UNIVERSITY OF CAMBRIDGE
INSTITUTE FOR SUSTAINABILITY LEADERSHIP

Building Entopia

An inside view of an ultra-sustainable retrofit

Authors
This paper was prepared by CISL and authored principally by Mr Jeff Blaylock, Dame Polly Courtice, Dr Tim Forman, Prof John French, Dr Jake Reynolds and James Cole. The findings, interpretations and conclusions contained in the paper are those of the authors and do not represent or imply any official position, judgement or endorsement on behalf of CISL or any other party involved in the Entopia project. The opinions expressed here are those of the authors and do not represent an official position of CISL, the University of Cambridge, or any of the Entopia Building project team or clients.

Research approach
To create this study, we conducted one-to-one and small group interviews with stakeholders, a comprehensive review of project documentation, and observational research. We collected data over a 13-month period from February 2021, and drew on analysis of documentation from earlier project stages. We conducted 24 primary interviews from October 2021 to February 2022 with 15 individuals drawn from principle contracting organisations and project stakeholders in executive and senior operational positions.

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Find out more
If you would like to find out more about the University of Cambridge Institute for Sustainability Leadership, its Canopy startup incubator, or Entopia please contact info@cisl.cam.ac.uk

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Foreword

The fact that the Entopia Building uses dramatically less energy than its predecessor is a success in its own right; that it has minimised the use of new materials through circular design and concurrently reaches three challenging building standards, is exceptional. Its true impact is still to come, however, through its role as a beacon project: an exemplar and teachable resource that creates positive ripples of change throughout the built environment community, influencing the course of other projects, policies and investments.

The publication shows that lessons from this project extend far beyond applying technology to sustainable design into new mindsets, collaboration models, and modes of leadership. These learnings challenge beliefs closely held by many in the industry, placing conventional processes and norms of design under the spotlight.

The communication of – and engagement with – the lessons from this project was a core ambition from the outset. Some projects use public relations to promote their project and brands, whilst others seek to protect the knowledge and insights gained by their innovation. We have chosen to do neither. By purposefully packaging the lessons from Entopia into this paper and using all our available avenues to reach industry colleagues, practitioners, town and country planners, and policymakers, we hope to maximise awareness of the lessons for all.

To support this ambition, a formal Communications Working Group was set up within the Entopia Project Board, chaired by CISL and with representatives from the University, the supply chain partners and major donors. In line with the project charter, this was a collaborative process in which our collective insights and opportunities were pooled into a repository of communications assets that all partners can draw on. This publicly available case study is one of the key outputs of the working group, designed as a reference point for industry practitioners. In addition, a website [https://www.cisl.cam.ac.uk/about/entopia-building] is being maintained with articles, blogs and videos about the project. A project data repository has also been created to support future communications and research. Moreover, the project's lessons (as captured by the case study) are being taught on CISL's built environment leadership Master's and online courses, potentially reaching hundreds of senior practitioners each year; tours and visits of the Entopia Building are being accommodated wherever possible; project partners (including small suppliers) are being empowered to speak at industry conferences and webinars, and media channels have been engaged successfully throughout the process.

We hope you enjoy reading the case study and that it is helpful in your journey towards transforming the sustainability of the built environment.

Entopia Communications Working Group

"The path to a sustainable and resilient world will not be feasible without radical changes in how we procure, design, construct and use our buildings. The central message of this paper is that those changes are both possible and affordable. Buildings like Entopia are attainable for all through sensible design strategy, careful analysis, collaboration and determined leadership against a clear, ambitious vision."

Clare Shine
Director
& CEO, CISL

Entopia is an internationally leading, fabric first, sustainable retrofit of a 1930s, five-storey concrete frame structure with a basement located in a local conservation area in the historic Cambridge city centre. Entopia demonstrates that a 'deep green' retrofit can be delivered at a cost that is competitive to a conventional office refurbishment. The project started in 2019 and was completed in 2022.

Inside this document

Entopia: the big picture

The challenge
The building sector, including the construction and operation of buildings, accounts for nearly a third of total global energy consumption and almost 15 per cent of direct CO_2 emissions. Yet as much as three-quarters of Europe's building stock is old and inefficient. Improving the energy performance of these buildings to align with Europe's net zero ambition is an enormous and urgent challenge.

The brief
"A low carbon retrofit for 1 Regent Street that is both pragmatic and practical in approach represents good value for money whilst challenging conventional norms around building refurbishment. A key indicator will be building performance and user satisfaction."

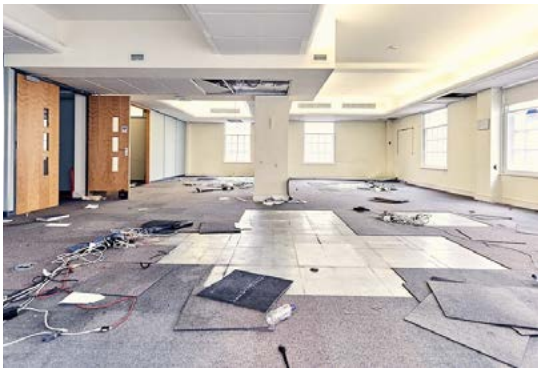
The University of Cambridge project brief set out key objectives: educate and lead the building industry; minimise carbon and negative environmental impact; inspire staff and visitors and encourage collaboration; achieve the highest possible level of efficiency; adopt recycled and bio-based materials, and deliver value for money.

£12.69m
total projected project cost

£4,250
project cost per sqm (£395 per sq ft)

6,340kg
$CO2e/m^2$ GIA saved over 100 years, compared to standard officefit-out

£1m
enhancement of external building envelope



9 ways Entopia can build change

1 Sustainability targets improve performance. Targeting BREEAM Outstanding, EnerPHit Classic and WELL Gold in one project, along with holistic sustainability objectives, has delivered a retrofit that outperforms nearly any existing building in energy efficiency, contains a fraction of the whole life embodied carbon of a typical new construction, minimises adverse sustainability impacts, and maximises usability and wellbeing for occupants.

2 Making it cost competitive. A low carbon, energy-efficient refurbishment of an existing building can be delivered at a competitive cost relative to a traditional fit-out when operating costs are considered. The capital cost of Entopia is estimated to be eight per cent higher than a traditional fit-out, but this is expected to be recovered within five to eight years through lower requirements for operational energy.

3 'Fabric first' cuts costs and energy. A fabric first approach prioritises reducing energy demand over obtaining energy from more sustainable sources and should be applied before designing the building services. We adopted it to improve energy performance of the building envelope and scale down mechanical, electrical and plumbing (MEP) systems, cutting carbon footprint and costs and freeing up space.

4 Circularity principles reduce embodied carbon. Circularity principles such as recycling and refurbishing were a core element of the brief, influencing the appointment of the main contractor and shaping our procurement strategy. We leveraged the contractor's supply chain to identify materials for reuse in the building.

5 Whole life design. Our design strategy was based on a 'whole life' perspective that considered sustainability and impacts and benefits across the lifetime of the building as fundamental parameters of design. It is crucial that lifecycle cost, not just upfront capital cost, informs decision making. A focus on energy efficiency reduces future liability for energy costs or deferred improvements to heating, cooling and ventilation systems.

6 Open communication improves outcomes. A norm was established from the outset that team members should feel able to communicate freely, unencumbered by group hierarchy, structure or power. The leadership team made it clear that anyone on the project team could contact any other team member for advice or consultation without hesitation or permission.

7 Sustainability champions. We embedded sustainability principles from kick-off through to handover by appointing a sustainability representative for every stage, and at every level, from every stakeholder. With clear client ambition, shared leadership, and good governance, this approach realised the project's objectives.

8 Carbon and energy-saving measures can sway planning decisions. We secured permission for critical design elements such as tripled glazing by making a case for energy performance amid heritage restrictions. In the UK, standards such as EnerPHit and whole life embodied carbon targets could be used as a condition of planning consent or regulatory approval, if balanced with heritage, social value and natural capital concerns.

9 The importance of post-handover assessment. Post-occupancy evaluation allows buildings to be 'tuned' to optimise energy performance and working conditions. Our plans for post-occupancy evaluation include a review of energy consumption patterns and performance against sustainability indicators, an occupant satisfaction survey and a workshop-based review of lessons learned in the post-handover stage.

Read the full case study here >

Entopia: the detail

The challenge

Existing building:
Six-storey concrete frame (five storeys above ground, with one basement storey). Originally constructed in 1939, with extensive internal refurbishment and extension carried out in 1998.

Building purpose:
Provision of space for offices, start-up incubator and collaborative activities.

Gross internal area
(post-refurbishment): 2,939 m^2.

Retrofit strategy:
Fabric first approach.

Planning restrictions:
Non-listed building, located in conservation area.

Windows:
Existing: single-glazed with transoms and mullions.
Improvement: triple-glazed; large window inset to control solar gain; transoms/mullions removed to increase glazed area by 60 per cent.

Walls:
Existing: masonry infill.
Improvement: Retrofit strategy for existing masonry walls includes an internal wall treatment using bio-based products, including wood fibre insulation and lime and cork plaster.

Floors:
Existing: Concrete floors.
Improvement: Asbestos found in some areas of screed and obscured service trench – airtightness layer added.

MEP (mechanical, electrical and plumbing):
Existing: Space heating was previously provided using gas boilers feeding radiators, air handling units with heating coil and 4-pipe fan coil units with reversible direct expansion cooling.
Improvement: The gas supply was disconnected, and an air source heat pump (ASHP) was integrated into a central air handling unit, which will be sufficient for the majority of space heating, and additional demand will be met by a few localised direct electric panel radiators and DX fan coil units. Heat is recovered from air exhausted by the ventilation system through provision of a Mechanical Ventilation with Heat Recovery (MVHR) system.

Results against targets

"The fact that the Entopia Building uses dramatically less energy than its predecessor is a success in its own right; that it has minimised the use of new materials through circular design and concurrently reaches three challenging building standards is exceptional. Its true impact is still to come, however, through its role as a beacon project: an exemplar and teachable resource that creates positive ripples of change throughout the built environment community, influencing the course of other projects, policies and investments."

Entopia Communications Working Group

Entopia is now a centre of sustainability thinking and practice: a physical hub for CISL's network, local organisations, citizens and global partners.

Area	Target	Result
BREEAM Refurbishment and Fit-Out 2014	Outstanding (≥85%)	Interim estimate: 92.0% (target 93%)
EnerPHit standard	Classic	Achieved
WELL standard	Gold (≥60 points)	Current: 24 (target: 85)
Whole life embodied carbon (for 100-year life)	300 $kgCO_2e/m^2$ over 100-year building life	Construction stage (RIBA Stage 5): 409 kg $kgCO_2e/m^2$ including in-use and end of life carbon, over 100 years (578 at RIBA Stage 2 assessment 434 at RIBA Stage 4 assessment)
Percentage new materials bio-based, with responsible sourcing and traceability	70%	Current: ~35% by mass, (~50% by volume)
Use of recycled and reclaimed materials, reflecting circular economy principles	Maximise where possible	5,139 items/43,409kg diverted from landfill 85,747kg of CO2e avoided

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Find out more

Entopia, University of Cambridge Institute for Sustainability Leadership

Canopy startup incubator

Key Entopia lessons are being taught on CISL's built environment leadership Master's and online courses

Website with articles blogs and videos.
Visit and tour the building