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# Ecologically constrained structural design: what can we build from the zero-emissions resource pool?

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## 1. Introduction

The construction sector faces the daunting task of meeting growing construction demand with a 'zero-emissions resource pool' - materials that are compatible with a near-future emissions-free economy (1). Most decarbonisation roadmaps and scenario analyses for the sector depend heavily on high-risk technologies such as carbon storage that have not yet been deployed at significant scale, or favour recycling whilst overlooking likely constraints from limited supplies of emissions-free electricity (2). This paper provides a critical review of options to supply construction materials in the UK with realistic expectations about the availability of carbon storage, emissions-free electricity and emissions-free transport. Then it assesses the scalability of the key structural materials compatible with a zero-emissions economy in the near future. Here, we focus on three key resource pools which remain unexplored in the UK and which have proven potential in low to mid-rise domestic construction: load-bearing stone, load-bearing straw, and re-used materials. We use interviews and spatial analysis to investigate both the barriers to scale up and to quantify the scale of opportunity to deliver construction demand from the zero-emissions resource pool. The results point to the need for a revision to the national construction strategy and a range of entrepreneurial opportunities in delivering the services of construction within a reduced material budget.

## 2. Methods

A zero-emissions resource pool framework was developed to assess the feasibility of key construction materials in achieving the UK's 2050 decarbonisation targets. This framework evaluates existing decarbonisation strategies across four life-cycle stages, determining their potential for electrification or emissions-free processing. It also examines the reliance of primary production routes on CCS and hydrogen, as well as opportunities for recycling and reuse.

To quantify the resource pool's capacity to meet UK construction demand, a supply and demand model was developed. A bottom-up demand-side analysis was conducted for seven low-rise domestic building typologies, with material intensity per m<sup>2</sup> derived from case studies in Drewniok et al. (2023) based on the English Housing Survey (EHS). Structural wall materials were categorised as straw (for strawbale construction), straw and timber (for straw-based panels), stone (for mass stone construction), stone and timber (for hybrid methods), or equivalent to steel or masonry (for reused materials). Material wastage was incorporated, and intensities were scaled to annual domestic building deliveries from the EHS.

A mixed-methods approach assessed current supply and expansion potential across three resource pools. Load-bearing stone was assumed widely available due to UK geology, but production barriers were explored through qualitative methods, including 19 interviews with quarry and mine managers across the UK and Europe. Structural material reuse was quantified

by analysing pre-demolition audit datasets to estimate recovery rates by building typology, then scaled nationally using demolition data from Drewniok et al [3] and the EHS. For straw supply, a nationwide assessment linked government survey data on straw usage with DEFRA crop production datasets, including cereal production and straw yield estimates. Straw supply for construction was then spatially mapped against material demand.

### 3. Results

The study has reviewed available decarbonisation strategies for zero-emissions material production in the UK by 2050 and explored which materials and their processes are compatible with a realistic view of delivering zero-emissions in the UK by 2050, or 'zero-emissions resource pool', as summarised in Table 1.

**Table 1** Summary table of the materials reviewed and their compatibility with the zero-emissions resource pool

	Primary production	Secondary production	
		Recycled	Direct Reuse
Concrete	✘	⚡	⚡
Steel	✘	⚡⚡	⚡
Aluminium	✘	⚡⚡	⚡
Structural glass	✘	⚡⚡	⚡
Timber	⚡ to ⚡⚡	⚡	⚡
Earth	⚡*	⚡	⚡
Strawbale	⚡	⚡	⚡
Stone	⚡	⚡	⚡
Lime	✘	⚡	⚡

\*compatible if unfired and unstabilised

#### Key

✘ incompatible with a realistic view of delivering zero emissions in the UK by 2050

⚡ compatible with a realistic view of delivering zero emissions in the UK by 2050 - approximate energy intensity (EI) (MJ/kg): ⚡  $0 < EI \leq 1$

⚡⚡  $1 < EI \leq 10$

Primary production of many key materials, including concrete, steel, aluminium, structural glass, fired bricks, and lime, is incompatible with the UK's zero-emissions target by 2050. Continued use of these materials will result in emissions that can only be mitigated through offsets, such as landscape restoration, which is a high-risk strategy, given the increasing competing claims on land. In contrast, recycling of these materials can be electrified but remains energy-intensive, constrained by the availability of emissions-free energy, which may meet only 60% of anticipated demand (4).

Traditional materials like timber, unfired earth, straw, and stone align more closely with zero-emissions targets. Direct material reuse is the least energy-intensive production mode, although scaling it requires the development of new supply chains. A key takeaway is that decarbonisation strategies must account for realistic deployment rates and resource demands for zero-emissions material production technologies. The analysis of three resource pools—stone, reused materials, and straw—revealed key challenges and opportunities for scaling their use in the UK construction sector.

#### 3.1 Load-bearing stone

While stone resources are abundant, we found from the survey that scaling production is constrained by labour shortages, regulatory barriers, and low demand for structural stone.

Shifting architectural preference towards utilising stone with variation in shape, size and aesthetics could reduce waste and costs. Additionally, expanding local supply chains and streamlining quarry planning processes will help scale production.

### **3.2 Load-bearing straw**

We found that the UK could meet housing targets from straw currently produced, with minimal impact (-12% change) on livestock bedding and feed sectors. Improved coordination between agricultural producers and the construction sector could optimise straw's potential, especially in regions like East Anglia, where surplus straw exists.

### **3.3 Structural re-use of construction materials**

The analysis of pre-demolition audit datasets, scale up to national supply, showed that the availability of steel and brick has the highest potential for re-use, whilst block and timber have the lowest. Building types with higher demolition rates, such as industrial buildings, offer greater opportunities for reuse.

Overall, the findings highlight the need for targeted policy interventions, infrastructure investment, and improved supply chain coordination to maximise the potential of these materials. In an optimised system, materials like reused stone and surplus agricultural straw could offset the need for newly produced resources, contributing to reduced reliance on virgin materials and advancing the UK's zero-emissions targets. Future work is needed to explore how to build the economic and environmental and social feasibility of scaling up the production of stone, straw and re-used materials.

## **4. Acknowledgements**

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## **References**

1. Taylor C, Allwood JM, Watari T, Hawkins W. The zero-emissions resource pool: construction materials compatible with a realistic view of delivering zero-emissions in the UK by 2050 . *Architecture, Structures, Construction*. 2025;
2. Hawkins W, Drewniok M, Dunant C, Horton P, Romain P, Stephenson S, et al. Construction Sector Innovation within Absolute Zero. 2021; Available from: [www.ukfires.org](http://www.ukfires.org).
3. Drewniok MP, Azevedo JMC, Dunant CF, Allwood JM, Cullen JM, Ibell T, et al. Mapping material use and embodied carbon in UK construction. *Resour Conserv Recycl* [Internet]. 2023 Oct;197:107056. Available from: <https://linkinghub.elsevier.com/retrieve/pii/S0921344923001921>
4. Skelton A, Allwood J, Horton P. Energy Sector Innovation within Absolute Zero. 2022; Available from: [www.ukfires.org](http://www.ukfires.org).