Institution: Leeds Beckett University

Unit of Assessment: Architecture, Built Environment and Planning

1. Unit context and structure, research and impact strategy

Context and structure

Research in unit 13 stretches across a range of disciplinary areas related to the built environment. This research includes work on building performance and energy, civil engineering (materials and water), spatial and neighbourhood planning, women in the built environment, construction informatics and digital research and architectural history. Our objective through this work **is to pursue high-quality built environment-related research that contributes to the creation and management of more sustainable built environments**. Our research is also linked closely to industry through industrial and professional partnerships and activities. The unit aims to: (a) **build a record of research that is focused on the technological and social aspects of sustainable urbanism;** and (b) **pursue research excellence and research impact across the unit's research areas.**

The unit's submitted staff are drawn from the **School of Built Environment, Engineering and Computing (**Surveying, Construction and Project Management 9 staff; Engineering 4 staff; Planning, Housing and Human Geography 8 staff) and the **Leeds School of Arts** (Architecture and Landscape Architecture 6 staff). The unit incorporates the **Leeds Sustainability Institute** (LSI, 8 staff), established in 2012 (under the directorship of (**Gorse**).

Since REF2014 the unit has maintained an upward trajectory of research development. For REF2014, the unit returned 18 FTE, submitted 71 outputs, produced 3 case studies, had 2 doctoral level completions, and generated just under £1.9 million of external research income. For REF2021 we have improved on these indicators. The unit is returning **33.7 FTE (35 headcount), submitting 84 outputs, 3 case studies, has 18 doctoral level completions, and generated external research income of c£3.4 million**.

Building on our REF2014 submission we have further enhanced our research environment and community through:

- Creating a strong **interdisciplinary community of staff and students**, which includes social scientists, psychologists, building physicists, statisticians, and construction professionals.

- Growing success in securing significant research funding from major funders including: **The Engineering and Physical Sciences Research Council (EPSRC); the Economic and Research Council (ESRC)**, **Innovate UK; the British Academy; Department for Business, Energy, and Industrial Strategy (BEIS); Department for Communities and Local Government (CLG); and the European Union.**

- Conducting high quality research that is directly relevant to, and has impact on, practice (for example, our work with the **Construction Industry Training Board**) and policy, such as our work on energy performance with the **Department of Energy and Climate Change (DECC), Department for Business, Energy, and Industrial Strategy (BEIS)** and the **International Energy Authority (IEA)**.

- Developing effective national and international research collaborations with organisations such as the **Department for Business, Energy, and Industrial Strategy (BEIS), Historic England, Friends of the Earth, the International Energy Agency and the United Nations**.

- Providing a **vibrant and dynamic research culture** through continued success in developing and retaining talented research students and researchers.

- Establishing a Director of Research post leading research in the unit, as well as creating research fora such as the Professors and Readers group and School-based research committees (BEEC and LSA).

Research strategy
Our research strategy has prioritised high quality and impactful research that produces pure and applied knowledge contributing to the creation and management of more sustainable built environments. Post 2014 we reviewed our strategy to help sharpen **our focus on the technological and social dimensions of urban sustainability**. Our approach to developing strategy was collaborative and established through consultation with the unit's Professors and Readers group, the research committees of BECC and LSA and with unit staff, through **School away days** and individual research meetings. Our strategy and performance are subject to annual scrutiny and review through **School Accountability meetings** with University senior management.

In 2017 the University strategically appointed Directors of Research in each REF unit to lead the growth and sustainability of our research environment. This change saw the Directors of Research work closely with newly appointed Deans of School, Heads of Subject and Directors of Research Centres to ensure that all academic staff are aligned with, and contribute to, our collective research excellence & academic enterprise. The Director of Research (**Strange**) role is key here, establishing a link between the unit and the DVC Research, as well as providing strategic research leadership and a research management position to guide and oversee the direction of the unit's work.

Our research strategy has been focused on the following aims:

- To **maintain and develop a team of high-quality research active staff** whose outputs and impact is transmitted to our research partners, users, and beneficiaries.

- **To strengthen and improve the quality** of the research outputs of individual staff members.

- **To further develop the value (financial and academic) and range of external research income**, with clear plans for dissemination of research projects and their impacts.

- **To establish a strong 'community of researchers' and vibrant research environment**. This includes members of academic staff, but also growing our numbers of research students who contribute to the development of our unit's research and research culture.

Achieving our strategic aims

- **Appointing highly qualified research leaders**. All new academic appointments are now made related to the research profile and ability of applicants to integrate within the research strategy of the Unit. Since 2014, we have appointed 4 Professors (2 of which, **Akintoye, Dulaimi,** were external appointments) and 8 Readers (**Ajay, Ahmed, Fylan, Glew, Oyegoke, Parker, Swan, Zulu)**.

- **Valuing the research contribution of existing staff** is recognised and demonstrated through the annual internal promotion round to a Professorial Chair or Readership. Of the Professors and Readers appointed since 2014, 1 Professor (**Paul**) and 8 Readers (**Ajay, Ahmed, Fylan, Glew, Oyegoke, Parker, Swan, Zulu**) came through this route.

- **Creating opportunities for staff to apply for University QR research funding** annually. The unit receives funding of approximately £150,000 per year in QR monies. This investment is agreed against a plan of expenditure on the unit's research objectives and plans. It has supported conference attendance, research networking events, seminar/symposium events, research group funding, research leave awards and research impact development.

- **Reviewing bids for external income**. In line with university policy, all draft bids are internally reviewed by senior research staff within and beyond the unit before submission is approved. **We have increased R&E income to c£3.3m** and we are now competing for and winning more grants from diverse funding agencies, including research councils, government departments and other high-profile research funders.

- **Expanding our postgraduate research student community (primarily at PhD level) and the introduction of a Professional Doctorate Programme**. The unit has increased its number of PGR students to 72. There have been 18 Doctoral completions between 2014-20 (traditional route PhDs). A smaller number of doctorates have also been awarded by existing published works for staff. In 2019 the School established a series of Professional Doctorates in the Built Environment. These professional doctorates expanded existing provision within the School, such as the DEng programme. The professional doctorates widen the range of available professional and practice-based research opportunities for study within the School, focusing on key areas of staff research expertise. In addition to the DEng, there are professional doctorates in Built Environment, Construction Law and Dispute Resolution, Planning and Housing, Civil Engineering and Project Management.

- **Establishing clear lines of access to internal support for research funding**. Staff have been able to request funding for research support (conferences, APCs, research leave, research related equipment), strategic areas of research have received investment and our PGR community and provision has grown.

- **Enabling the development of staff research agendas** via annual Personal Development Review (PDR) meetings (staff appraisal). These include research objectives that align with the unit's strategy, identify support needs, and that are realistic (see Section 2).

- **Ensuring research time and deployment allocation for research active staff**. All staff identified as research independent and with significant responsibility for research have a minimum of 20% of their workload allocated for research. The research activities associated with this deployment are agreed through PDR and deployment process.

Impact strategy

Our institutional research strategy sets a context for the unit's work and research impact. The university's mission as a 'civic university' is concerned with reaching different publics and engaging our local, national, and international communities. Its research strategy engages with the 'grand challenges' facing us in terms of the sustainability of our society and its economic, community, political and physical structures. The unit's research is at the heart of this strategy, reflecting its significance and importance for the institution and making a positive impact on the built environment through technological and social interventions towards more sustainable places and spaces. We have three major principles for achieving impact form our research (1) promoting collaborative research with diverse stakeholders and encompassing dissemination events with users; (2) presenting our research at conference and events aimed at practitioners and end users; and (3) utilising print, broadcast, and social media to engage with our stakeholders and others about our research.

The unit's research is producing significant research-driven impacts on the built environment that cuts across economic, social, policy and cultural domains. For example, our work continues to

focus on bringing quality of life benefits to many by improving the quality of basic drinking water in the global South. In 2015 our water research on improving water quality in Malawi was awarded **first prize at the UK Research Councils Water Research Impact Awards 2015 – Process Technologies**. Equally, our engagement with industry is well developed through work with major utility and construction companies such **Balfour Beatty, ASDA, and Earthsense Systems** for example. Our research is also contributing to better informed public policy making and evaluation, for example through providing evaluation studies of university Economic and Social Research Council research centres (**Strange)** and the **Technology Strategy Board Future Cities Demonstrator Programme** project (**Strange**); spatial plan analysis and neighbourhood planning (**Bradley);** and participation in high level national policy groups (for example those established by the Technology Strategy Board, Innovate UK, DECC and BEIS) (**Glew, Gorse, Johnston**).

Our commitment to having research impact that improves the sustainability of built environments flows through our work and through each of the **impact case studies**. The case studies highlight this impact, showcasing not only the range of work contained in the unit, but also its excellence. The case studies also demonstrate the differential scale and reach of our research and its impact, while underscoring the longevity of the unit's research. For example, the underpinning research for the case study on **Increasing energy efficiency and reducing the performance gap in buildings** stretches back to the late 1990s. Research from this case study directly led to Building Regulations changes to reduce heat loss from homes. These changes have saved 5 million tons of CO_2 and resulted in lower fuel bills for hundreds of thousands of new build homes worth over £100 million pounds during this REF period. The "co-heating" research method developed by staff in the building performance group has been adopted as the de-facto approach to understand the true energy efficiency of buildings.

The research supporting the work in the case study on **Sustainable development of water quality infrastructure and operational reliability of rural community water points in developing countries** extends back to 2005. Multidisciplinary research work conducted by LBU, and partner organisations, has helped improve the water supplies for rural people in southern Malawi, and has led to the establishment of the country's first postgraduate course on water management. Graduates are now working in-country on water improvement projects as well as the development of new policy to promote and implement good practice.

The case study on **Neighbourhood and community planning** highlights research at national and local scale and is a clear response to policy changes within the planning system since 2012. With its concentration on civic and public engagement in the betterment of urban neighbourhoods and communities, the research of this case study has focused on increasing the capacity of neighbourhood groups in England to change statutory planning policy, enabling them to input into the renewal of the neighbourhoods in which they live. The research has brought about a four-fold increase in the percentage of urban neighbourhoods participating in statutory planning policy and changed planning policy decisions, empowering urban communities across the north of England to plan and create safer and greener environments and to build a strong sense of place.

Future direction and strategic approach

Our future strategic research aims will cultivate and grow further those we have been pursuing through the current REF period. Specifically, our aims for the next REF cycle are:

- To recruit research leaders that can contribute to and strengthen our research.
- To build on our growing success and reputation in income generation from academic, government and industry funders.
- To maintain our record of publishing in high-ranking academic journals and producing outputs that progress academic debate and inform and develop policy.
- To preserve and sustain our vibrant community of researchers by providing a well-resourced and institutionally supported research environment.

- To use our internal investment strategy (through strategic use of QR) to provide a strong platform for existing and emerging areas of research.
- To embed pathways to impact and impact as a key driver of all research.

Our research focus will be on activity that offers technological and social solutions to the problems and challenges of urban sustainability. While we are mindful of sustaining the international reach and impact of our work, particularly in relation to the challenges of water purity and energy production and access in developing countries, we will also continue to push forward on research that impacts on, and influences UK policy, in relation to the sustainable performance of buildings. Equally our research on planning for better and more socially cohesive local communities will remain a core part of our engagement with local communities and which contributes to our wider civic and local role. Finally, while our work on gender and the built environment/women in planning and construction informatics has emerged during this REF period, we see these as growth areas with potential to make significant contributions to our research culture and to policy debates and action for more diverse and inclusive places and more digitally informed construction. In sum, we will align our work to the 'grand challenges' that face our built environments, nurturing mutually productive links with industry and local communities as we expand our contribution to practice, policy, the academy and our communities.

2. People

Staffing Strategy

Staff are our key resource and are at the heart of our research activities and strategy to create a thriving research community. This staff-centred approach is recognised and encouraged by the Schools' and University's commitment to promoting research and is reflected in LBU's policy and practice for staff recruitment, staff development and support.

The University's staffing strategy is concerned with enabling all colleagues to achieve the best they can for themselves and for our university. In addition to the University's *People Strategy*, at local level the unit provides a supportive and stimulating environment within which academic staff can develop their research interests and capabilities. Our unit is committed to the principles of equality, diversity, and social justice. Our success and competitiveness rests upon our ability to draw from the broadest population of researchers to conduct research that makes a significant contribution to society. We expect our researchers and partners to demonstrate that equality, diversity, and inclusion are embedded in their everyday business and practice. Our unit aims to:

- Be consistent and transparent in our strategy for excellent research and evidencing good practice using Leeds Beckett Equality benchmarks, such as the Race Equality Charter Mark, Athena Swan, Stonewall Index, REF, TEF and other equality standards.
- Lead a sustainable culture change in relation to equality and diversity especially in underrepresented and under-served areas.
- Optimise the potential of our researchers by recruiting, retaining, developing, and promoting from the most diverse possible demographic.

Unit Staffing

The unit has 7 Professors (**Akintoye – Dean of BECC** -, **Dulaimi, Gorse, Johnston, Paul, Simson and Strange**), 1 emeritus Professor (**Bell**), and 9 Readers (**Ahmed, Ajay, Glew, Fylan, Oyegoke, Parker, Pritchard, Swan and Zulu**). The remaining unit staff are senior lecturers and those at an earlier stage of their research careers. The recruitment and promotion of excellent research staff is key to the success and sustainability of the unit and its research aims. Indeed, in the hiring of new appointments, the candidates' potential to contribute to our aims with a successful research trajectory is considered an essential criterion. The Director of Research (**Strange**) or another Professor, participates in all recruitment panels to ensure that we attract excellent researchers and/or those with significant research potential. Recruitment strategy and

decision-making on appointments are undertaken locally with consultation and support from Dean(s) of School.

Over the REF period, the unit has strengthened its research leadership with the internal promotion of (**Paul, Simson**) to Professorships, the appointment of 2 external Professors (**Akintoye, Dulaimi**) and the internal promotion to Readerships (**Ahmed, Ajay, Glew, Oyegoke, Fylan, Parker, Swan** and **Zulu**). Our strategy over this REF period has been to grow the complement of FTE staff in our areas of research strength. Since 2014 the staff base of the unit has grown. We have appointed staff in construction and surveying, in engineering, in planning, and research assistant posts for externally funded projects. These appointments have been made with the intention of increasing our research capacity for future research strength at the intersections of the technical and social dimension of built environment research and education. Strategic investment in staffing associated with construction and engineering reflects our aim to support these key areas of our activity and to further develop our reputation in STEM related aspects of built environment research. In academic years 19/20 and 20/21 we invested over £100,000 in strategic QR investment into STEM research in the unit (see Section 3) and this is planned to continue as we strengthen and develop our STEM related activity.

Staff development

Our approach to staff development is to facilitate, enable and support research such that individual staff research aspirations can be met and which in turn support and help achieve the research aims of the unit. One key area of research support is through annual quality research (QR) funding. The unit receives funding of approximately £150,000 per year in QR monies. Since 2019 the unit has also received an additional allocation of £100,000 per year from a University-wide strategic allocation fund. This has enabled the unit to develop key areas of work that brings together staff within the unit on STEM focused research, for example work on urban heat islands in Leeds undertaken by staff in the LSI and in the Planning, Housing and Human Geography subject group, or the match funding of two PhD studentships with YORhub and staff in the Construction group. Indeed, internal investment in research (in addition to our growing external research income) is an important contributor to improving our research structures, facilities and equipment, our research profile, our reputation, and the development of our staff.

Opportunities are offered for staff to apply for funding available through the unit. Indicatively this has included:

- Research and Enterprise Services offered research cluster, early-career, and mid-career funding opportunities in the early part of this REF cycle. The following unit staff were awarded funding from these schemes (**Bradley, Glew, Parker, Swan).**

- The unit offers funding for research leave. The following staff have benefitted from this funding: **Swan** (FP7 AGUASOCIAL project and REF case study), **Hope** (Tomorrow's Cities UK Research and Innovation (UKRI) Global Challenges Research Fund (GCRF) Urban Disaster Risk Hub programme), **Bradley** (Neighbourhood planning REF case study), **Edwards** (Women in the built environment) and **Horwood** (Women in Planning Network).

- The unit has an internal research funding process for the development of research, with the objective of supporting and developing both existing and emerging areas of research.

Our approach to staff development is underpinned by mentoring, research partnering, team working and inter-institutional collaborations. All staff participate as necessary in the University's staff development programme and research training support offered by Research and Enterprise Services. Equal support is also given to research officers and research fellows as well as to academic staff, and this has allowed several research fellows to continue their education to doctoral level whilst working on research projects and producing outputs (**Fletcher, Brooke-Peat**). Research Mentoring is available to all colleagues according to need, whether they are early-career academics, or whether they are mid-career or senior researchers. This process is

managed by the Professors and Reader across the unit and is available either as a request from an individual, or as a targeted action arising from a PDR meeting.

All members of staff have an annual PDR meeting with their line manager where clear and achievable research objectives are set and embedded into the forthcoming years' work activity. These reviews provide the basis for monitoring progress and identifying individual support needs, for example, the allocation of research time, conference attendance, and/or research training requirements. The PDR is therefore not only an important opportunity to support the professional and personal development of staff, but also a key mechanism for monitoring the effective use of research time and outputs. Linked to the annual deployment round, which makes research a core part of academic workloads, time spent on research articulated through the PDR process is thus clear and accountable. All staff identified as research independent and with significant responsibility for research have a minimum of 20% of their workload allocated for research.

Equality and diversity

LBU is a Disability Positive employer, holds institutional Athena Swan accreditation, has received Stonewall Top 100 employer status, and is a member of the pilot group of universities for the Race Equality Charter Mark. Both BEEC and LSA is fully committed to the University's protocols on equality and diversity viewing them as essential to a progressive and empowered research environment. We monitor equality and diversity through the School's Equality and Diversity committee. Both BEEC and LSA are seeking Athena Swan accreditation. This work is led by **(Edwards)** in BEEC and **(Schiffer)** in LSA. The unit's gender balance 7 females and 28 males (headcount). Of the senior staff, one reader is female. Ten colleagues identify as Asian/Asian British or Black/Black British, while the remaining staff are of White ethnicity.

To determine our REF submission, a panel comprising the Director of Research, 3 Professors and a Senior Lecturer, internally assessed staff's research independence. Our **Code of Practice** (CoP) emphasises transparency, consistency, accountability, and inclusivity as its core principles. In-line with this, our CoP was shared with staff through presentations and a Q&A and is available digitally and in print to all staff. The University established an independent Equality panel to consider requests from staff with complex circumstances. An Appeals panel adjudicated any potential appeals resulting from our processes. All staff were invited to submit for research independence, with the unit panel assessing whether staff had a responsibility for research and were independent researchers or were working towards research independence. Demonstrating our commitment to inclusivity, all staff rated 1* - 4* through our internal assessment are included in our submission. There were no appeals in Unit 13.

Postgraduate research community

The unit has experienced considerable success through its industrial, professional and community engagement in attracting students. Sectors previously outside the traditional research arena are increasingly interested in the unit's research agenda. Indeed, part-time research undertaken in collaboration with partners is an important element of our PGR provision. As such, a key objective for the unit is to maintain and enhance its 'community of researchers' and postgraduate students. This includes retaining and recruiting research active staff, but also increasing research student numbers. For REF2014 the unit had 25 enrolled research students. In the current REF period, the unit has increased this number to 72 enrolled research students and there have been 18 Doctoral completions, compared to 2 completions in the previous REF cycle. The unit has also established a Doctorate in Engineering (DEng) programme with 4 cohorts of students enrolled. To build on the success of this programme and to meet a demand for professional doctoral opportunities from a wider range of students, the School established a suite of part-time Built Environment professional doctorates in 2019. In addition to the DEng, there are now professional doctorates in Built Environment, Construction Law and Dispute Resolution, Planning and Housing, Civil Engineering and Project Management. The unit has funded 12 bursaries (full fee waiver) for students from practice or industry on the doctoral programme. We have also used QR allocation strategically to offer five 50/50 matched-funded PhD studentships with industry partners, including Citu Leeds (**Parke**r) YORhub (x2) (**Dulaimi**),

Saint Gobain (**Glew**) and the Property Care Association (**Brooke-Peat**), capitalising on our research relationships with these organisations.

The unit also takes the development of staff without doctorates seriously and funds all staff that do not hold doctoral level awards to undertake a programme of PhD study. All staff PhD students have an allocation of 150 hours in their deployment, which is in addition to their automatic allocation of 155 hours for Research and Scholarly Activity. Staff PhD projects reflect both staff interests and supervisory research expertise. All PhD enrolled staff are expected to publish work as the research develops to help build their research profiles and post-doctoral research development. In some cases, such staff PhD work is building into a substantial body of research that will be ripe for inclusion in future research excellence framework assessments. For example, the PhD work of **Stott** and **Warren** (Architecture) in the pedagogical field of architecture live projects, although not included in this submission, is particularly promising as a future case study demonstrating local community engagement and impact at the neighbourhood development level.

All research students take part in a University Induction programme on the commencement of their programme of study. This is organised and managed by the **Graduate School**. As they progress, students are required to undergo a 'Confirmation of Registration' viva (4 months for FT students and 6 months for PT students) where their research proposals are considered and assessed. Each student also has an annual progression meeting where they are required to formally report on their progress to a panel of academic staff in the School. Research student training is accessed via different routes. In addition to a central programme of events, there is a Research Training Programme (RTP) delivered via the University's Graduate School. Initial training needs are identified as part of the Confirmation of Registration process. Students are alerted to the RTP events from their compulsory Induction onwards, and in consultation with their research supervisor they are also encouraged to identify other relevant training. All full-time research students are provided with a laptop and office space and have access to funding for one conference visit per year during their period of registration. Part-time students receive the same benefits, except for the laptop, on a pro-rata basis. Research students are also encouraged to attend staff research seminars provided by the research groups, as well as participate in the School of Built Environment and Engineering Research Seminar Series. As well as providing a space for research presentations, the seminar series also allows research students to present on methodology and emerging research issues as part of their training. Structured research sessions are also provided for students on the Professional Doctorate Programme, the sessions are also open to other research students associated with unit staff. Student research skills are further developed through a personal research training needs analysis and programme which is available to students via the online student portal. The unit also hosts an annual Postgraduate Research Symposium in May, when students present work to staff and other research students. As well as traditional research presentations, session are provided on key aspects of research student learning, research skills, teaching and career development.

3. Income, infrastructure and facilities

External income

Since 2014 our external income trajectory has developed substantially and grown sustainably. HESA-guided returns for 2014-20 show that our external research income exceeded £3.4m. The funding source of this income is from a diverse range of funders including industry, central government departments, the European Union and charities and UK research funding councils (see Table 1).

Table 1: Research Income 2013-14 – 2019-20

Income Source	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
BEIS Research Councils			£19,000	£179,000	£148,000	£1,000	£18,469
UK-based charities (open competitive process)	£39,000	£48,000					
UK-based charities (other)						£9,000	£22,735
UK central government bodies/local authorities,	£209,000	£141,000	£247,000	£87,000	£80,000	£300,000	£832,120
UK industry, commerce, and public corporations	£127,000	£100,000	£267,000	£68,000	£29,000	£88,000	£27,400
UK other sources				£1,000		£6,000	
EU government bodies	£101,000	£125,000	£59,000	£6,000	£9,000	£5,000	

The range and quality of research projects undertaken since REF 2014 has been substantial and we have undertaken over 50 externally funded research projects. We have a success in securing significant research funding from major funders such as the **European Union, Department for Business, Energy, and Industrial Strategy (BEIS), Department for Communities and Local Government (CLG), Innovate UK, the Economic and Social Research Council, the Engineering and Physical Research Council, and the British Academy**. Much of the work funded through these routes produces research that is directly relevant to, and has impact on, practice, such as our key work on energy performance with the **Department of Energy and Climate Change (DECC), Department for Business, Energy, and Industrial Strategy (BEIS) and the International Energy Authority (IEA**). Some key projects are listed in Table 2 below.

Table 2: Key Projects

Project	Funder	Income received
Leeds Core Cities Green Deal Go Early	Department of Energy & Climate Change	£157,000
DECC Extension Project	Department of Energy & Climate Change	£107,723
Knauf Insulation Energy Performance Challenge	Knauf Insulation	£56,388
Thin Internal Wall Insulation BEIS	Department for Business Energy and Industrial Strategy	£52,000
Demonstration of Energy Efficiency Potential (DEEP)	Department for Business Energy and Industrial Strategy	£981,729

To meet our aim 'to develop the value of external research income' staff are supported by our Research and Enterprise Services (RES). All prospective applications are entered into the University's internal financial management package, REMS (Research and Enterprise Management System). The REMS system ensures that applications are kept centrally in RES. Drafts of applications for externally funded projects pass through an internal peer-review process, providing supportive commentary and evaluation for applicants. This process is administered by RES and led by the Director of Research (**Strange**) with support from Professors and Readers in the unit. RES also offers one-to-one support and advice on applications for funding schemes and calls, as well as regular workshops (often led by unit staff) on topics including Proposal Writing, Research Impact and Benefit, and Networking and Mentoring. Further support includes e-mail briefings through Researcher Connect on new funding opportunities, application 'surgeries' for those at an early stage of preparing applications, and general research funding advice.

Quality Research funding

The unit receives annual Quality Research (QR) funding through a clear process of allocation. The unit is automatically allocated annual QR income based on its performance in REF 2014. The unit receives funding of approximately £150,000 per year in QR monies. This investment is agreed against a plan of expenditure on the unit's research objectives and plans. It supports activities such as conference attendance, research networking events, seminar/symposium support, research group funding, research leave awards and research impact development. Investment such as this is key to the unit's growth, as it allows for local and context dependent decision-making allowing the allocation of funds within the unit that can best support research development of staff and enhance the research environment.

Since 2019 the unit has also been able to bid for strategic QR investment with competitively allocated funds designed to strengthen key areas of the unit's work or support the development of new and innovative areas of research. The unit has secured approximately £200,000 of internal strategic investment, alongside its annual QR funding. The strategic funding has been STEM focused and used to develop work that bridges our energy performance research and planning research, focusing on the impact of urban heat islands in cities and how best to capture and use data associated with the spatial variation in urban heating. This funding has extended research from the project ***Innovate UK Green Urban Infrastructure Assets in Urban Heat Island* (2018-2021)** (**Gorse, Parker, and Simson**) funded under the **Innovate UK – Shanghai-UK Industrial Challenge Programme**. The second area of investment has focused on developing civil engineering research. Here it has supported REF case study development, the purchase of essential computing equipment and proposal/bidding support. The latter has resulted in a successful **Innovate UK collaborative MANTIS** project bid (£86k) with Environmental Monitoring Solutions Ltd.

Impact of QR investment

Since 2014 then, our QR funding has allowed research in unit 13 to continue its growth trajectory. Staff have been able to request funding for research support (conferences, APCs, research leave, research related equipment), strategic areas of research have received investment and our PGR community and provision has grown. QR has supported the unit to achieve the following:

- ***Research and Enterprise Prestige***: increase research income, with approximately £3.3 million of research income since 2014.
- ***Research Intensity***: 33.7 FTE staff to REF with 84 outputs in Unit 13.
- ***Research Environment***: increase the PGR student offer and community, with an increase in FT student numbers and growth in the numbers of students enrolled on the Professional Doctorate.

We will continue to use QR allocation and strategic investment funding to support ongoing research commitments and activity. We also plan to invest QR to:

- **create opportunities** for strategic collaboration funding proposals and projects.
- **support match-funded** studentships.
- establish a **new research impact funding post** for research impact development.
- **support the development** of new areas of research activity.

Infrastructure and facilities
Dedicated research and office space are available for staff based either in Northern Terrace (Built Environment and in Broadcasting Place (Architecture) at our City Campus. Those areas that undertake more technically oriented work (in civil engineering for example) have direct control over a large amount of equipment for scientific field work and testing. This is particularly the case for work in civil engineering which has two specialised laboratory facilities (approx. 550 m^2 of floor space in total).

Research Infrastructure and Governance
Overall responsibility for Research at LBU is under the remit of the Deputy-Vice-Chancellor (DVC) for Research and Enterprise. The DVC is supported by the Director of Research and Enterprise Services who leads the different research-related teams (the Graduate School for PGRs, The Research Service which supports bidding activity and the development of impact, and the Enterprise Service which has oversight of the institution's academic enterprise activity). Directors of Research provide the interface between these central services and the Schools.

The work of the Research and Enterprise Services is the core business of our University's Research and Enterprise Committee, which reports directly to Academic Board, and which also has oversight of the work of the University's Postgraduate Research Degrees Sub-Committee, and the Research Ethics Committee. The Research and Enterprise Committee scrutinises policy, procedure and practice relating to research and makes recommendations to Academic Board for implementation. All Directors of Research are members of this committee, alongside representatives from Research and Enterprise Services, the Library Service, and the PGR student body. The specific policies relating to Ethics, Open Access, Research Concordance, the HR policies that attach to HR Excellence in Research, and the policies deriving from UKCGE for PGRs are debated and defined by this Committee structure.

Ethics infrastructure
All research projects, whether staff or student, must gain ethical approval before they begin. All researchers are required to undertake training in ethics to ensure that they understand their obligations. Research Ethics Online provides a simple one-stop repository for all ethical approvals. Simple approvals for desk-based research which does not involve human subjects are approved locally, by the research supervisor for students, or the Local Research Ethics Co-ordinator (LREC) for staff. More complex cases are considered by LRECs, and where they feel that there are issues of concern that arise from the project, it may be referred to the University Ethics Committee for final decision. Annual audits of research ethics compliance are undertaken to ensure that we are meeting our ethical obligations to all human participants, and to the general ethos of good governance across the whole of our activity. Ethics approvals are also the location of our 'risk assessments' where a given research project may involve risk to the researcher, the participant, or the university.

Open access
The university has a fully searchable open access repository, the Leeds Beckett Repository, which is an online collection of Leeds Beckett research outputs. The Open Access Research Policy can be accessed via our library's information pages. The institutional Open Research Policy, which encourages staff to deposit, where copyright allows, any output type, will increase the volume of other outputs openly available.

4. Collaboration and contribution to the research base, economy and society

Our collaborative approach

A strategic objective is to provide research support to the construction industry and built environment professions, as well as to the academic community and those beyond academia. As a result, a key research aim has been to orientate our work towards the following areas: ***building performance and energy; civil engineering (materials and water); spatial and neighbourhood planning; women in the built environment; and construction informatics***. The unit has placed significant investment into a range of research projects in these areas which have attracted significant industry and professional interest. This is evidenced by the international scope of a significant amount of the work and activities of staff in the unit, as well as our focused project work undertaken for UK central government and UK based industry. The following sections highlight examples of unit staff research activity in working with international, national, and local research partners and collaborators to achieve our strategic aims and objectives.

International collaborative research

The unit has increased its international profile across broad fields of sustainability and energy efficiency with some notable international research impact. For example, **Simson's EMonFUr** project is establishing a monitoring network to assess lowland forest and urban plantations in Lombardy and urban forests in Slovenia (EMoNFUr - A LIFE+ Project. LIFE 10 ENV/IT/000399). In this project (Simson) is working on linking environmental with social aspects in studying and managing urban forests (GreeInUrbs) and working with partners across 37 other countries.

Other aspects of our collaborative work similarly focus on the urban environment and its green assets. For example, our **Innovate UK project on urban heat islands (UHI) (Gorse, Parker) funded as part of the 'Shanghai-UK Industrial Challenge Programme – Future Cities' (with VRM Technologies Ltd, University of Hull and East China Normal University**) focuses on how the use of vegetation, termed Green infrastructure assets (GIAs), offers a potential low-cost strategy for mitigation of UHI impacts to help improve the quality of life for urban citizens. There is limited data available relating to the localised performance of GIAs in UHIs and even less of this type of data is available to the citizens adversely affected. This project is applying a low-cost, flexible methodology that integrates a variety of novel imaging sensors with real-time environmental data to enable quantification of the effects of different GIA layouts. LBU is leading the data analysis and modelling elements of this work, with a focus of UHI characterisation and evaluating high risk areas using big-data analysis and machine learning techniques.

Water research is also providing significant opportunities for collaborative international work. For example, WETS is a University funded interdisciplinary research cluster (**Paul**, **Pritchard, Schiffer, Swan**) drawn from across LBU with a common focus upon water issues within developing regions of the Global South. Members of the cluster are currently engaged in research projects across Africa (Paul, Pritchard, Sawn) and South America (Schiffer, Swan). In terms of funding, members of the cluster received a £30k Research Cluster Development Award; a £10k HEIF Enterprise award; and a £5k Innovate UK award to produce a report on 'Collaborative 'R&D' activities towards a prototype of an adaptable low-cost monitoring tool for water projects in the developing world. Staff (**Schiffer, Swan**) have also been participants in the **FP7 AGUASOCIAL** project. AGUASOCIAL is a 5-partner network between the Universita degli Studi Roma Tre (Italy), LBU, the Universitat Autonoma de Barcelona (Spain), Universidade Federal do Para and the Universidade do Estado do Amazonas Fundao (Brazil), focusing on water quality in the developing South.

Materials research into more sustainable use of highways construction is also underway. Indeed, work on sustainable alternatives to concrete for utilisation in highways application has recently been funded through the Newton Fund (**Ahmed**) to investigate the viability of using agricultural waste derived from rice harvesting (rice husk ash). The project is in collaboration with the highways industry and Sriwijaya University, Indonesia. Following the research findings from the project, successful trials have taken place on the UK motorways network by using the

low carbon high strength concrete (based on rice waste) developed by (**Ahmed**). On completion of additional field testing the findings will feed into the UK Design Manual and Specification for Road Building thus creating global exposure as many countries globally follow this manual.

This international work is complimented by the research of (**Schiffer**) in its exploration of how a human-centered design can help create more sustainable energy futures. Since 2010, her research has been predominately focused on rural Gambia where she employs immersion, mapping, and co-design methods. This has led to insights into energy practices and the culmination of socio-political, socio economic, socio-technical, socio-environmental, and socio-cultural factors that shape it. Recently, Schiffer's research has received funding through **the H2020 SHAPE Energy Research Design Challenge and the British Academy**. Her research has been adapted for a policy ask listed in the *Friends of the Earth International People Power Now Manifesto* which was launched at the December 2018 climate change conference (COP24). It thereby contributes to closing the gap between dominant techno-centric approaches and the lived experience of the everyday.

The unit's research has also begun to focus on post-disaster planning. (**Hope**) is part of **Tomorrow's Cities UK Research and Innovation (UKRI) Global Challenges Research Fund Urban Disaster Risk Hub** programme. International partners include teams in Istanbul, Nairobi, Kathmandu, and Quito. **Hope's** research involves working with the humanitarian agency Concern Worldwide to develop an aftershock forecasting tool to inform humanitarian emergency planning and response. Rapid community response to aftershocks is crucial to prevent subsequent loss of life in earthquake-stricken areas. Yet local response can be delayed or inhibited by social, cultural, and political factors. To enable local populations to collect data and respond effectively to actionable forecasts the research is identifying the specific cultural, social, and political factors that impede communication between the different communities of practice, distort risk perception and reduce information and technological uptake post disaster.

As well as these specific examples, unit staff have established research connections and partnerships with institutions such as the Ecole des Ponts et Chaussees, Paris (**Gorse**); Central University of Technology – South Africa (**Ahmed**); The University of Malawi, The Polytechnic (**Pritchard**); Stellenbosch University – South Africa; Southern University Utah USA; and the National University in Singapore on the development of an Environmental Rating System for Assessing Infrastructure Projects in the Middle East **(Dulaimi**). Through the International Energy Agency, (**Gorse, Johnston, Parker**) are taking a lead on Annex subtasks and international standards (IEA EXCCS Annex 58 - Full Scale Building Energy Characterisation, IEA EXCCS Annex 67 Energy Flexibility and a new working with a CEN Technical Committee 89, working group 13 to develop a new CEN standard for whole building testing).

National policy and industry research collaboration

Building Performance

Research on building performance in the LSI has significantly developed over this REF period. For example, major contracts have been undertaken with Technology Strategy Board (Innovate UK), BRE, Joseph Rowntree Foundation and the Zero Carbon Hub. The research is also collaborative with staff working with global companies, such as Knauf Insulation and Saint Gobain, advancing the performance of building material and test methods. The knowledge gained from Passivehaus field trials, the TSB Gentoo, and Lancaster Cohousing projects, has similarly advanced understanding of buildings capable of meeting net zero carbon standards. Work has also been undertaken in Northern Ireland through the Innovate UK 'Simpler' project, exploring the thermal upgrade project in collaboration with technology providers Tensor Systems, VRM Technology and the Building Research Establishment.

Researchers in the unit continue to have a significant impact in the field of Building Performance, advising government **(DECC, CLG**) and informing Building Regulations. For example, (**Glew**) secured a secondment with DECC, working 2 days per week from 2015 to 2017. This work was extended by **BEIS** between 2017-2019, with (**Glew**) working on the project ***Measuring Energy***

Performance Improvements in Dwellings Using Thin Internal Wall Insulation. Building performance research continues to deliver energy saving measures and identify heat loss mechanisms that were previously unrecognised (see impact case study). Staff in this group have also secured other significant projects with BIES, for example the ***Smart Meter Enabled Thermal Efficiency Ratings (SMETER) Technical Assessment Contractor (TAC)*** (2018-20) project with partners in the University of Loughborough and University College London. Researchers have also been involved in **BEIS** funded work on ***Party Wall investigation: Measuring U-values in-use and validation through whole building analysis***. Working with colleagues at Cambridge Energy and Bridgewater Surveys, our role here has been on the evaluation of the potential energy savings from insulating cavity party walls.

In 2019 the LSI was chosen as lead partner for a £2.7 million project funded by **the Department for Business, Energy, and Industrial Strategy (BEIS)**. The ***Demonstration of Energy Efficiency Potential*** **(DEEP)** project is one of the largest single retrofit projects to have ever been attempted in the UK. The results on risk and performance will guide future retrofit policy, specifically around the accuracy of existing assumptions used in government carbon modelling and forecasting, as well as highlighting the benefits of whole house retrofits compared to piece meal retrofits (in terms of reducing carbon emissions and reducing the risk of moisture problems in homes). The project is undertaking 30 retrofits in homes across the North of England to measure the improvements in energy efficiency that are achieved. Building performance evaluation (BPE) field trials (including the Leeds Beckett Co-heating Test and novel assessment methods such as the QUB and Pulse testing equipment) will be used to measure and explore how single measure and whole house retrofit impact homes.

Construction Informatics and Digital Research
Research related to construction informatics is developing considerably. Our activity here focuses on the investigation, design, development, deployment and use of digital technologies and solutions such as BIM, digital twin, big data analytics, IoT and Machine Learning, among others, to address various issues affecting productivity, sustainability and/or efficiency in the AEC industry. We are currently working with a range of industry **(Balfour Beatty Construction Plc, White Frog Publishing Ltd, Earthsense Systems Ltd**) and academic partners (Hertfordshire University) on two **Innovate UK** funded projects ***Big Data and Machine Learning-enabled Automated BIM for Projects (Auto-BIM): A Common Data Collaborative System for Improved Project Performance*** **(Ajay)** ***and Live Visualization of Emission - Towards Avoidance of Pollution Hotspot (LiVE-TAP)*** **(Ajay)**. Both projects take forward our construction informatics work in their application of digital technologies in construction with a specific focus on Building Information Modelling (BIM) and digital twins, the built environment as an enabler of healthy living, and the development of the Smart City.

Engaging with communities - Neighbourhood Planning, Gender and Place
Neighbourhood planning is a key aspect of the unit's research. For example, (**Bradley's)** work that has helped to establish a support network around the 35 neighbourhood planning groups in Leeds, including the development of a programme of workshops and seminars since 2015. This assistance has helped correct some of the inequalities in the take-up of neighbourhood planning and has meant that Leeds now has the highest number of deprived communities participating in neighbourhood plans of any metropolitan borough outside London. In 2017 the neighbourhood planning research cluster held three public events, and its conference Neighbourhood Planning in One City (May 2017) was featured in a case study published by **RTPI Planning Aid England.** The latest project for the cluster is research into the Save Greater Manchester Green Belt campaign, a movement of 60 local groups set up to influence the Combined Authority's Greater Manchester Spatial Framework. The research aims to investigate how local groups network to mirror the spatial constructions of governance and particularly to analyse how local issues of place attachment translate across scale and networks to become universal concepts of environmental protection.

Our heritage focused work (**Edwards, Strange**) has direct connections with policy and practice. Working with colleagues in the School of Cultural Studies and Humanities at LBU, unit staff

(**Edwards, Strange**) were CO-PIs on an **Historic England funded project on LGBTQ heritage, *Pride of Place* (2015**). Pride of Place was designed to be an innovative project that connected LGBTQ history to the built environment and landscape, focusing on public engagement and providing Historic England and the wider heritage sector with on-line knowledge and the methodological tools for the continuing development of LGBTQ heritage. The project's key objectives were to show that LGBT heritage is a fundamental part of our national heritage and to improve knowledge of, and access to, this history. The project explored the relationship between lesbian, gay, bisexual, and transgender (LGBT) history and the country's buildings and spaces.

The unit's research on *women and the built environment* (**Edwards, Horwood**) brings to the fore our focus on diversity in the built environment. This work has brought together women and men across the University who share research interests related to the themes of women and built space (buildings and the broader built environment), thinking about women as designers / planners / builders, and looking at spaces inhabited by women, designed for them, and adopted by them, both the occasional and the everyday. The primary focus on 'women' rather than 'gender' is important in addressing contemporary societal concerns, for example the Gender Pay Gap and #MeToo campaign, and the university sector's efforts to address gender inequality. This focus on gender also speaks to the compelling case for researchers within built environment subject areas to turn their attention to women, as part of an overdue and concerted effort to address significant underrepresentation and inequalities in most of the built environment professions. Despite some important beginnings, women and the issue of gender are significantly under-researched in built-environment studies. The focus on women additionally reflects a strong thread of feminist perspectives and methodologies running through the research and responds to the distinctiveness of women's historical and contemporary relationship with built space.

Building on this work the unit hosted the **Women and Planning Conference** in May 2019 (**Horwood**). The themes of the conference included the histories of women and planning, and the current activities of women in planning including examples drawn from practice. Contributors from academia included Prof Clara Greed, Prof Marion Roberts, and Dr Janice Morphet, alongside practice-based perspectives from Charlotte Morphet MRTPI (Co-founder of Women in Planning) and Natalya Palit MRTPI (winner of the RTPI 2019 George Pepler International Research Fund). The conference also led to the launch of the Women and Planning Research Group (WaPRG). **Horwood** is editing a special edition of ***Town Planning Review*** which will feature papers from the conference.

Discipline engagement and contributions to practice

Staff act regularly as **expert peer reviewers** for research funders. These include the ESRC **(Strange)**; Swiss National Science Foundation **(Strange)**, the EPSRC **(Akintoye, Glew, Gorse)**, the British Council Newton Fund **(Pritchard)**; the Norwegian Research Council **(Ajay)**; and UKRI Future Leaders Programme (**Ajay)**. They also provide guidance and advice to government bodies, agencies and NGOs such as, the British Standards Institution **(Johnston),** Leeds Climate Change Commission **(Fylan, Glew, Gorse),** Ofgem Technical Advisory Panel for Innovation in ECO3 Policy (**Glew)**; the All Party Parliamentary Group on Healthy homes and Buildings **(Glew – contributor)**; BEIS **(Glew)**; the United Nations (Special Advisor in Urban Forestry) **(Simson)**; DEFRA (Simson); the Belgium, South African and Hong Kong Research Councils **(Akintoye)**; Road Safety Scotland **(Fylan)**; UKROEd **(Fylan)**; and the Abu Dhabi Chamber of Commerce and Industry **(Dulaimi)**.

Unit staff also carry-out **editorial panel duties for academic journals** including: The Journal of Architecture **(Bernath**); the International Journal of Building Pathology and Adaption **(Gorse);** Construction Research and Innovation **(Gorse**); Built environment Journal **(Gorse);** Urban Forestry and Greening **(Simson);** the International Journal of Urban Forestry **(Simson**); Infrastructure Asset Management Journal **(Dulaimi**); the Journal of Financial Management of Property and Construction **(Akintoye)**; Remote Sensing **(Pritchard)**; and the International Journal of Materials Science **(Ahmed)**.

More broadly, staff knowledge and expertise is called upon frequently through **reviewing for academic journals** including *Building Research and Information, Built Environment Project and Asset Management*, *Buildings Journal, Energy and Buildings, Construction Management and Economics, Construction Innovation: Information, Process and Management Journal, Construction Information Quarterly, Construction Management and Economics, Environmental Monitoring and Assessment Housing Studies, Information, Process and Management Journal, International Journal of Materials Science and Engineer*ing, *Journal of Environmental Management*, *Planning Practice and Research, Remote Sensing Journal, The Australasian Journal of Construction, Economics and Building, The West Indian Journal of Engineering, Town Planning Review, Urban Design International,* and *Urban Studies.*

Staff representation within professional institutes and societies is strong, with the majority of submitted staff holding full or associate membership of their professional bodies. Indicatively these include: The Royal Town Planning Institute **(Bradley, Horwood);** The Chartered Institute of Housing **(Bradley);** The Royal Institution of Chartered Surveyors **(Akintoye);** The Royal Institute of British Architects **(Bernath, Epolito, Mills, Molinari);** The Architectural Humanities Research Association **(Molinari);** The British Council **(Pritchard)**; The Chartered Institute of Building **(Akintoye, Dulaimi, Gorse);** The Association of Researchers in Construction Management **(Brooke-Peat, Gorse)**; The Association for Project Management **(Gorse)**;The International Society for Environmental Geotechnology; The International Council for Research and Innovation in Building and Construction; The Landscape Institute **(Simson);** the Arboricultural Association **(Simson).**

Staff also play **key roles** in professional boards and committees, for example, the Association of Researchers in Construction Management **(Gorse – Chair)**; the Chartered Institute of Building **(Akintoye, Dulaimi)**; and the Chartered Institute of Architectural Technologists **(Brooke-Peat – vice chair);** Joint Chair of CEN Technical Committee 89 Working Group 13 (CEN TC/89/WG 13) **(Johnston);** Director of CIB MENA Research Network **(Dulaimi)**; and the Building Simulation and Optimisation 2020 Scientific Committee **(Parker)**. Equally, staff hold **visiting positions and fellowships** including **(Simson)** Visiting Professor at the University of Florence and University of British Columbia, Vancouver; **(Ajay)** Visiting Fellow of the Big Data Enterprise and Artificial Intelligence Laboratory (BIG-DEAL), Bristol; **(Dulaimi)** Visiting Professor at the School of Engineering and Built Environment, Glasgow Caledonian University; **(Bernath)** Visiting/Summer school co-director, AAVS Budapest; **(Molinari)** *British Academy Fellowship* funded by the Accademia Nazionale dei Lincei.

We have also established an international conference - **SEEDS (Sustainable, Ecological, Engineering and Design for Society)**. The inaugural SEEDS conference took place in September 2015. The conference has been held at LBU, except for 2018 (TU Dublin) and 2019 (University of Suffolk) and has grown to be a major research gathering in the discipline. The conference has provided a strong international research platform and to date we have published 3 edited books based on presented research papers (**Gorse, Strange**). Staff within the unit have also instituted new research awards related to sustainability research – Research, Innovation, Sustainability, and Innovation Awards (RISE). The inaugural RISE Award event was held in Leeds in September 2015 and these have been held annually from that date. The awards are sponsored by one of our key research and industrial partners, Saint-Gobain. The award event attracts over one hundred guests bringing together our researchers with industry partners from local, regional, and national companies.

Future research, discipline engagement and contribution

Our research will continue to focus on activity that contributes and offers both technological and social solutions to the problems and challenges of urban sustainability. Our future strategic aims for the unit will remain and allow us to cultivate those we have been pursuing through the current REF period. We will:

- **Appoint research leaders** that can contribute to and strengthen our research focus.
- Build on our **success and reputation in income generation** from government, industry, and academic research funders.
- Maintain our record of **publishing in high-ranking academic journals and producing outputs that progress academic debate and inform and develop policy**.
- **Preserve and sustain our vibrant community of researchers** by providing a well-resourced and institutionally supported research environment.

We will work to sustain the international reach and impact of our work, particularly in relation to the challenges of **water purity and energy production and access in developing countries**. We will also continue to push forward on research that impacts on, and influences UK policy, in relation to the **sustainable performance of buildings**. Our research on **planning for better and more socially cohesive local communities** will remain a core part of our civic engagement work and which contributes to our wider societal regional and local role. We see our developing work on **gender and the built environment** and **construction informatics** as growth areas, with potential to **make significant contributions to our research culture and to policy debates and action for more diverse and inclusive places and more digitally informed construction**. In all these endeavours we work to maintain and strengthen mutually productive links with business, industry, and local communities, expanding our contribution to practice and to academic enterprise in the construction and built environment sectors.