



Bringing the building envelope into a safer, more integrated, sustainable built environment

About this briefing

- Recent issues in construction have demonstrated the complexity of delivering a safe, integrated and sustainable building envelope.
- An expert community from research, the construction industry and policy was invited to come together for two workshops held in January 2022, to identify the key questions around the delivery of a safer, more integrated and sustainable building envelope.
- This briefing highlights the challenges currently faced in the built environment and sets out how a truly interdisciplinary building envelope network can address these challenges.
- UCL BERN, the Building Envelope Research Network, is a UCL cross-faculty research network established to help integrate knowledge of the building envelope into UCL's research and teaching programmes.

Building use and construction account for nearly one third of global final energy consumption and 15% of direct carbon emissions ([IEA 2022a](#)). Moreover, the UK building stock has a low turnover rate, and 400,000 households are at risk of entering fuel poverty due to recent rises in wholesale gas prices ([Ambrose 2021](#)).

As a much-needed response to the climate crisis, the UK Government has committed to a net-zero target by 2050 ([UK Government 2021](#)). Achieving this target requires a joint effort in reducing carbon emissions throughout the life cycle of new and existing buildings. Therefore, there is an urgent need for buildings and their users to become more energy efficient and do so in a way that limits unintended consequences, such as worsening of indoor air quality or an increase in overheating risk.

However, the construction industry has so far struggled to deliver low-carbon, energy efficient buildings that fully satisfy occupants' needs in terms of indoor environmental quality. The performance gap identified between design and operation is evidence of the shortcomings of current practice, together with the unintended consequences of energy efficiency interventions and policies.

Recent failures, including the high-profile Grenfell Tower tragedy, have brought into view several long-standing issues associated with the fragmented nature of the UK construction industry. In 2016, the Each Home Counts review aimed at addressing consumers' lack of trust in the retrofit industry, as a response to failures in domestic retrofit ([Bonfield 2016](#)). The more recent Hackitt review into the fire tragedy at Grenfell has scrutinised the practices around the assessment, design, construction and use of the building envelope, and its interaction with its context ([Hackitt 2018](#)). A key recommendation of this review was the creation of a 'golden thread' of information for all higher risk buildings, such as high-rise residential blocks. This highlights the importance of communication across different disciplines and (digital) information management throughout the lifecycle of a building project, from inception to construction to occupation. This would ensure that a formal process is followed for any design changes. These reviews highlighted the complexity of the industry and identified serious failures, calling for a culture change, systems thinking and a new, outcome-based, regulatory framework.

In response to the reviews' recommendations, the UK Government has established a series of initiatives, including setting up a Retrofit Standards Task Group at the British Standards Institution ([Rickaby 2017](#)), and a review of building regulations in England, Scotland, and Wales. Similarly, the catastrophic European 2003 and 2006 heatwaves increased awareness of climate change related risks to the built environment and communities in the UK. This led to the introduction of the Heatwave Plan for England in 2004 ([PHE 2021](#)). More recently in 2021, as part of the revised Building Regulations, the new Approved Document O was introduced ([DLUCH 2021](#)). This covers indoor overheating mitigation requirements as part of the Government's plans to reach the net-zero target. However, to support such culture change, more effort is needed across the construction industry and beyond.

Current challenges

In this context, two recent UCL BERN workshops highlighted some of the challenges:

- There are barriers to the adoption of a low-carbon culture. These are associated with perceptions and attitudes in both policy makers and the wider public. The Grenfell Tower tragedy – among other examples – demonstrated that disasters are significant drivers of immediate reaction. Policy and programmes have often been developed as a reaction to disasters, in a somehow disjointed way, dictated by short-lived political agendas. In contrast, there is an emotional disconnect to longer-term drivers, including climate change - as

demonstrated by the limited interest in low-carbon building retrofit.

- There is unequal stakeholder representation in policy development – while small and independent stakeholders (including residents associations and Small and Medium Enterprises) are underrepresented, others, such as large manufacturers and developers, have the time, capital, and human resource to influence policy development.
- There is still insufficient upskilling and understanding of the principles underpinning building envelope design, installation, and use (e.g., life cycle emissions, prevention of overheating and condensation), of the interaction between the building envelope, building services and users (e.g., ventilation), and of the potential unintended consequences of inappropriate actions at all stages.
- The supply chain is reluctant to adopt positive changes and innovative best-practice solutions, if those depart too much from the current practices. For example, installers of external wall insulation have been 'pushing back' against industry-defined good practice construction details that require them to go beyond previous practice. Similarly, in domestic retrofit, many insulation installers have refused to acknowledge or act upon the need for improved ventilation when dwellings are insulated, as required by new standards.

What is needed?

UCL BERN workshops participants agreed that it is time for a paradigm shift toward a systems-based, interdisciplinary approach that moves away from working in silos.

The building envelope industry needs evidence-based policy development to drive the transition to measured building performance with increased awareness of unintended consequences. This transition needs to be supported by novel methodologies and tools that allow practitioners to measure and predict the building performance in operation, and to minimise the performance gap between design and operation throughout the building life cycle.

To address these issues, the disciplines contributing to building construction and operation need to be integrated; a joined-up process focused on delivering building envelopes that provide a healthy, safe, and inspiring environment for occupants, while meeting the requirements of a net-zero carbon society and adapting to a changing climate. So far, most of these disciplines are practiced, researched, and taught separately; the UCL Building Envelope Research Network has now been set up to proactively address this.

While many of the issues identified are not new, the culture change called for by the recent reviews requires an overhaul of the current compartmentalised approach, together with a rapid shift towards interdisciplinary frameworks that consider the integration of building envelope functions, set within a wider socio-technical context.

The UK Government has embraced systems thinking and systems integration in its own project delivery authority, the Infrastructure and Projects Authority. Its Project Initiation Route Map was developed as a support tool for novel or complex major projects, including large construction projects, and has systems integration at its core ([IPA 2021](#)).

Pioneers in the construction industry are also embedding systems integration in the delivery of their buildings. Examples, such as the world's largest Passive House certified project at Cornell Tech, show that such integration is possible ([Buro Happold 2022](#)).

Workshop participants found the systemic issues affecting the delivery and performance of the building envelope particularly complex. Hence, the involvement and integration of a wide range of disciplines is really necessary.

UCL BERN provides leadership within UCL and at local and national level to help create a safe, integrated, sustainable future in building envelope design and construction.

We do this by coordinating and disseminating research, knowledge exchange and education to support the design and construction of buildings that embed a safe integrated approach and building envelope sustainability principles into the construction sector. We also support the development of appropriate Government policy for the sector.

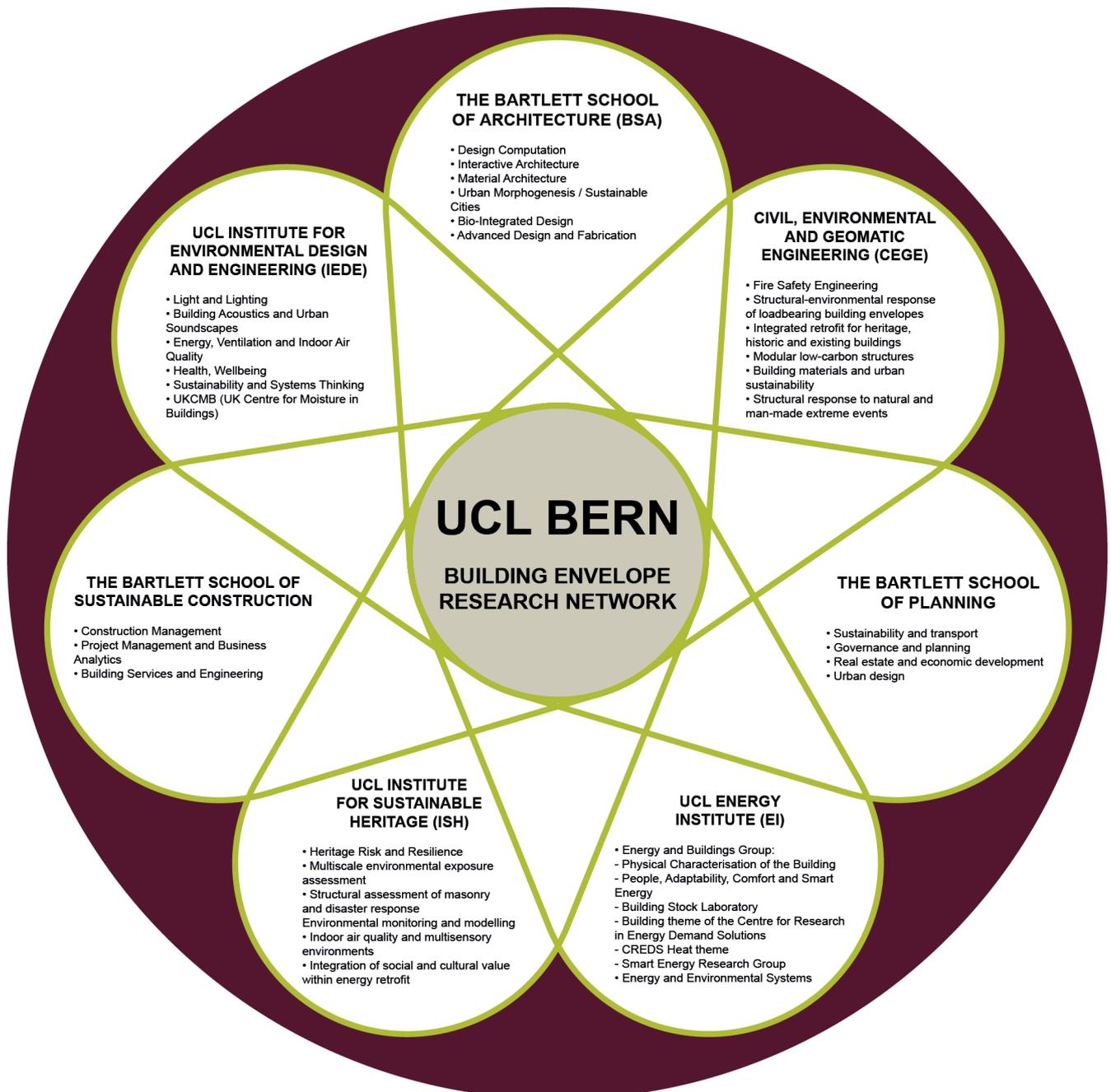


Figure 1: Areas of expertise at UCL BERN

Research at UCL has adopted a systems-thinking and interdisciplinary approach; the group at the Bartlett School of Environment, Energy and Resources has done extensive research on the Unintended Consequences of Decarbonising the Built Environment, addressing the complex issue from an interdisciplinary and systemic perspective (UCL 2022a). Several research projects, aligned with this approach, have focused on the urban scale, e.g., the project on urban sustainability and health (UCL 2022b) and the project on heritage and “deep” cities (CURBATHERI 2022), and at the building scale, e.g., the project on housing, energy and wellbeing (UCL IEDE 2016a); the project on total operational performance of low-carbon buildings (UCL IEDE 2016b); and the IEA Task 59 / Annex 76 on the low carbon retrofit of historic buildings (IEA 2022b). This world-leading expertise on systems thinking and interdisciplinary research across the UCL community, combined with diverse disciplinary excellence, can now be applied towards solving the complex issues around the delivery and performance of the building envelope.

The UCL BERN knowledge map

To achieve its purpose, UCL BERN proposes to map:

- the key stakeholders relating to the wider building envelope system
- existing research, knowledge, and data across various parts of that system

This will help to identify

- specific gaps in research/ knowledge/ data within the scope of the building envelope,
- socio-technical barriers that are preventing the industry from achieving the purpose identified above, and
- potential areas for systemic change across various actors within the building life cycle.

Ultimately, this exercise will allow UCL BERN to develop and promote responses to enable the industry to overcome the barriers identified.

It is envisaged that this mapping exercise will consider three dimensions, as in Figure 2. The first dimension of the map would be the **stakeholders**, involved in different stages of the building life cycle, from design and assessment to construction, use, and renovation or demolition. The second dimension would be the building envelope **domains**, and the interplay between the different factors when dealing with the building envelope (i.e., context and local drivers, environmental sustainability and global drivers, people, the internal environment, the external environment, building services and the building envelope itself).

The third dimension would be the **building sectors**, which might otherwise be thought of as building typologies related to use (e.g., Social housing, Private rental, Owner occupiers, Healthcare, Schools, Universities, Cultural, Offices, Retail).

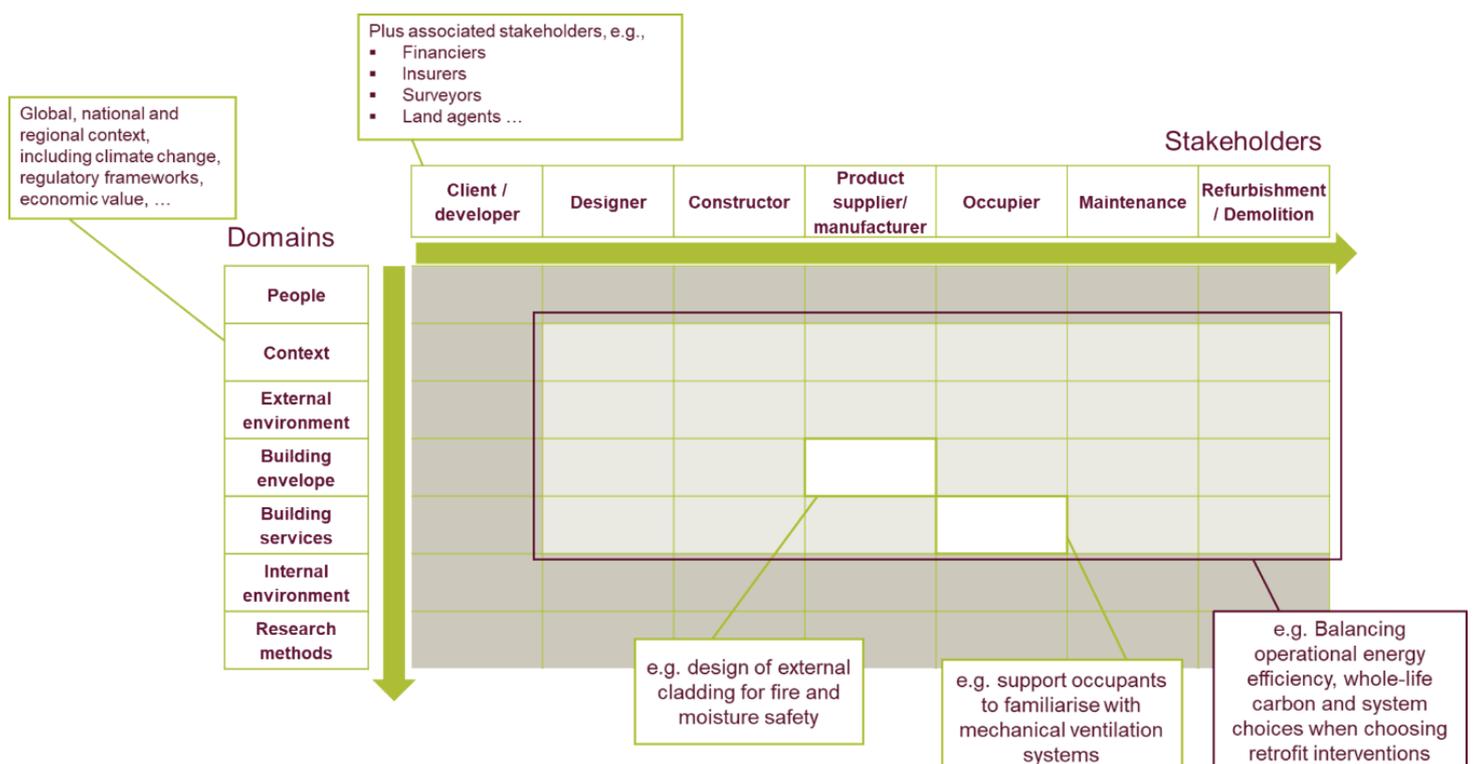


Figure 2: Dimensions of the knowledge map. The map presents a non-exhaustive list of stakeholders and domains, and examples of knowledge gaps and cross-sectional issues.

There will inevitably be synergies and approaches that can be translated across experience within two or more sectors. Other sectors are inherently cross-cutting of these sectors, such as heritage, requiring an appreciation of their distinct considerations within the context of research that informs the design, evaluation, and consideration of the building envelope. A research network such as UCL BERN can provide opportunities to explore these synergies.

Knowledge map: current gaps on building envelopes

Some of the current gaps in the knowledge of the building envelope identified in the second UCL BERN workshop are summarised in the diagram in Figure 3.

The diagram shows that there are some technical issues which are yet to be solved. These are usually those that require an interdisciplinary approach. For example, it is unclear whether cladding systems are safe or not, and who bears the responsibility in case of failure. Overall, the reliance of material decision-making processes on regulation requirements for isolated cladding elements creates configurations of unknown performance: the unique configuration of the combined products (assembly) needs to be assessed, since it is the assembly's performance that matters. Because of these unknowns, there is a current ban on combustible materials on high-rise buildings, reflecting a lack of trust in the industry on the part of the Government. An interdisciplinary approach is needed to balance fire safety not only with emissions reduction, but also with other wider issues such as health, comfort and durability, towards the development of a circular economy for buildings. To enable this, material and system properties are needed for the evaluation of risks to structural and material integrity

of the building envelope, as well as the estimation of embodied and operational carbon throughout the life cycle of the building envelope. This data, combined with tools, methodologies, and rules of thumb, can help improving the assessment and design of the building envelope.

Across the construction process, design and build of cladding, value engineering and cost cutting, lack of design and installer qualifications were all identified as problems leading to fire safety issues. Moreover, until recently (in the aftermath of the Grenfell Tower fire), the move to outcome-based regulations was made without the necessary attention to competence building or adequate funding to overcome the current challenges in procurement, undermining trust in the industry.

Finally, an interdisciplinary approach is needed to address complex areas such as residential and non-domestic retrofit at scale, moving Government-thinking towards an integrated approach to retrofit and supporting occupants in relation to the design and operation of buildings.

It is important to understand current attitudes and perspectives towards retrofit and sustainable buildings, with the view of fostering change towards a low carbon-built environment by engaging with multiple drivers and supporting occupants in their relationship with buildings. Professionals in the building industry must explain and manage the complexity from occupant-facing elements, and mechanisms to provide independent and accurate advice and guidance are needed. Smart building services, for example, can allow better flexibility in principle, but can be too complex to operate and take control away from occupants.

Finally, we need to support occupants to familiarise themselves with the impact of building practices (e.g., ventilation, window opening) on the indoor environmental quality and the long-term performance of their buildings.

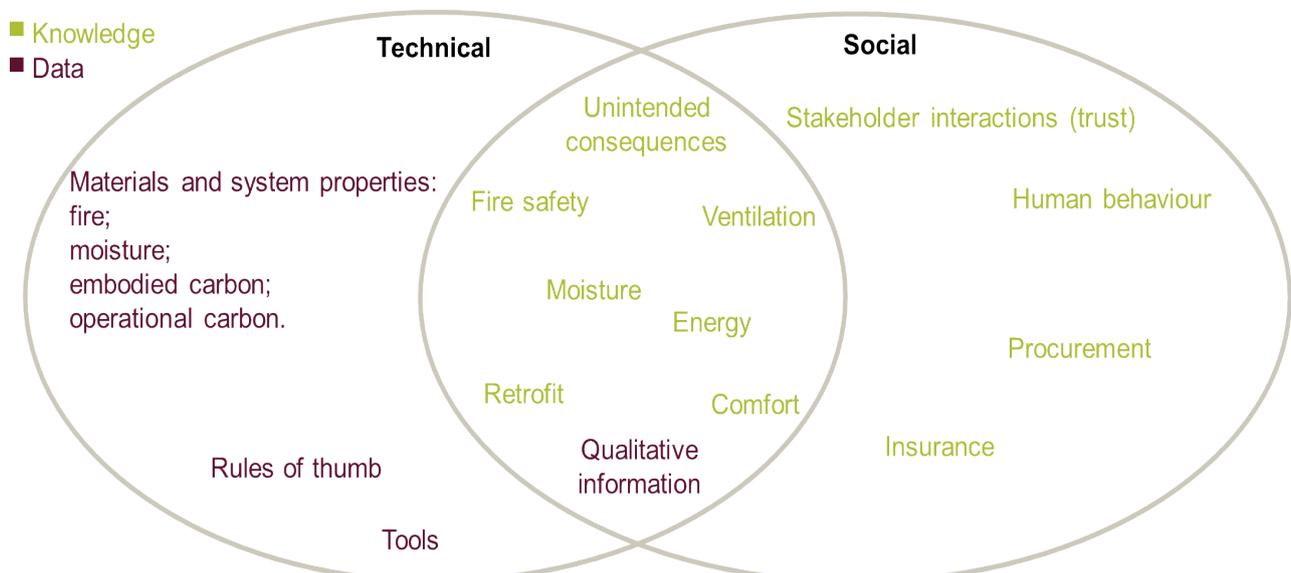


Figure 3: Knowledge and data gaps on the building envelope performance

Addressing these issues from an interdisciplinary perspective

The interdisciplinary perspective that UCL BERN offers can lead to a sustainable building envelope that provide a healthy, safe and inspiring environment for occupants, while meeting the requirements of a net-zero carbon society and adapting to a changing climate.

The research expertise at UCL BERN can support the construction industry in:

- Finding mechanisms to bring low-carbon systems to market, leveraging the circular economy, improving procurement processes, and enabling the provision of insurance;
- Identifying optimal solutions across disciplines, e.g., balancing carbon, comfort, safety, health, and adaptability;
- Supporting occupants and consumers for a change towards a low-carbon built environment;
- Delivering successful outcome-based policies, moving away from single-focused policies, and rebuilding trust in the industry.

We do this by coordinating and disseminating research, knowledge exchange and education to support the design and construction of buildings that embed a safe integrated approach and building envelope sustainability principles into the construction sector. We also support the development of appropriate Government policy for the sector.

“UCL BERN might be (a once in a generation) opportunity to form a network that promotes bunker busting, and act as a think tank and multi-disciplinary solution provider to everything that finds itself within the domestic and commercial building tent.

By multi-disciplinary I mean from academic and researcher to legislator, builder, developer, regulator, product supplier, architect, theoretical scientist, and climatologist - who form an end-to-end resource that can work together to consider a challenge and deliver a solution that anticipates and eliminates unintended consequence, rather than feed them.”

Steve Hodgson

Chief Executive, Property Care Association

UCL BERN Stakeholder Engagement Workshop participant



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(All links last accessed 02/03/2022)

Acknowledgements

In January 2022, UCL BERN hosted two high-level stakeholder engagement workshops designed to further UCL BERN's external engagement ambition - to coordinate UCL's extensive technical knowledge of the building envelope into a coherent and comprehensive research programme, in collaboration with building envelope external stakeholders from industry, Government and academia.

Maria Cotera, UCL BERN Engagement Manager, and **Dr Ann Thorpe**, Senior Partnerships Manager (Advanced Urban Systems) at UCL Innovation & Enterprise and UCL BERN Steering Group Member, supported by **Dr Anna Parkin**, Innovation Development Manager at UCL Innovation & Enterprise, led the organisation of the workshops, designed to:

- Engage with a range of influential stakeholders to collect diverse views from industry, academia, government, and the professions that would help set research agendas.
- Identify where UCL BERN can add value to the wider building envelope community.
- Identify activities that UCL BERN should prioritise, utilising UCL's expertise to address technical and social challenges and generate positive impact.
- Explore ways to categorise and map knowledge of the building envelope and identify current research gaps.

Prof. Jose Torero Cullen, Professor, Civil Engineering and Head of UCL Department of Civil, Environmental and Geomatic Engineering and UCL BERN Steering Group Member was the leading workshop host, supported by five UCL BERN co-hosts. Twenty-one high-level external stakeholders from the building envelope communities also participated.

The discussion outcomes from both workshops have been turned into this briefing on key issues surrounding the building envelope, with the generous financial support from the UK Centre for Moisture in Buildings (UKCMB).

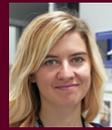
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Our mission is to enable, connect, engage and inspire people living and working in all types of buildings; in particular, those working on improvements to the building envelope.

www.ucl.ac.uk/building-envelope-research

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