BDP. Ideas

Innovative Cities

Achieving Net-Zero Labs

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Achieving net-zero labs

Introduction

Maxwell Centre, University of Cambridge

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Foreword

We have a collective responsibility to address the climate emergency; our everyday design decisions directly determine the impact of the science and technology buildings and research facilities we create.

BDP's multidisciplinary teams regularly discuss ways to reduce the carbon impact of laboratory buildings, although at times the challenge of meeting the energy demands and unique technical requirements of science projects can be overwhelming. But the simple truth is that every project we undertake must strive to be carbon neutral or better – and this applies not just to the building, but to its operation, including the 'plug loads' from the equipment needed for scientific endeavour.

When asked by a client what it would take to deliver one of the UK's largest net carbon zero laboratory projects, I tasked a team to review our recent experience in the sector, and from this we set out to test the impact of all decisions – big and small – on embodied and operational carbon emissions, cost and impact on scientific activity. From this we determined the primary features which drive carbon emissions in science research projects and developed the BDP Net Zero Carbon Toolkit which we now apply to all our projects. The following pages outline some of key drivers of embodied and operational CO_2e emissions and how we can address them to make the challenge of achieving net zero a reality.

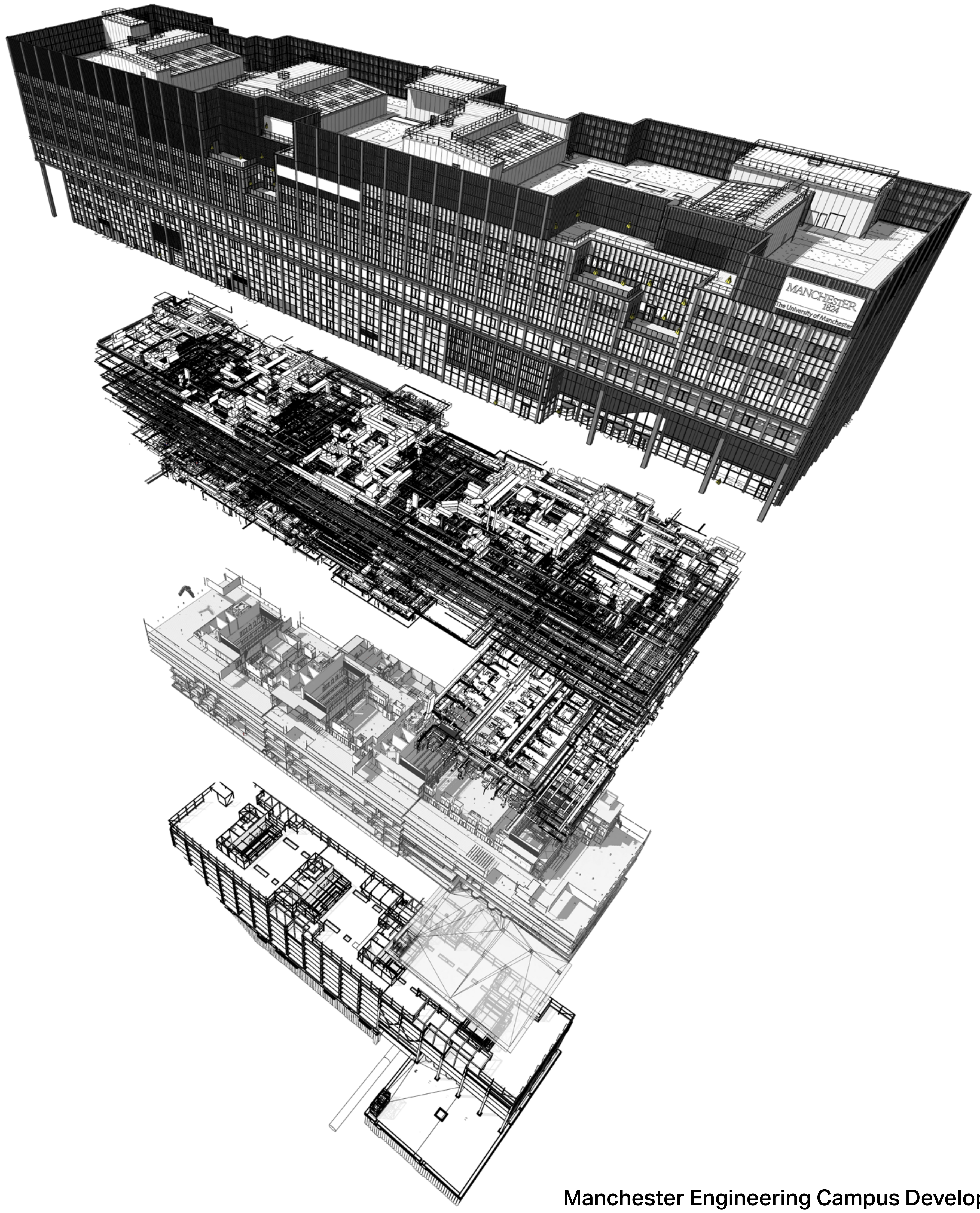
Keith Papa
Architect Director,
Head of Science, Research and Technology

Introduction

Creating a science research building can be a carbon emission challenge.

It's no secret laboratories are CO_2e emission-intensive buildings. Most are required to operate 24/7 and cater for complex environmental requirements for the manufacture and storage of chemicals, biological containment, or close temperature control for micro-, nano- and sub-atomic scale work. Chemical labs are the worst offenders, consuming three to four times as much energy per square metre as an office building. Meanwhile life science labs with their energy-hungry equipment (bio containment, big freezers, environmental growth chambers, incubators, ovens etc) have a worrying carbon footprint.

Heavy construction is favoured to control vibration performance, but this often means pouring vast quantities of concrete to form floor plates – and cement accounts for 8% of global carbon emissions. As designers it is imperative that we collaborate to meet the global goal to half emissions by 2030 and reach net zero lifecycle emissions for all buildings by 2050. This is a huge opportunity for laboratories to make a significant difference.



Manchester Engineering Campus Development

Step one

Challenge the brief

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Manchester Metropolitan University, Science and Engineering Building

Challenge the brief

A key driver of carbon emissions from laboratories is the unthinking imposition of benchmarks and performance standards. This can occur through a mismatch of understanding a building's performance and how it relates to the laboratory activity as well as a desire not to limit future use – which itself could form part of a low carbon emission approach.

Full and open engagement with the client and, where possible, the building users to test and challenge the environmental requirements for the proposed activities can reduce carbon emissions from structural design and heating, ventilation and air conditioning (HVAC). This includes investigating equipment isolation, zoning activities by the intensity of their performance and optimising space through interrogation of uses.

A better understanding between scientists and architects/engineers about decisions made early in the project will aid the holistic development of designs which support the scientific endeavour while minimising carbon emission impact. In one of our projects, redesign of adjacent traffic calming measures was a more cost-effective measure to help control vibration rather than focusing on just the performance and specification of the building structure.

Defining future requirements is fraught with uncertainty. Scenario planning to achieve future increased performance requirements through building adaptation allows the optimal performance levels to be incorporated into the initial design while identifying the potential costs for later enhancement. Challenging the base building technical performance requirements avoids over-specifying the building's construction and systems and ensures future adaptability.

Pears Building, Royal Free, University College London

Step two

Crunch the numbers

AstraZeneca Discovery Centre, Cambridge, UK
Image courtesy of Hufton + Crow

Crunch the numbers

The carbon impact of every decision made must be reviewed and benchmarked using the wide range of tools and intelligence available.

We are currently working on proposals for the largest net zero carbon laboratory in the UK, Next Generation Infrastructure project for the John Innes Centre (JIC) and The Sainsbury Laboratory (TSL), in conjunction with BBSRC at Norwich Research Park. We investigated the content and context of the zero-carbon agenda and applied present standards of measurement to all elements of the project, taking account of the embodied and operational carbon impacts. We carried out the TM54 analysis to evaluate the operational performance of the building at stage 2, rather than stage 3 or 4, which identified areas where energy use could be reduced.

Next Generation Infrastructure, Norwich Research Park

Step three

Build less and zone

Alderley Park

Build less and zone

The most obvious solution to reduce carbon emissions from construction is to build less.

An interrogation of potential synergies between scientists and areas where facilities could be shared offers opportunities to optimise space requirements and we constantly review the metrics and benchmarking collated from our science research and technology projects to identify approaches for optimising space. When defining the brief for the Ray Dolby Centre (Cavendish Laboratory) at the University of Cambridge we facilitated workshops with all cleanroom users to determine the benefits and challenges of a large, shared, centrally located cleanroom suite. Beyond embodied carbon reduction, this increased space, encouraged collaboration and simplified operational and technical support.

For the NGI project at JIC, detailed studies of the lab and office usage identified where area savings could be made without impacting research activity or opportunities for collaboration. The area reductions in the offices allowed the use of narrower floorplates, maximising daylighting, reducing operational costs and enhancing wellbeing. A sizeable portion of the roof plant space was reclassified from internal to external space, using fewer materials and further reducing cost.


Ray Dolby Centre (Cavendish Laboratory), University of Cambridge

Build less and zone

Zoning – for both adaptable and bespoke space – is a simple way to locate central shared activities with the same technical performance requirements. It also allows for future flexibility within defined high performance technical zones. Our concept layouts for the Ray Dolby Centre located low and ultra-low vibration spaces in the 'quietest' part of the site; created large 'halls' for comparable equipment and zoned the rest of the building to optimise construction performance and technology.

In many cases stripping back to the original structure remains the preferred approach to reusing existing laboratory buildings and reducing embodied carbon, but this still results in significant new construction. We believe that a detailed cost benefit analysis which defines the extent of refurbishment (embodied carbon spent and cost – including VAT) against operational energy reduction (operational carbon saved) guarantees the most sustainable decision is reached.

Manchester Metropolitan University, Science and Engineering Building

Step four

Use materials inventively

Next Generation Infrastructure, Norwich Research Park

Use materials inventively

There is ongoing debate over the value of timber versus concrete. Timber can be ultra-sustainable and lightweight but can also be challenging to satisfy vibration performance in laboratories. This means that most laboratories use heavier systems such as reinforced concrete floor plates and are not yet unlocking the potential of low carbon systems. Simply selecting materials that have low embodied carbon is not enough to create low carbon buildings and infrastructure. The engineer instead must creatively merge a range of materials together in a way that unlocks their potential and plays to the strengths of materials, geometry, technology and assembly; then demonstrate to the client the levels of performance that can be achieved by implementing bio-based materials and alternative methods of construction.


Department of Chemical Engineering, University of Cambridge

Use materials inventively

For the NGI project, we developed a 'lab neighbourhoods' concept and adopted an optimised structural approach to the superstructure with a fully timber solution for the office areas and a hybrid timber and concrete frame for the labs. Combined, this offered a significant reduction in embodied carbon while meeting the specification vibration requirements for the laboratory. Our investigations, together with market testing to determine cost uplifts, led us to develop a library of low carbon materials to share across the practice. Facade materials can have a big impact on the embodied carbon in a building, so by using timber we could lock up the sequestered carbon by growing trees and have a carbon negative facade design.


The Enterprise Centre,
University of East Anglia, Norwich, UK


80 Atlantic Avenue, Toronto, Canada

Step five

Specify the kit

Physics of Medicine, University of Cambridge

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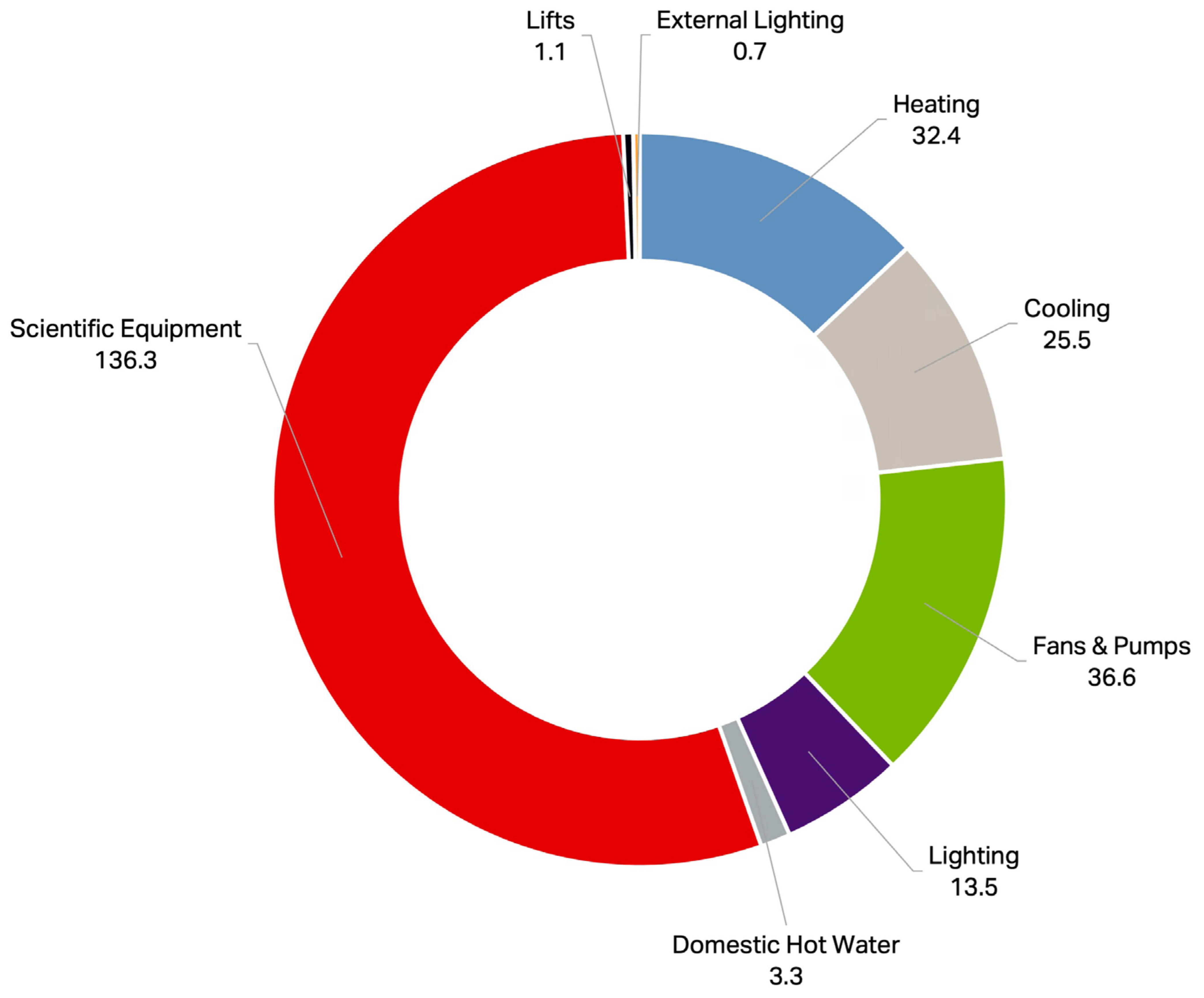
Specify the kit

Scientific equipment can represent over a third of energy consumed by laboratories. The industry has made valuable advances in building services efficiencies, with heat pump technology significantly reducing energy demand for lighting and energy sources via ventilation systems.

Clients must be encouraged to purchase the most energy efficient equipment available, taking the entire life cycle cost into consideration, not just the ongoing energy consumption. Legacy equipment may represent a significant portion of the bench-top equipment but a planned replacement programme can phase in the most sustainable alternatives.

Most scientific equipment emits heat, so requires the provision of cooling, adding to energy use. If this heat can be dealt with at source, there is a real contribution to achieving the net zero target. Positioning of heat emitting equipment to a place where it can be isolated or removed is key, as is housing certain equipment in ventilated enclosures. This not only limits heat gain but also allows for waste heat to be recovered through the ventilation system.

Energy use kWh/m²



Example of a low energy all-electric physics lab, where equipment load has been assessed as more than 50% of total building demand.

Step six

Energy plan

AstraZeneca Discovery Centre, Cambridge, UK
Image courtesy of Hufton + Crow

Energy plan

An energy plan is as essential as a cost plan in setting targets for energy use, from initial inception through the design and construction process, and, ultimately, as a building in use. Targets should be ambitious, affordable, but achievable.

Taking a fresh review of the individual elements is the best start to formulating the energy plan as benchmarking often lacks the detail to support the analysis. Once the plan is agreed, it should be tracked regularly through design development to ensure it stays on track and highlights areas for improvement using evolving technologies. A 10% increase in ventilation can increase fan energy by as much as 20%, as well as impacting heat and cooling demands.

Next Generation Infrastructure, Norwich Research Park

Achieving net-zero labs

Conclusion

Technology and Innovation Centre, University of Strathclyde

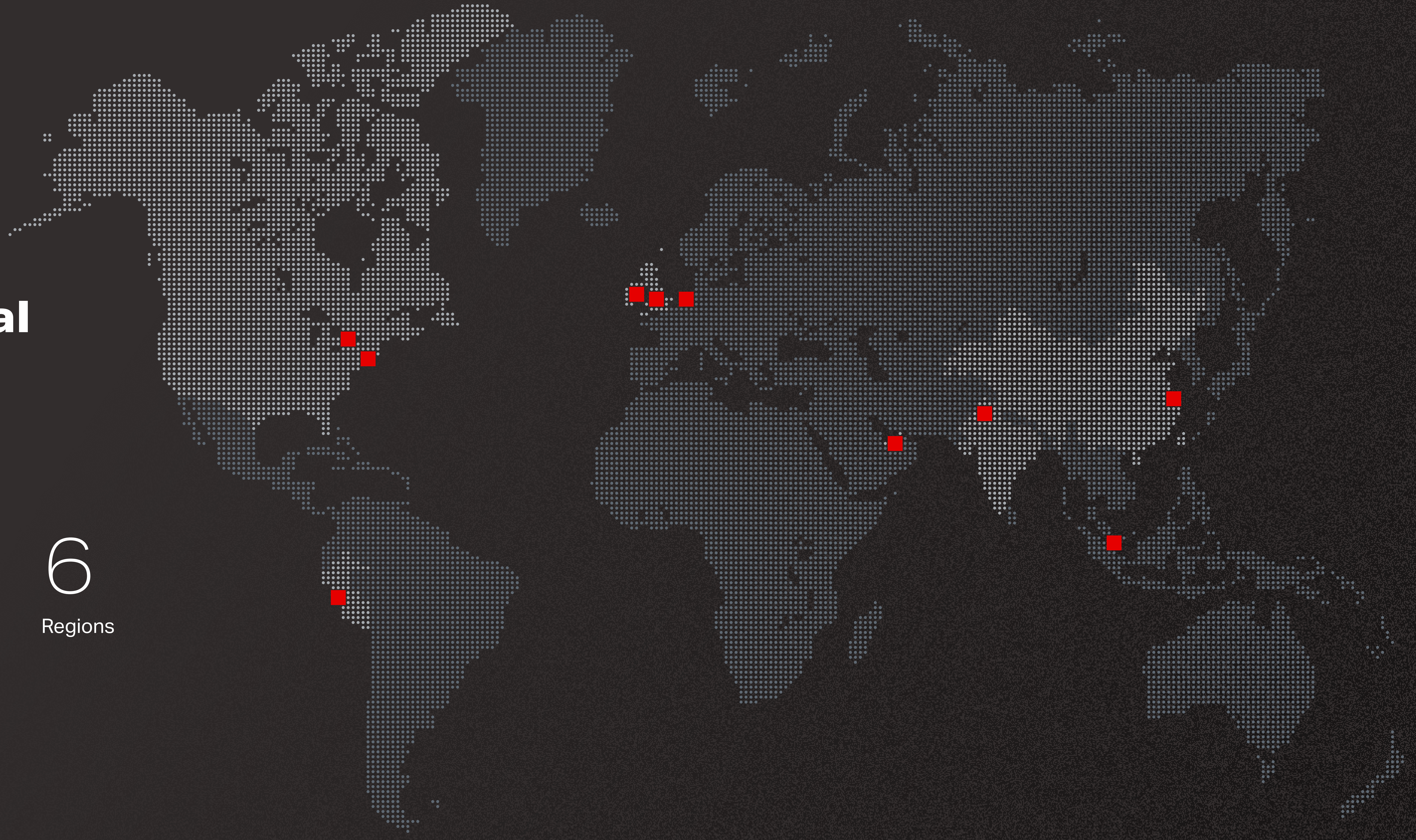
Conclusion

Every design decision can help reduce CO_2e emissions from the construction and operation of any new building or refurbishment project. From our experience the key approaches to reducing emissions to a level that can be effectively offset or eliminated entirely are to:

- Understand, analyse and utilise the underlying data that drives CO_2e emissions.
- Target the big wins and take a holistic view to reducing CO_2e emissions across every aspect of the project.
- Focus on the benefits of reducing CO_2e emissions both for the health and wellbeing of occupants, and reducing ongoing operating costs, i.e. local energy generation and future price of fossil fuels.
- Only build what is needed, but enable flexibility for future trends to ensure the project does not become a zero-carbon white elephant.
- Take responsibility for the impact of your building and the activities within.
- Offset any remaining embodied carbon emissions within the project or through hyper-local carbon offsetting initiatives.


Department of Chemical Engineering, University of Cambridge

Our global practice



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Studios

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Countries

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Regions

North America
New York
Toronto

South America
Lima

UK
Birmingham
Bristol
Cardiff
Edinburgh
Glasgow
Leeds
Liverpool
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Shanghai
Singapore

We collaborate with our clients to realise their aspirations at the cutting edge of research and technology to foster and inspire world class discovery, creating places that celebrate science as a cultural activity.

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