costs, would help encourage greater adoption. For material suppliers, there is a greater value in using their products for higher quality purposes – such as the use of bio-based materials and timber in construction, rather than being burnt for power, or in the upcycling of waste products.[18] Instigating collaborations between suppliers and innovators can generate outputs for research, has benefits for SME development and helps in monetising waste streams. As such, there is a clear business case for investment in the tech industry, and the development of bio-based or recycled material products, that can help address national needs for low-carbon materials, while capitalising on our research excellence, and increasing employment opportunities.[19] However, seed funders may need to help bridge the gaps left by a lack of governmental investment.

STRATEGIES FOR CIRCULARITY AND REUSE OF MATERIALS ARE NEEDED. Construction sector waste streams constitute 60% of the UK's waste.[20] Rather than send these materials to landfill, building with existing materials makes better use of their pre-existing carbon impact, and helps lower the Whole Life Carbon of a scheme. Further research is required to identify construction waste streams which can be brought back into use in the construction sector, and there is a need for intermediary bodies who can harvest, refurbish, test and certify materials salvaged from buildings

18 UK timber is unsuitable for housing construction due lack of structural and fire integrity. This is currently typically designated as C16–C24 strength grade, and that it is wetter than from overseas. Although this is often found to be better in performance than preconceptions suggest, there is also opportunity to use this in non-structural applications already. DEFRA are currently supporting the UK timber industry to ensure that these applications can be developed further through initiatives such as The Timber in Construction (TiC) Innovation Fund. Funding is available for projects which explore "the development of innovative timber products, supply chains and ways of working with wood" until March 2025. Such development and application of these supply chains is further reinforced through the aims set out in the 25 Year Environment Plan, England Trees Action Plan, and Net Zero Strategy. Available at: https://assets.publishing.service.gov.uk/media/5ab3a67840f0b65bb584297e/25-year-environment-plan.pdf, https://assets.publishing.service.gov.uk/media/60a3ddd1d3bf7f2886e2a05d/england-trees-action-plan.pdf and https://assets.publishing.service.gov.uk/media/6194dfa4d3bf7f0555071b1b/net-zero-strategy-beis.pdf respectively.

19 This could also lead to increasing exports for overseas markets, if the appropriate standards can be adhered to in their development.

20 See Point 3.8.2.1 of the Government's Guidance Note on 'Promoting Net Zero Carbon and Sustainability in Construction'. Available at: https://assets.publishing.service.gov.uk/media/631222898fa8f54234c6a508/20220901-Carbon-Net-Zero-Guidance-Note.pdf.

earmarked for demolition.[21]

For housing typologies, the reuse of components and buildings is only feasible at present in small-scale developments. The reproducibility of volume housebuilding schemes based on standardised construction and detailing cannot accommodate the variation in reused material supply this would entail. However, existing waste streams can be used to develop alternative construction products, as precedents have shown.[22] When used in conjunction with lime mortar, such products can even sequester carbon over their lifetime, further reducing the overall carbon impact of construction.[23]

The harvesting and reuse of materials, and their associated research and testing, holds great potential for generating new employment opportunities in the circular economy. Councils and developers have the potential to have meaningful impact – if a few strategic sites could be identified for interim use prior to development, with access and insurances put in place to cover workers and materials, this could help catalyse supply chains of reused materials from local micro hubs and SMEs across the UK. This will necessitate undertaking a recruitment and education drive, including

21 Research undertaken by Presso has shown that up to 50% of carbon contribution for reused construction elements comes from transportation. It's therefore imperative that local networks are established to ensure this aspect can be minimised. There is much to learn from initiatives such as ReLondon and FCRBE which have instigated such strategies in Northern Europe. ReLondon is currently more impactful in reducing aspects of clothing and food waste, though advocates for similar principles to be adopted in the construction sector. Available at: https://relondon.gov.uk/resources/why-we-need-a-london-circular-construction-coalition; https://vb.nweurope.eu/projects/project-search/fcrbe-facilitating-the-circulation-of-reclaimed-building-elements-in-northwestern-europe/.

22 Examples include Carmody Groarke's waste brick and their Future Observatory Design Exchange Partnership 'A feasibility study into ultra-low carbon bricks utilising local construction waste for coastal infrastructure', as well as work undertaken by Local Works for The Phoenix and the application of their work in Devon. Available at: https://carmodygroarke.com/work/gent-waste-brick, https://futureobservatory.org/research/strands/design-exchange-partnerships/coastal-communities-2023, https://localworksstudio.com/projects/the-phoenix-lewes/ and https://localworksstudio.com/projects/landscape-audit-and-material-design/ respectively.

23 An alternative strategy which enabled the use of low-carbon materials was identified by Carmody Groarke in their design of the Design Museum in Gent. As the carbon sequestering bricks they had developed for the project required structural certification in Eurocodes which had not yet been developed, they instead accommodated these structural requirements through other means, whilst using the innovative brick in a non-structural, rain screen application.

providing training for efficient strip outs and material rehabilitation, a greater understanding of which materials can be reused, and where and how these might be efficiently employed.

CHANGING THE NARRATIVE

CONFIDENCE NEEDS TO BE BUILT WITHIN THE INSURANCE SECTOR

Further testing and certification, along with details of timescales for supply and outline costs, need to be well communicated to help nurture a greater appetite for construction. Generally, there is a lack of support for bio-based construction materials in the insurance sector. However, Aviva has recently become one of the first UK insurers to underwrite large-scale timber construction projects. Their confidence in doing so was developed through "working with a handful of developers on sustainable building projects".[24] Following this model, the production of data, generating feedback and transparency for the delivery of such projects, is essential to build surety for their use.

The perceived risk of taking on insurance for future potential fires is also being addressed by initiatives such as the Mass Timber Insurance Playbook, developed by the Alliance for Sustainable Building Products (ASBP).[25] However, this addresses only one, well-coordinated sector of the construction industry – the timber supply – and its development has demanded much investment into data research and education. Similar research is needed across other bio-based material strategies too, which are often more fragmented in terms of their sourcing, development, and supply networks. In lieu of this, a 'letter of comfort' from the National House Building Council (NHBC) to support the use of low-carbon materials in housing projects was given as an example of how some of the concerns arising from the current lack of testing and assurances for the use of bio-based materials might be allayed. The New Home Quality Bonds (NHQB), introduced in 2022, incentivise contractors to adopt low-carbon construction as a 'Gold Standard' which offers a premium return on the product.

DATA NEEDS TO BE EQUITABLY BENCHMARKED AND COMMUNICATED

If robust calculations can be put in place, clear provenance data for material sourcing in projects can then be communicated efficiently to the regulating authorities, as well as to clients. Linking this data to ESG benchmarks can also help promote 'responsible' use of materials, by providing insight as to the scheme's embodied carbon, the waste produced

24 It should be noted that this is currently limited to the commercial, rather than residential, sector. https://www.aviva.com/newsroom/news-releases/2023/08/aviva-expands-underwriting-appetite-to-include-engineered-timber-for-commercial-buildings/.

25 See the Mass Timber Insurance Playbook. Available at: https://asbp.org.uk/project/mass-timber-insurance-playbook.

and the potential for subsequent reuse.[26] ESG carbon reporting data can then be provided for investors and lenders, serving as a means of linking this value to emissions trading by 'pricing in future value' for schemes which exceed current benchmarks, and potentially facilitate trade-offs against other projects where carbon-saving strategies are precluded from being implemented.[27]

It will be necessary to harvest data on embodied carbon from completed projects to set new standards in legislation. The incoming Future Homes Standard sets parameters for operational carbon, and similar strategies enacted through legislation (such as Part Z) or policy (such as via the GLA's London Plan, or LLDC's 1.5 Design Guide) will be required if upfront carbon consumption is to be affected.[28] Local and national authorities can

26 'Responsible use' in terms of reducing carbon can also be in terms of using less, rather than different, materials. ESG data may also include Environmental Product Declaration (EPD) information for the materials used in each scheme. Details available at: https://bregroup.com/services/testing-certification-verification/en-15804-environmental-product-declarations/.

27 Carbon asset-backed securities initiatives such as those by Aureus Earth (https://aureusearth.com/) quantify and certify the carbon stored by timber (or other biogenic material) construction, enabling this to be monetised in future investment strategies (potentially using Blockchain technologies preventing these from being sold twice) so the current cost premiums for using this material will pay off in the longer term. Timber has greater safety of investment if used in construction, as these tend not to burn down (in comparison to forests). There may also be an unrealised value in being able to comparatively calculate a building's embodied carbon. If carbon data can be robustly associated with the construction, this quantified data may be able to be traded as 'carbon tokens' against underperforming schemes in lieu of S106 contributions, encouraging investment from a financial imperative.

28 The Future Homes Standard (https://www.gov.uk/government/consultations/home-energy-model-future-homes-standard-assessment) will replace the Standard Assessment Procedure (SAP) (https://www.gov.uk/guidance/standard-assessment-procedure) for the energy rating of dwellings. However, this procedure has already faced criticism for falling below current standards, so would require further revision before the Home Energy Model is launched in 2025, if this is to provoke implementation of the sector changes necessary. Details of the assumed shortfall of the Future Homes Standard are outlined in Architects' Journal, 'Government Future Homes plans "least ambitious option"'. Available at: https://www.architectsjournal.co.uk/news/government-future-homes-plans-lower-than-todays-standards. The proposed introduction of Part Z is thought to help 'level the playing field' since its status as a statutory instrument would mean all schemes must be compliant, and – unlike the requirements of the Local Plan – this compliance cannot be negotiated or traded off. It is thought that this could catalyse industry change, given sufficient lead-in time to adjust and develop alternative approaches.

then use this data to ascertain whether the sector is able to meet – or even exceed – such limits and regulations, and adjust these accordingly in a manner which is conducive to optimising carbon reduction. To facilitate the development of appropriate embodied carbon benchmarks, data from completed projects will need to be collated. UKGBC have noted that being more open with the means of calculation is essential if lessons are to be learnt from like-for-like projects.[29]

NEW DESIGN TOOLS ARE NEEDED

Coupled with the need to invest in the research and development of national standards and protocols for assessing embodied carbon, it is also necessary to further develop the tools with which this work can be undertaken. Integrating carbon data within Building Information Modelling (BIM) platforms for housing schemes can support carbon reduction in the design process. If undertaken successfully, the use of BIM tools can also help reconnect between embodied carbon strategies as set in the design strategy phase, and how these relate to the potential ascertained carbon savings which can be delivered in the construction phases, to enable the requirements of low-carbon construction strategies to inform the earlier stages of the design process. This can also provide options for swaps of alternative, deliverable low-carbon construction approaches at the outset which can be tested for their impact on the scheme's design. They can also help pass material information on at the end of life of the scheme, to facilitate subsequent reuse of these materials.

However, this requires modelling and associating materials with their carbon values, the data management for which is currently very processor heavy and slow, making this prohibitive for both larger projects and smaller firms. Investing in the design development of new platforms or more nimble BIM plug-ins which can help alleviate the tagging impact is necessary to streamline this process.

MORE EDUCATION IS NEEDED AROUND BENEFITS OF REDUCING EMBODIED CARBON

Further collaboration across disciplines within (and adjacent to) the construction sector is essential for increasing uptake of low-carbon construction strategies:

29 The UKGBC is currently undertaking research in this regard, by requesting the submission of analysis of embodied and operational carbon for case study projects. The Net Zero Carbon Buildings Standard collaborative initiative was launched in June 2023, to help form a database of precedents that would not be owned by one singular organisation, so could be disseminated freely. Details available at: https://www.nzcbuildings.co.uk/. Samples of this data will need to be made to ensure parity of calculation. The current tendency to keep such information confidential due to commercial concerns is detrimental to the sector's ability to catalyse the carbon saving opportunities available, and requires further cross-sector collaboration.

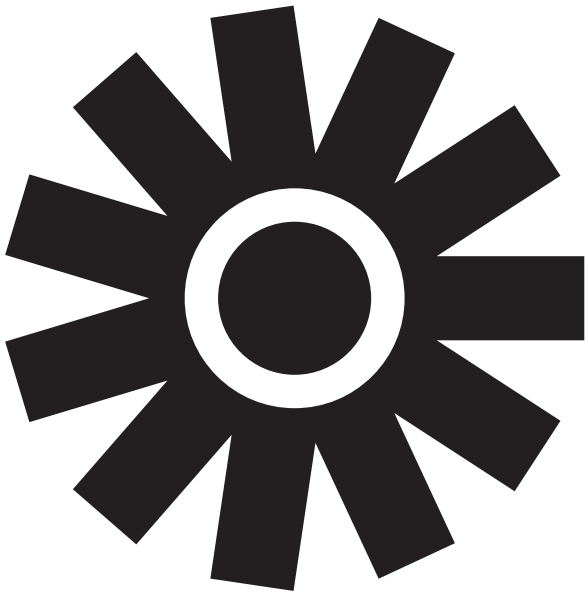
For architects, it is necessary to provide education as to the opportunities available for reducing embodied carbon, and insight as to how these might be implemented through on-site experience and collated 'best practice' precedent projects to overcome perceived risks and thus improve uptake of such strategies. To do so, RIBA/ARB would need to change the criteria for accredited courses, to include providing an understanding of the carbon impacts of different materials (and their use) as part of training processes. The gap in knowledge and competency regarding such issues would need to be addressed both in academia, and through the new training addressing mandatory competencies of those who are already practicing. To help boost the adoption of low-carbon materials, LETI propose providing greater information regarding how these might substitute more standard construction materials, including giving insight into the impact on time/cost for the project.

Educating clients as to the economic and environmental values of low-carbon construction, and the ways this could be considered in weighing up project costs against initial land values, was identified as potential leverage for change. There are also social values regarding the move away from extractive practices, and human rights issues, which could be taken into account if expressed more clearly, as well as contributing to ESG data. Identifying key case studies which could be well communicated – including costs, supply chain requirements and opportunities, time implications for development, and benefits – as proof of strategy will be a useful tool to help encourage adoption of such strategies by clients, quantity surveyors and estate agents who contribute to the financial viability assessments of such schemes.

The current additional costs of low-carbon construction need to be addressed by encouraging private buyers to consider this cost uplift as investing in a healthier place to live in the longer term.[30] Improving education and access to relatable data around low-carbon materials and their suitability for building through the promotion of the discerned benefits from using low-carbon materials, the demystification of materials and their use – particularly regarding fire safety – along with any beneficial impacts of using non-standard construction methods, can help improve market demand.

30 The UK Green Building Council (UKGBC) recently reported that the cost uplift was 3.5% for residential projects, but they also pointed out that building in a more sustainable manner will save on costly retrofit works as our climate changes. UKGBC, 'Building the Case for Net Zero: A feasibility study into the design, delivery and cost of new net zero carbon buildings'. Available at: https://ukgbc.org/wp-content/uploads/2020/09/Building-the-Case-for-Net-Zero.pdf.

5
A Roadmap for implementation



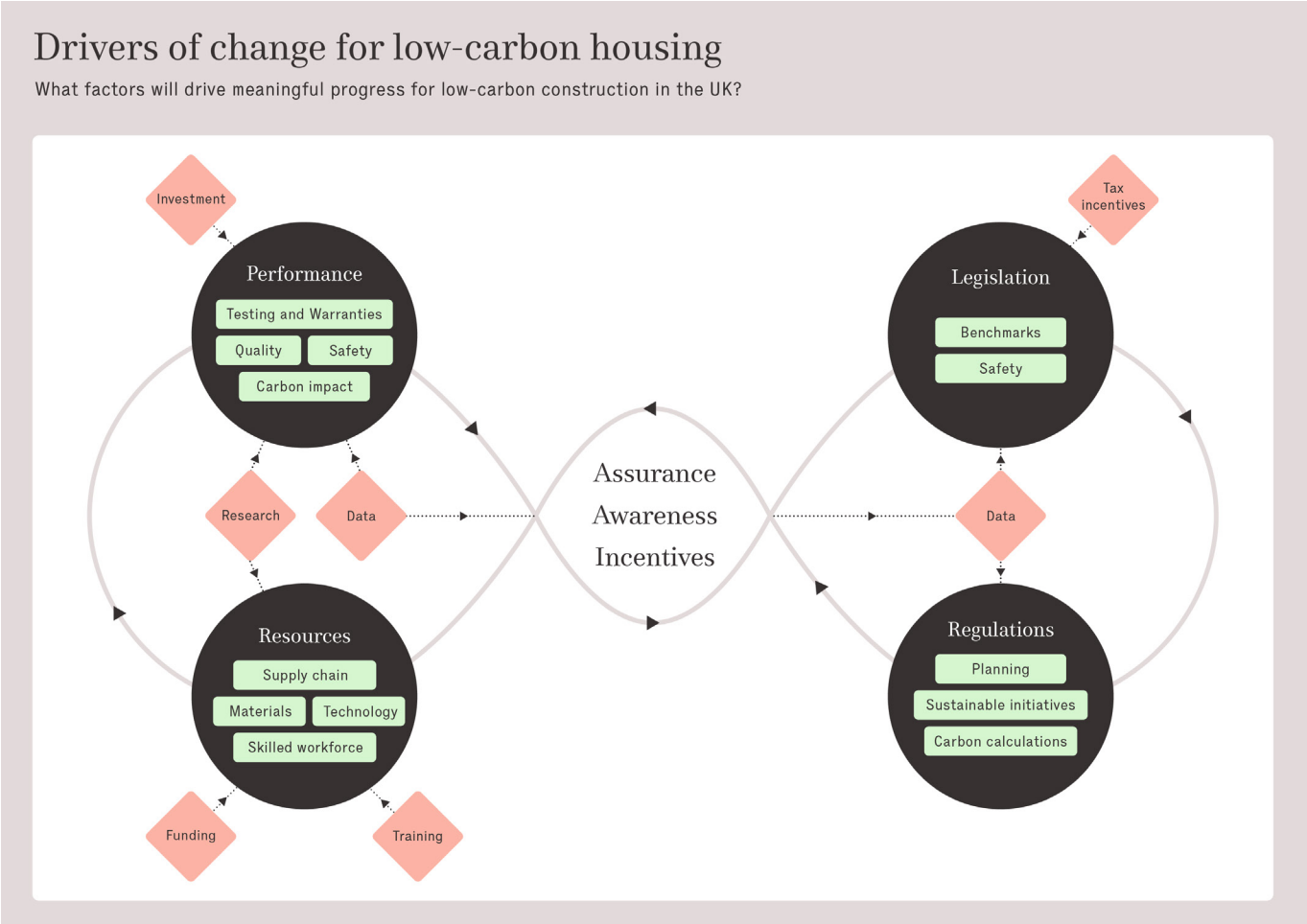


FIG. 3 KEY POINTS OF INTERVENTION FOR ELICITING REDUCTION OF EMBODIED CARBON

While each of the strategies outlined in the previous section can be considered as a discrete intervention, as Figure 3 shows, these thematic aspects are interlinked. Initiatives should be put in place concurrently to develop a robust ecosystem for delivery, through engagement with policy, data, further research and product development, education and strategic funding.

At the heart of this ecosystem, a widescale re-education programme is required across industry (including policy makers, regulatory authorities, construction sector professionals and project stakeholders) and public audiences, to ensure that the means for adopting low embodied carbon strategies will be able to gain traction, and the appetite for delivery will be in place. This will subsequently provoke the need for greater low-carbon materials (requiring research and certification) and the workforce to apply them in the construction sector, requiring investment and training in developing these resources. As previously noted, robustly benchmarked data is a critical requirement for the development and reinforcement of policies regarding lowering embodied carbon. This will also generate tangible incentives for funders, and provide greater assurance for investors.

The following proposals outline how these aims might be delivered on a

more granular level within the current frameworks of the construction sector.

PROVIDE DEPENDABLE TARGETS

Legislation is needed to provide reliable benchmarks on low-carbon materials available for the construction sector. A route map for moving the housing construction sector away from the 'business as usual' model is urgently required. Financial incentives or penalties, such as an embodied carbon tax, will need to be introduced to overcome prohibitive costs of using low-carbon materials.

The current uncertainty as to what carbon limitation demands might be made, when and how, and whether these may be rolled back (as with other net zero strategies) has led to a lack of appetite in the industry to develop business adaptations which could be seen as being 'at risk'.[1] While this situation currently feels to be at an impasse, strategies for establishing stable, incremental change to regulatory requirements for embodied carbon through national policy could help level the consistency of market challenges, to facilitate the growth of the associated material supply chains, and the necessary adaptations to the construction sector to put these into practice. To do so, it will be necessary to undertake research into the appropriate levels at which such limitations can be set, and on what timescales, to enable such benchmarks to be set with clarity and commitment. Penalties for non-conformity, or incentives for meeting/exceeding targets will need to be implemented to catalyse adoption of these benchmarks.[2]

INVEST IN LOCAL AUTHORITY RESOURCES FOR SUPPORT AND ASSESSMENT

To ascertain whether benchmarks are met in practice will also require further national investment in Planning and Building Control services – both in terms of the human and technical resources available, and also in the development of specific skills and education regarding net zero strategies. Investing in boosting expertise within local authorities will be an essential part of this process, to both support the development of these targets, and to assess the compliance of schemes.

COLLATE AND PUBLISH BENCHMARKING DATA

The construction sector requires reliable information regarding low-carbon materials, and ready availability of their supply for these to be integrated. The publication of data regarding potential carbon savings, along with the manner in which low-carbon materials can be used in

1 Importantly, the full range of roles for carbon management set out in PAS2080 and ISO 15686 need to undertake change in order to deliver decarbonisation of construction. Details of PAS2080 are available at: https://www.ice.org.uk/news-insight/news-and-blogs/latest-news/news/what-is-pas-2080-2023-version.

2 The decision over whether penalties or incentives would be more effective requires further exploration with a specific focus group of developers.

construction, would help increase adoption of these strategies by boosting understanding of and confidence in the application of these materials. It will be essential to gather data regarding the impact of carbon savings in current built projects, as well as for potential new construction practices.

As part of the process of setting appropriate benchmarks, the introduction of a single system for calculating the embodied carbon of materials is needed. This system would be used by all sectors, including engineers, architects and surveyors. This needs to be undertaken on an equitable, transparently measurable basis, to ensure parity of data across typologies and locations. Ideally, this will also unite the Net Zero Carbon Buildings Standard (NZCBS) and the Built Environment Carbon Database (BECD) on a single platform, in order to overcome the added levels of complexity currently in place, which builds uncertainty for the users.[3] Sharing this insight can be used to model alternative low-carbon construction strategies in the future, to ascertain where savings can be made, and what the impact might be on the overall project in terms of cost, timescales and aesthetics.[4]

This information also has benefits for ESG reporting, which will become essential as funders look to decarbonise their portfolios.[5] The information regarding material qualities and performance can also be passed on throughout a building's lifespan via Material Passports.[6]

3 The UKNZCBS is currently under development. The BECD was launched in October 2023, but as yet feedback on the success of its implementation is not available. Available at: https://www.becd.co.uk/. Tools from Feilden Clegg Bradley Studios (the FCBS Carbon Tool: https://portal.fcbstudios.com/fcbscarbon) and McKinsey (the EC3 Embodied Carbon in Construction Calculator: https://www.mckinsey.com/capabilities/operations/our-insights/data-to-the-rescue-embodied-carbon-in-buildings-and-the-urgency-of-now) have been developed to help project teams better understand the impact of their decisions during the design and specification process.

4 Arup, 'Digital for sustainable development'. Available at: https://www.arup.com/services/digital/digital-for-sustainable-development.

5 Initiatives can learn from the Task Force on Climate-related Financial Disclosures (TCFD), or Sustainable Finance Disclosure Regulation (SFDR), to help set an agenda for investment beyond commercial sales interests. Both TCFD and SFDR quantify the sustainability risk in relation to investments. This might therefore be appropriate for operational carbon, but not for embodied, unless the supply chain is taken into account.

6 To ensure continuity of information throughout the design, construction and deconstruction process, previous issues highlighted regarding the technology of BIM tagging need to be addressed as part of this strategy – though non-BIM strategies for component asset management, and end-of-life information are available. Although the housebuilding sector is less likely to adopt circular strategies due to the necessary scaleability of residential designs, the introduction of material passports as used in housebuilding now can help identify future applications for construction materials, thereby reducing the whole life carbon consumption of projects. To accelerate impact, audits of current built resources should also be undertaken before

DE-RISK LOW-CARBON CONSTRUCTION

National government funding is needed for the testing and certification of low-carbon materials. Research is required into standard detailing for using low-carbon materials in a manner which can reduce compliance risks, so that data and recommendations can be developed. Initiatives for developing supply chains for sustainable resources to replace carbon-consuming materials – such as the 'England Trees Action Plan' which encourages the use of timber in construction – still need to overcome legislative barriers to implementation if they are to be effective.[7] A set of 'robust details' for using timber and bio-based materials in a manner that gave greater certainty of complying with the new Building Act has helped overcome concerns for Building Control compliance, particularly for project teams which lack the time and resources to explore alternative applications.[8] Further research funding could enable other materials to be explored in the same manner, without the onerousness of a particular body adopting responsibility for standardisation. It is imperative that the resulting information is aligned in the basis for their calculation of measuring and reporting (as outlined above) and shared via open feedback loops, rather than kept in house by those who have financed this research.[9] This information could also be shared with potential home owners as proof of their investment's carbon credentials, providing incentives for future investment.

CREATE NATIONAL HUBS FOR TESTING, CERTIFYING AND DEMONSTRATING LOW-CARBON CONSTRUCTION

New construction testing hubs and demonstrations of low-carbon materials in use are needed to build greater confidence in the sector. To overcome the current lack of testing facilities, a two-fold approach could be undertaken. The first part of this is the establishment of new testing hubs, on a local

demolition of schemes commences. Potential strategies have been developed by ORMS [https://orms.co.uk/insights/materialspassportspolicypaper/]; Madaster [https://madaster.com/platform/]; Fabrix/Symmetris [https://www.fabrix.london/impact-and-news/urban-mining/]; and Material Index [http://www.material-index.co.uk/].

7 'England Trees Action Plan 2021 to 2024'. Available at: https://www.gov.uk/government/publications/england-trees-action-plan-2021-to-2024. Creating a proof of application through the detailing and testing of CLT construction to meet requirements of current Building Act – as undertaken by Waugh Thistleton in the development of their New Model Building toolkit – is an essential catalyst for increasing confidence in use, and generating further uptake. Available at: https://waughthistleton.com/new-model-building.

8 Technical information on fire safety for timber has been collated by the Structural Timber Association, Timber Development UK, and Swedish Wood, to help support design development: https://timberfiresafety.org/.

9 Recommendations will also need to be developed to include options for deconstruction and reuse, if Whole Life Carbon strategies are to be taken into account.

or national scale, and the streamlining of UKAS accreditation for testers to support this, so that warranties can be put in place to build greater confidence for the use of bio-based materials (in particular) in the sector.[10]

The second is the development of 'robust details' demonstrating how such materials can be applied while adhering to building standards and legislation – particularly with regard to fire regulations, and to future proof against future climactic conditions.[11] Having been approved once before large-scale roll outs are undertaken would minimise the timescales and costs entailed in using non-standard constructions, and provide a greater degree of standardisation and certainty for the application of low-carbon materials. This would instill greater confidence in their use by designers, contractors, insurers and investors, to whom these would otherwise be viewed as a risk. This could also facilitate the creation of 'letters of comfort' regarding the use of such materials on the part of industry bodies such as NHBC, which would instill greater confidence in investing in the changes needed to the supply chain and workforce.

IMPROVE SKILLS AND TRAINING ACROSS THE DESIGN AND DELIVERY TEAM

In order to de-risk the cost and time impact of working within new low-carbon construction paradigms, an awareness of opportunities for carbon savings needs to be shared throughout a project team, across quantity surveyors, architects, project managers, engineers and construction workers, as well as consumers.

Financial support for training initiatives in the construction workforce for how low-carbon construction can be undertaken – to complement the GLA's Green New Deal fund – is also needed.[12] A recruitment and education drive to support a green transition in building and construction will produce a larger workforce able to work with low-carbon materials and, as a result, will reduce the cost of building with those materials. This will need to be better integrated within education routes – from the national curriculum to vocational courses with a specific low-carbon construction focus.

INVEST IN SUPPLY CHAINS AT A NATIONAL SCALE TO REDUCE COSTS AND GENERATE RETURNS

Upfront investment in UK supply chains for low-carbon construction technologies (such as bio-based materials) is needed, to ensure these networks are in place before the introduction of legislation and industry

10 Such testing centres have the opportunity to be revenue generating, rather than being seen as an overhead, due to the desire for testing new products to enable them to be available on the market. Details available at: https://www.ukas.com/.

11 It is essential that such details are created to be shareable, rather than developed for commercial interests alone. Consideration is necessary for how this research should be funded.

12 'Green New Deal Fund'. Available at: https://www.london.gov.uk/programmes-strategies/environment-and-climate-change/climate-change/zero-carbon-london/green-new-deal-fund.

benchmark deliverables, otherwise the sector will stall. Long-term investment in resource development, training and material innovation are needed to reduce the current cost barriers to using low-carbon materials. This needs to be undertaken as a sustainable development process, rather than applying short-term subsidies.

Developing national frameworks, wide scale public procurement, or consortia could catalyse the supply of materials through aggregated purchase networks. This can help reduce overall costs for production and certification, and to share the costs of research and development, due to the economies of scale this entails.[13] This is as applicable for the supply of new low-carbon materials as it is for the development of material reuse platforms, both of which stand to deliver a significant impact on reducing embodied carbon in future constructions, and provide opportunities for a return in revenue generated.

INCREASE SURETY FOR THE MARKET

There is a misconception that more durable, higher carbon materials are more sustainable in the long term. Preconceptions regarding the quality of natural materials such as timber and stone in the UK need to be overcome through the dissemination of data in comparison to similar carbon-intensive materials.[14] To support this, the development of equivalent EPC certificates for carbon values – which could also make use of the data from material passports used in their construction, though this is not a necessity – could help communicate the issues surrounding embodied carbon efficiency more clearly, and thus instil greater literacy for these considerations. If clients can be persuaded that the cost and maintenance of bio-based materials can be equitably covered within a project, then lower carbon materials have a greater possibility of being used.[15] The education of clients and occupiers as to the benefits of bio-based materials can help ensure that such construction isn't seen as inferior, and that instead buildings with lower embodied carbon might become aspirational.

13 Purchase networks could be created for local authorities, or smaller scale SME developers, to make them more competitive with larger housebuilders.

14 Although these can already be sourced from overseas, the necessary subsequent transportation impacts negatively on the overall carbon footprint of these materials. This can therefore be minimised by identifying sources closer to the point of application. These could also be designed to be replaced or maintained over the lifespan of the building – and its associated mortgage term – to provide more durable construction.

15 Paloma Gormley, Frame 'Why high(er)-maintenance buildings might be more sustainable'. Available at: https://frameweb.com/article/sustainability/why-higher-maintenance-buildings-might-be-more-sustainable.

Contributors

STUDIO INTERVIEWS:
Andrew Waugh, Director, Waugh Thistleton Architects
Joseph Hamblin, Solidspace
Tristram Taylor, Dominus Real Estate
Stewart McKenzie, Regional Mortgage Valuation Manager, Nationwide Building Society
Aaron Caffrey, Technical Director, Ballymore Construction
Bruce Bell, Director, Facit Homes
Steve Webb, Director, Webb Yates Engineers
Russ Edwards, Head of Residential, Clarion Housing
Amin Taha, Director, Groupwork Architects
Niklas Nølse, Lendager Group Architects
Kevin Carmody and Andy Groarke, Directors, Carmody Groarke Architects
Summer Islam, Paloma Gormley, and George Massoud, Directors, Material Cultures
Rachel Hoolahan, sustainability co-ordinator, Orms
Loretta Bosence and Ben Bosence, Directors, Local Works
Ed Clarke Group Leader, Building Engineering Team and Nina McCallion, Associate, Arup engineers
Ben Ayling, Business Development Manager, Lundhs
Albena Karameros, Employment and Skills Manager, Economic Development Team, and Michael Adeniran, Construction & Partnership Advisor, Royal Borough of Kensington and Chelsea
Juliette Butler, Network and Projects Manager, INTBAU
Phoebe Cramer, Assistant Green skills and Social Value Project Manager, and Nordeen Fahmy, Head of Community Development and Co-Design, Lancaster West Neighbourhood Team, Royal Borough of Kensington and Chelsea
Matt Robb, Digital Media Executive, Stone Federation
Jonny Wates, Ambassador, World Benchmarking Alliance and owner, Wates Construction

ROUNDTABLE 1:
Alexia Laird, Sustainable Design Executive, Landsec U+I
Sophie Maubon, Associate, Waugh Thistleton Architects
Amin Taha, Architect/Director, Groupwork
Mahsa Khaneghah, Climate Emergency Engagement Officer, RBKC
Nell Brown, Senior Policy Advisor, RIBA
Richard Keys, Director, By Others
Alex Johnstone, Architect, Architype/LETI

ROUNDTABLE 2:
Sian Ricketts, Architect, Carmody Groarke (Design Ecosystem Partnership)
Elzbieta Kaleta, Net Zero Manager, UK Government
Steve Webb, Director/engineer, Webb Yates
Ana Costa, Principal Investigator "Building a Circular Future: Accelerate Material Re-Use in Construction", Lancaster University (Design Ecosystem Partnership)
Alex Benstead, Senior Advisor, Advancing Net Zero programme, UK Green Building Council (UKGBC)
Larry Tate, Alliance for Sustainable Building Products/Good Homes Alliance
Lyndal Mackerras, materials passport research, ORMS
Dario Bosco, Associate Founder, Presso
Edward Jarvis, Urban Design Manager, Planning Department, Camden Council
Jennifer Walsh, Strategic Planning and Implementation Team, Camden Council

ROUNDTABLE 3:
Arun Rao, Principal Policy and Programmes Officer, sustainability team, GLA
Sarah Fitzpatrick, Head of Planning, NortonRoseFulbright
Oliver Bulleid, Executive Director, London Community Land Trust
Catherine Adams, Director of Net Zero and Greener Buildings, DLUHC, and co-chair of Future Homes Standard implementation board
Joe Giddings, UK Networks Lead, Built By Nature, ACAN
Emyr Poole, Manager, Centre of Technical Excellence, Homes England
Tim Den Dekker, Fielden Clegg Bradley, Part Z/LETI
Levent Kerimol, Community Led Housing
Ludovica Pototschnig, Structural Engineer, Arup, Part Z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