Institution: University of Strathclyde
Unit of Assessment: 13
1. Unit context and structure, research and impact strategy

Overview

Unit 13 at Strathclyde is supported by an expansive Faculty of Engineering within a leading technological university. We fully embrace Strathclyde's founding mission as a 'place for useful learning' and this is reflected in our research. Renowned for its commitment to environmental and societal challenges facing the built environment, in local and global contexts, this Unit places emphasis on the opportunities those challenges create. The Unit is comprised of 12 FTE from the Department of Architecture and 3 FTE from the Department of Mechanical and Aerospace Engineering (MAE). Our research focuses on real-world problems and improving peoples' lives, and comprises two main research areas: **Sustainability and the Built Environment** and **Urbanism and Global Cities**. These themes and the associated research sections align well with the University's Strategic Research Themes (Table 1), reflecting the broad impact of our activities. Since REF2014, in order to increase our overall research capacity, we have established new research groupings, including the Digital Construction Research Unit (DiCRU) and the Cluster for Research in Architecture and Urbanism of Cities in the Global South (CRAUCGS), and consolidated existing research groups, by integrating the areas of 'building performance evaluation' and 'health in the built environment' into the Cluster for Research in Design & Sustainability (CRiDS).

Table 1: Alignment of Architecture Research Sections with the University Strategic Research Themes

Strathclyde Strategic Research Themes	Architecture Research Sections Contributing to Themes						
	Sustainability and the Built Environment					Urbanism and Global Cities	
	ADCRU	CRiDS	CLRU	DiRCU	ESRU	CRAUCGS	UDSU
Advanced Manufacturing and Materials	X	X		X	X		
Energy		X		X	X		
Health and Wellbeing		X				X	X
Innovation and Entrepreneurship		X		X			
Measurement Science and Technologies				X	X		
Ocean, Air and Space	X	X				X	X
Society and Policy	X	X	X		X	X	X

Leaders of each research section work closely with the Directors of Research and Knowledge Exchange who oversee research activity, research staff and PGR mentoring, advise the Head of Department on research appointments and visiting researchers, funding calls and applications, and articulate research programmes in coordination with the Unit's senior team. The Directors also support development of KE activities (annual symposia, seminars, industry facing events, Knowledge Transfer Partnerships) that facilitate effective dissemination of research outputs, increase the impact of our research, and enable consultation with stakeholders.

Sustainability and the Built Environment

Architectural Design & Conservation Research Unit (ADCRU) deals with the challenges of properly conserving built heritage while allowing changes to adapt it to contemporary uses in an appropriate way. Some of our areas of focus include Architectural Stratification & Complex Architectural Conservation Projects; Environmental Design of New buildings; and Architectural Conservation Theory.

Cluster for Research in Design & Sustainability (CRiDS) conducts studies on the identification of social ecologies and environmental systems for supporting resilient communities, innovations in solar design technology, improvements in health, Social Innovation and Resilience, Energy Efficiency and Indoor Air Quality, and advances in education for sustainable development, to help address challenges faced by communities across the world.

Construction Law Research Unit (CLRS) researches the legalities of the construction process. Some of the research areas under this unit include Mediation; Arbitration & Adjudication; Corporate & Construction Professional Ethics; Construction Law & Technology-enhanced Learning; Regulatory Compliance; Law, Regulation, and Offsite Construction.

Digital Construction Research Unit (DiCRU) evaluates and develops advanced technologies, methodologies and approaches for cutting-edge Information and Communication Technologies (ICT). Some of the areas under this unit include Building Information Modelling/Management; Big Data in Construction and for Smart Buildings and Cities; Applied informatics and Artificial Intelligence.

Energy Systems Research Unit (ESRU) is a cross-discipline research group concerned with new approaches to built environment energy utilisation and the introduction of sustainable means of energy supply at various scales. ESRU pursues the development and testing of new computational tools to assist designers in their attempts to devise clean and sustainable overall solutions.

Urbanism and Global Cities

Cluster for Research in Architecture & Urbanism of Cities in the Global South (CRAUCGS) includes research expertise in areas that encompass knowledge economy and sustainable urban qualities, socio-spatial practice of migrant and minority communities, lifestyle trends and housing transformations, cultural identity and image making, urban traditions and user-centred assessment, and architectural design pedagogy.

Urban Design Studies Unit (UDSU) studies cities, their form, functions, and impact, with the ultimate goal of improving their design. Areas under this unit include analysis of urban form and relation to socio-economic dynamics; resilience in urban systems; informal settlements; urban design quality assessment; and environmental-behavioural studies and user engagement.

Research Strategy

Our research and impact strategy aligns with the aims of the University's Vision2025 strategy (see Institutional Statement) and external societal drivers for research in the Built Environment including climate change and health. Strategic activities over the REF period have included:

1) Developing our research capacity by identifying existing strengths and targeting recruitment into these areas to both strengthen and expand expertise. Considering the size of the UOA, the

reinvigoration of research leadership and talent has been substantial, with a significant change in personnel since REF2014. This included the appointment of three professors (*Dimitrijevic, Salama, Sharpe*), two senior lecturers (*Rahimian (now Teeside University), Motawa*), one Lecturer (*Chen*), and one Chancellor's Research Fellow (*McGill*). The appointment of *Chen, Motawa, and Rahimian* in 2016 led to the establishment of the *Digital Construction Research Unit*. A recent professorial appointment was made (*McElroy, 01/08/2020*), with two further professorial and Chancellors Fellow posts advertised in early 2021 in the areas of sustainable design, resilience, building performance evaluation, Building Information Modelling and Simulation (BIM).

2) Diversification and increasing our research income: the strategic development of the research sections during the REF period has resulted in national, international, and industry funding of £5,838,886 equating to £389,259 per FTE over the REF period – a substantial increase compared with REF2014 when our total was £1,247,903.

3) Growing the number of PhD students and awards: Strengthening of the research sections has resulted in a thriving postgraduate research population of more than 50 PhD students with more than 42 PhD degrees awarded during the REF2021 census period (compared to 18 awards in REF2014).

4) Pursuing interdisciplinary collaboration: For example, three research projects have been undertaken with academics from the Department of Electronic and Electrical Engineering. These have included internally funded research on exploring the use of image processing to survey and quantitatively assess historic buildings, and joint PhD supervision projects on the application of image processing to monitor historic buildings, and on utilising machine learning methods in modelling energy performance of domestic buildings. Interdisciplinary collaboration activities include joint GCRF funded research with the University of Philippines in 2018; and with Cairo University, Egypt, in 2019. Both were undertaken in collaboration with the Hunter Centre for Entrepreneurship and the Institute for Future Cities, both based at Strathclyde.

5) Developing strong industry linkages and national, regional, and international connections: This was achieved by developing partnerships with local industries and professional practices, and includes five KTP awards. Further examples are industry-funded research for Scottish Hydro-Electric Power Distribution, Wave Energy Scotland Limited, and Marine Biopolymers Ltd, and providing leadership and advice to the International Building Performance Simulation Association (IBPSA). Internationally, examples include fruitful connections with universities in the West Balkan and Europe which resulted in a KLABS EU-funded project, and with Qatar University which resulted in a Qatar Foundation-funded project.

6) Expanding capacity with contributions across various research areas: In our *Cluster for Research in Design & Sustainability,* we have addressed current strengths in areas of research excellence by undertaking intensive KE activities that include a series of annual symposia addressing sustainability, resilience, place making, and social innovation in the built environment. Our *Cluster for Research in Architecture & Urbanism of Cities in the Global South*, has generated a substantial number of activities such as joint seminars with academics at Qatar University and Hamad Bin Khalifa University in Doha, keynote and public lectures in Malaysia and China, and guest editing of journal special issues on multicultural societies and sustainable urbanism in the Gulf region that published more than 40 outputs addressing Architecture and Urbanism of the Global South (see section 4). This is coupled with the enhanced activities of the established Urban Design Studies Unit (*Porta, Romice*) that has generated £180,000 from consultancies on urban design, training and education, as well as research on resilience and urban morphology (see section 3).

7) We have also had significant success influencing and informing planning, industry, and policy matters. This includes work undertaken for Scottish Government Building Standards Directorate

(*Howieson, Tuohy and Sharpe*) that addresses emerging challenges for sustainability and ventilation, which has resulted in changes to Building Regulations. Our efforts in seeking opportunities for informing policies at both national and European levels include collaboration with Ricardo Environmental Engineering in producing guidelines for architects on Designing Out Waste in Construction, competitively won from Zero Waste Scotland (2017 *Grierson*, *Dimitrijevic);* collaboration with Axel and Margaret Axson Johnson Foundation in Sweden, 2017-20, and with Russian Municipalities in capacity building programmes, 2018-19 (*Porta, Romice*); and collaboration with Scottish Hydro-Electric Power Distribution PLC (Clarke), This is associated with intensive engagements with funders and beneficiaries (see sections 3 & 4).

Future Research and Impact Strategy

Our future research and impact strategy within the context of the University's Vision 2025, is to retain the themes developed over the current review period and to capitalise on recent investment and appointments to develop additional research capacity and breadth within the UOA. This includes a broadening of the research expertise in Architecture, Built Environment and Urbanism to include key areas such as energy, climate change and the low carbon agenda; and also related areas including health. This will enhance the development of inter- and multi-disciplinary research links in the Faculty, University and beyond, with a particular objective of consolidating and linking built environment research within the Faculty. This will be pursued through sustaining and enhancing our objectives to include:

- Increasing the quality and number of our academic staff, research assistants and research students by focussing on areas of research that can attract significant research funding including sustainability and resilience of built environments; supporting staff to develop funding bids; and attracting research active staff using investment from Strathclyde's Global Talent Programme (GTAP) and Strathclyde Chancellor's Fellowship Scheme (CF).
- Building on current strategies to provide the research and management leadership, guidance and support needed to enable all academic and research staff to realise their potential. We will do this by consolidating our research groups including a review of structure and capacity, to align with strategic aims and contribute to external agendas.
- Securing more diverse, and international, funding through international partnerships to maximise impact on policy and decision making in contexts that need support. This will involve enhancing our current partnerships with the Middle East and Malaysia, developing new partnerships in Africa and South Asia (*Salama, Grierson*) and capitalising on engagement with EU initiatives including IEA EBC Annex 86 (Energy Efficient Indoor Air Quality Management in Residential Buildings) (*McGill*) and IEA EBC – Annex 83 – Positive Energy Districts (*McElroy, Tuohy*).
- Further expanding links with national key partners and stakeholders, city and cultural institutions to facilitate the co-construction and co-production of knowledge and to enhance its impact on industry, policy and practice. Examples are engagement in the AHRC funded Health Effects of Modern Airtight Construction network and further engagement with Scottish Building Standards development (*Tuohy, McElroy*) and UK regulations and British Standards (*Sharpe*).
- Further developing the trans-disciplinary and global dimensions of our research in terms of project content, networking, and authority. We will do this by expanding our collaborations at the Faculty level with the Departments of Electronic and Electrical Engineering, and Aerospace and Mechanical Engineering, and, at the University level, with the Hunter Centre for Entrepreneurship, the Institute for Future Cities, and the cross-University research cluster 'Socially Progressive Innovation and Entrepreneurship'.

Enabling Impact

Our approach to facilitate impact is centred on transdisciplinary action and knowledge production, sharing and exchange, and promoting collaboration (see sections 3 and 4). Our work is performed at the interface between academia and industry, and between scientific and experiential knowledge, in order to forge research impact. This is achieved by creating an enabling environment conducive to critical inquiry and knowledge production; exploring and disseminating knowledge through scholarly architectural and urban design research; and advancing and applying professional knowledge and expertise through effective international partnerships and service to the profession and society at large. Central to our performance is addressing real world problems, interdisciplinary collaboration, and engagement with industries and practices as exemplified by our two impact case studies.

The first impact case (Clarke *et al.*) is in the area of energy systems, conservation strategies and simulation tools which demonstrate benefits to municipalities and city councils, government, and the construction sector. The second impact case (*Howieson, Tuohy, Sharpe*) is based on research into energy reduction and ventilation undertaken to improve sustainable building performance in Scotland and the UK to protect occupant health, save energy and reduce carbon emissions. This has protected occupant health by influencing Scottish common law, shaping UK Government policy and public health advice to reduce Covid-19 transmission, and informed Building Regulations and industry guidance to improve building performance in Scotland and the UK.

Research Integrity

We are committed to the highest standards of research integrity and Strathclyde's Research Code of Practice which fully supports the principles of the Universities UK Concordat. All researchers are expected to follow good practice in authorship and adhere to the guidance from the UK Research Integrity Office.
As part of their induction, staff participate in mandatory Equality, Diversity and Inclusion training. Academic policies and procedures within the University are designed to encourage research integrity and are guided by the Research Code of Practice and the Policy and Code of Practice for Postgraduate Research Study.

Architecture mandates the use of Research Data Management (RDM) plans to ensure that research is FAIR – findable, accessible, interoperable, reusable. Datasets associated with published research are uploaded to the institutional database, assigned a DOI, and stored in an accessible manner that complies with the FAIR principles.

The dissemination of research through publication and the data management plans that are associated with this are an outward manifestation of the Unit's commitment to research integrity, which is also supported through actions including:
Mandatory induction courses that include research ethics and integrity.
Requiring ethics compliance statements on funding applications to ensure that appropriate consideration and precautions are in place.
Requiring all PGR students to undertake training in research ethics and integrity as part of the PG Certificate in Researcher Professional Development.
Staff publish their research in compliance with HEFCE policy, a policy implemented within Strathclyde since 2014. All authors deposit their work upon acceptance into PURE, the University's institutional repository which provides pre-publication versions of all published work from the Unit (Green Open Access). In addition, academics strive to publish their work in open access (OA) formats through journals that provide this option where possible and institutional support is available to staff where required (Gold OA). The institutional support takes a number of forms: (i) "block grant

funding", which primarily benefits research funded through UKRI mechanisms; (ii) "Read and Publish" agreements with a number of publishers, which provide free Gold OA; and (iii) the Institutional Open Access Fund, which provides targeted funding for outputs to allow Gold OA if the publisher is not covered by any of the other agreements.

2. People

Staffing Strategy and Staff Development

The principal objective has been to consolidate scholarship in the context of the two themes in **Sustainability and the Built Environment** (*Agapiou; Chen; Dimitrijevic; Gonzalez-Longo; Grierson; Howieson; McGill; Motawa; Sharpe*) which incorporates (ESRU) Energy Systems Research Unit (Clarke*, Costola,* Johnstone*, Kelly, Tuohy*), and in **Urbanism and Global Cities** (*Porta; Romice, Salama*). Our policy has been to develop critical mass, ensuring vitality and sustainability in each research grouping, and to achieve a balance of staff across each group in both absolute numbers and experience. We have benefited from the University's Chancellor's Fellowship Scheme (CF) and the Global Talent Programme (GTAP) (see Institutional Statement) as well as making other targeted academic appointments to achieve our strategy.

The success of the staffing strategy is evident from the quality and number of research outputs and the growth in income from a more diverse range of funders. We have produced 140 outputs during the period with an increased presence in high quality journals such as Architectural Science Review; Energy and Buildings, Indoor and Built Environment, Scientific Reports, Environment and Planning B; Journal of Urbanism; Archnet-IJAR: International Journal of Architectural Research; Journal of Applied Sciences; and Sustainable Cities and Society**.** There has been a more than 4-fold improvement in research income over the period (section 3), we increased our industry engagement with 5 KTPs (see Sections 3 and 4), enhanced knowledge exchange to business and industry (see Section 4) and extended our international profile and reputation (see Section 4). As part of the University's Vision2025 strategy, we aim to grow the complement of research-active staff FTE in the next five years by at least 40% across our two main themes, thereby maintaining the momentum and positive trajectory achieved during the current REF period.

Support for Knowledge Exchange

We appointed a Knowledge Exchange director (*Dimitrijevic*) in 2015 which has been pivotal in expanding KE contributions and increasing the impact of the UOA. The following indicate the range of activities during the period:

- The KE Director has acted as PI on KE projects funded by Erasmus+ *Sustainable Built Environments* with the University of Belgrade (Serbia), 2018-2020,
- Created the Network of Knowledge Labs for Sustainable and Resilient Built Environments (KLABS), 2016-2018 (with *Salama* and *Grierson).*
- Presenting at KE events organised by the Institute for Future Cities, Glasgow City Council, Impact Engagement Scotland and EcoConnect (Edinburgh).
- Liaison with industry and practices on potential collaboration in KE projects, e.g. on the guide for architectural practices '*Designing Out Construction Waste'* for Zero Waste Scotland.
- Supported the development of KE activities by organising seminars for staff on KTPs in collaboration with West of Scotland KTP Centre.
- Organised a KE session with academics from 10 EU and Western Balkan countries who were partners in KLABS project funded by Erasmus+.
- Attracted sponsorship for KE events from the Royal Society of Arts, Scottish Natural Heritage, and Climate Change Scotland.

- Delivered departmental annual symposia under the general theme of sustainability and resilience since 2015.
- Coordinated online CPDs on architectural practice entitled *Social Benefits of Innovative Lighting* (with colleagues across the university*)*, and in *Decision Making for Place-Making.*

Staff Development and Support

The main process for identifying the mentoring and development needs of all staff is through the University's annual Accountability and Development Review (ADR). The ADR process at Strathclyde embraces the current best practice of organisational management. This includes setting objectives for the forthcoming year aligned with the values of the University (Bold, Collaborative, Ambitious, People-oriented, and Innovative). Reviewees are coached by their reviewer to ensure that they set SMART (Specific, Measurable, Actionable, Realistic, Time-bound) objectives not only for research, teaching and KE, but also for their professional development. This latter aspect of objective setting is often the most challenging. However, it provides all staff with a genuine opportunity to reflect on aspects of their career that they want to enhance and obtain feedback from their reviewer on how to progress.

Staff development is planned and reviewed using the ADR process, but staff development activities are also supported through several University mechanisms that we have utilised to develop our staff. The main researcher development programme is the Strathclyde Programme in Academic Practice, Researcher Development and Knowledge Exchange (SPARK) which is accredited to Masters level. The University's Organisational and Staff Development Unit (OSDU) provides courses which support programmes such as the PG Certificate in Advanced Academic Studies for new academic staff and is accredited by the Higher Education Academy (HEA) and upon completion, it is expected that staff apply for fellowship of the HEA.

For senior academics, OSDU offers a series of courses through participation in the University's Strathclyde Programme in Research and Leadership (SPIRAL) and mid-career researchers are encouraged to attend our programmes on leadership in research and knowledge exchange. For new professors, (either recruited or promoted), OSDU runs a 'New Professors Programme' that focuses on leadership, management strategies and sessions on coaching and mentorship. This commitment to personal development has seen Architecture's research staff, at all levels, complete 139 approved courses over the REF period.

In addition, the Unit supports research active staff in activities such as conference participation and travel through a specific budget allocated for this purpose. Approval is on a case-by-case basis and priority is given to research areas that align with Departmental, Faculty, and University priorities.

Early Career Researchers (ECRs)

ECRs are supported and developed by the University's Researcher Development Framework in alignment with the UUK Concordat for the Career Development of Researchers. Utilising the University's Researcher Development Framework, support is provided for career planning and promotion which includes training in producing high impact publications, grant writing, research supervision, and leading and managing research projects. ECRs and PhD students receive support for external networking through participation in the "Engage Strathclyde" programme and the annual competition and exhibition "Images of Research", where industries, professional practice firms, and government organisations are key partners. We have supported ECRs/PhDs to attend more than 20 conferences during the period and are encouraged to participate in the organisation of the Unit's Annual Symposia which include speakers from various academic institutions, industries, and practices. This year this will take the form of the XVIII International Seminar of Urban Form that we

will host (https://www.strath.ac.uk/engineering/architecture/ourinternationalactivities/isuf2021/). PhD supervisors with extensive research experience and a wide partnership base are encouraged to support their ECRs/PhDs to network as part of the supervision process and the dissemination of interim research findings. Networking and multidisciplinary collaborations at local, national and international levels are also supported through organisation of industry-facing events, seminars and symposia. For ECRs, early engagement in our Supervisor Development Programme is necessary before being approved to operate as 1st supervisor of a PhD student. This programme ensures staff are familiar with our Policy and Code of Practice for Postgraduate Research Study and introduces them to tools and methods to support students through their research, thesis writing and examination.

Recognition and Reward

The University has well developed schemes to reward exceptional performance of staff. There is an annual promotions process for all academic and research staff. Professorial staff can also be rewarded financially for their research, knowledge exchange and impact excellence through the University's Senior Academic Review and Development (SARD) panel. During the review period, one promotion case to Reader (*Grierson*) and one promotion case for Senior Lecturer (*Gonzalez-Longo*) were successful. Exceptional performance of staff at all levels is also recognised through the University's annual Contribution Pay programme, which allows Heads of Department to seek financial reward for individual staff through a salary increase or one-off payment.

Flexible Working, Sabbaticals and Research Leave

The University has a range of benefits and policies that help and support staff to balance work and family commitments. These include maternity and paternity leave and support, adoption leave and pay, parental and shared parental leave, support for carers, flexible and homeworking arrangements, as well as family-friendly research leave. Our people-centred approach to employment is also reflected in our agile working policy that complements the existing rights of the workforce to flexible and part-time working by supporting staff with the technology to enable them to work from anywhere, at any time when conditions necessitate. In addition to the University policy of family-friendly research leave, the Unit applies the same policy to those members of staff returning from extended sick leave, providing 3 months of protected time to devote to re-establishing their research programmes. Staff seeking a period of sabbatical leave discuss arrangements and eligibility with the Head of Department.

Research Students

Strengthening of the research sections has resulted in a thriving postgraduate research population of more than 50 PhD students, which equates to approximately 3 students per FTE academic staff. Our enhanced international profile is attracting an increasing number of international research students which now come from 16 countries including several from Africa, the Middle East, and South East Asia. An increasing proportion of the international students hold competitive scholarships from overseas universities, and national governments and agencies.

PhD students are recruited mainly through targeted advertising or direct contact with the Unit. We also provide support to applicants to identify their preferred research area and develop their proposal when applying for competitive grants provided by overseas universities and governments.

The introduction of three new research areas has assisted postgraduate recruitment at taught Masters and PhD level. A focus on **Heritage Conservation** has led to the MSc in Architectural Design for the Conservation of Built Heritage, which together with the *Architectural Design &*

Conservation Research Unit, has attracted 20 international postgraduate taught and research students. **Architecture and Urbanism in the Global South,** which is part of *Cluster for Research in Architecture & Urbanism of Cities in the Global South,* has attracted 12 PhD international students and a four-year funded research project from the Qatar Foundation in partnership with Qatar University. The third theme is **Digital Construction**, which is part of the *Digital Construction Research Unit,* which introduced the MSc in Advanced Construction Technologies and Building Information Management that has attracted 20 international postgraduate taught and research students.

Growth in the PhD cohort has led to an increase in the number of PhD degrees from 2 in 2013-14 to 8 in 2016-17 and 11 in 2018-19, with a total of 42 PhD degrees bestowed over the REF period**.** Of these PhD completions, 15 students had received competitively won bursaries from the University's scholarship schemes and external funders, worth over £800,000.

All new students are provided with a PGR Departmental Handbook and are required to attend induction events delivered by the Strathclyde Doctoral School. Once initiated into the PGR programme, each student is enrolled in Strathclyde's PGCert in Researcher Professional Development Programme (RDP), conferring two awards at graduation.

The PGCert provides PGRs with training in a range of professional skills and personal development activities. The RDP process is monitored and reviewed at annual research progress meetings and less formal 6-month reviews. PGRs must attain a satisfactory 1st year review in order to proceed further. Reviews are also independent of the supervisory teams. During the final year of PGR research, the students are advised about the support available via VITAE in relation to post-doctoral opportunities.

From the research perspective, PGRs are supported by their primary and secondary supervisors. This support takes the form of researcher training but is also pastoral in nature where appropriate. The PGR Co-ordinator is also available to provide academic advice and pastoral care to students, involving the Head of Department as required for issues that require higher-level intervention. Participation in weekly PhD seminars, when students present progress in their research and receive feedback from their fellow students, offers a further layer of informal feedback as part our strategy for effective peer learning.

Our research students are fully integrated into the Unit, benefitting from co-location and access to a wide range of IT facilities and the community support that comes from being part of one of our research groupings. Our doctoral training infrastructure has been significantly enhanced by the introduction of a dedicated PGR Suite. During 2020 and as a consequence of limitations caused by COVID-19 restrictions, 35 seminars were conducted online to support students socially and in their research progress. The quality and standing of our research students are evidenced by the 20 conference presentations given and 15 peer-reviewed journal publications contributed by PGR students during the current REF period.

The flexible working policy also applies to research students. When research students have need of leave, this is discussed with their supervisor and the PG Co-ordinator, and the best course of action agreed. Over the review period, this has included voluntary suspension of studies, flexible research hours and extension to periods of study. General issues of importance to the PhD cohort are discussed and actioned at regular meetings of the Staff Student Liaison Group and with the PGR Co-ordinator.

Equality and Diversity

The Unit is committed to fostering an inclusive and socially progressive environment for all staff. Staff awareness of Equality, Diversity and Inclusion, is supported through the range of courses offered by OSDU and extends beyond gender. Architecture ascribes to the philosophy and policies regarding equality and diversity that are described in the Institutional Statement, which include gender equality, new policies on dress code and LGBTQ+ as well as the legal obligations around pay, impact assessments and procurement. This commitment was recognised in our Athena Swan Bronze Award in 2016 and building on this achievement, our submission for the Athena Swan Silver Award in November 2021. Matters relating to the health, safety and wellbeing of staff and students are reported to the Health, Safety and Wellbeing (HSW) Convenor and discussed at the HSW committee meetings. General developments in Equality and Diversity policy are discussed at departmental meetings.

Currently 43% of our PGR/PhD cohort and 30% of staff are female. We are aware that our staffing profile is under-represented at all levels by females. In an effort towards improvement, we have recently appointed two female staff: one Chancellor's Fellow (*McGill*) and one Professor (*McElroy*). Examples of female staff leadership include: *Dimitrijevic*, who leads the area of knowledge exchange and directs Postgraduate Research and PhD provisions; *Romice*, who leads the Unit's Athena Swan Committee and co-directs Urban Design Studies Unit; and *Gonzales-Longo*, who leads the Architectural Design and Conservation Research Unit and its associated Master Programme.

Policies have been implemented to help minimise unconscious bias in the short-listing and interview stages of the appointments process. This includes unconscious bias training for panel members, anonymising applications, as well as the requirement that all panels have balanced gender representation.

3. Income, infrastructure and facilities

Research Income Strategies

Our recruitment and research strategies have allowed us to diversify and increase our research income over the REF period and this has been sustained with national, international, and industry funding of £5,838,886 equating to £389,259 per FTE. This success is based on prioritising international collaboration and proactive engagement in exploring interdisciplinary ways of working and promoting research collaborations. The recent appointments to build new capability (*Sharpe, McGill*) are resulting in research opportunities in the areas of health, indoor air quality, and building performance assessment studies. There has also been notable research income (£200,000) following the recruitment of *Salama*. Departmenta1l KPIs for research income have been set as part of the Vision2025 Strategy with an aim of achieving a research income of £1m by 2025. Staff receive support for the development of their research activities and research bids through our internal peer assessment process in addition to institutionally provided support.

The majority of funding from UKRI/EPSRC has been achieved by the Energy Systems Research Unit (ESRU) with two EPSRC projects awarded to the Urban Design Studies Unit (UDSU). Our internationalisation strategy has resulted in various collaborations, for example, in the Middle East, the Far East, and within Europe. Leading the Qatar Foundation's funded research project on Urban Transformation in the Gulf Region (*Salama*) involved collaboration with Qatar University over a period of four years. Collaboration with Korea Institute for Energy Technology Evaluation and Planning in two projects (*ESRU*) took place over a period of three years. The Erasmus+ funded KLABS project (*Dimitrijevic, Salama, Grierson*) encompassed research collaborations with TU Delft (Netherlands) and IAUV, Venice (Italy) as well as several universities from the Balkans. ESRU

(Clarke*, Costola,* Johnstone, *Kelly, Tuohy*) has been engaged in various collaborations in European Commission – Horizon 2020 projects. The Urban Form Resilience project involved collaboration with the Axel and Margaret Axson Johnson Foundation (*Porta, Romice*). Erasmus+ KA107 project (*Dimitrijevic, Salama, Grierson*) includes research collaboration with the University of Belgrade involving reciprocal research visits of three academics and four PhD researchers from the two institutions.

The variety and significance of research awards secured during the period is illustrated by the following examples: EPSRC grants (*Porta (£56,524)* and Clarke *(£452,532)*; European Commission – Horizon 2020 (Clarke*, £345,393*); European Commission/Erasmus+ and KA107 (*Dimitrijevic, Salama, Grierson, £37,202*); Newton Fund/British Council (*Salama, Grierson, Dimitrijevic, £33,100*); The National Priorities Research Programme, The Qatar Foundation (*Salama*, £199,902); and the Korea Institute for Energy Technology Evaluation and Planning (Clarke*,* £121,235). Industry-based research funding includes Norscot Joinery Limited (*Motawa,* £126,459); KTPs (Clarke*, Costola,* Johnstone*, Kelly, Tuohy, Sharpe*) with ARBNCO/CO2 Estates Limited (£318,407 and £127,067); European Marine Energy Centre (£180,677); Hurley Palmer Flatt (£136,550); Peak Scientific Instruments (£71,356); and Turnbull & Scott (£3,888); John Gilbert Architects (£187,000).

In addition to the UKRI and internationally funded research, the UOA has been awarded research funding from the Scottish government and UK-based charities and has attracted funding to support the already established research themes. This includes awards from The British Council (*ESRU, CRAUCGS*), Royal Academy of Engineering (*UDSU*), and Scottish Hydro-Electric Power Distribution PLC (*ESRU*). The strategy set for diversification of funding sources continues to be successful, with new applications submitted in 2020 in addition to the funding reported during REF 2021. Examples include applications to: Construction Scotland Innovation Centre, £32,000 (*Agapiou*); the University's GCRF, £52,000 (*Salama*); and NERC, £507,945 (*Sharpe*).

Organisational Infrastructure Supporting Research and Impact

The Unit benefits from dedicated and substantially renovated accommodation in the James Weir building (£44m in 2014). Facilities include customised workshop spaces, a modelling workshop, library, studio facilities and general office space. When multi-disciplinary research is undertaken, agreements are made with other Faculties or Departments to enable access to specialist research infrastructure. The Unit receives support through the Faculty's centralised IT support service, and staff and students have access to specialist IT equipment and packages appropriate to the research of the Unit including for example, ARCHIE-WeST (high performance computing facility) and the Advanced Materials Research Laboratory (AMRL) based in the Department of Mechanical and Aerospace Engineering.

We also benefit from other University services such as the Research and Knowledge Exchange Services department, which supports grant preparation and submission, and contract negotiations; and the University's Commercial Office and the West of Scotland KTP Centre, which support staff when developing impact activities. Additional support and advice are provided at the meetings of the Faculty Research Committee (FRC) and Faculty Knowledge Exchange Committee (FKEC).

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

Collaborations, Networks and Partnerships

Our staff have used the University's Global Challenges Research Fund (GCRF) Pump Priming scheme (annual Scottish Funding Council allocation totalling £1m for 2020) to establish international research links and develop collaborative research proposals. For example, in collaboration with the

School of Business and Hunter Centre for Entrepreneurship, our staff (led by *Salama*) have been co-investigators in Re-Enterprising the 'Forgotten Villages of Greater Cairo' (GCRF Pump Priming) which subsequently led to successful partnerships with Cairo University and Arab Academy for Science & Technology in subsequent projects related to COVID19, funded by GCRF and Scottish Funding Council. These projects addressed Sustainable Entrepreneurship and Cultural Heritage in Greater Aswan, Egypt and more recently Navigating COVID-19 related transitions and transformations of economically marginalised women entrepreneurs within urban poor communities of the Greater Cairo Region in Egypt (GCR). These projects generated tool kits, as enabling mechanisms that support female entrepreneurs to support their families. Utilising GCRF funding, our staff (*Dimitrijevic)* collaborated in multi-disciplinary research-informing workshop, in collaboration with the University of the Philippines Diliman to engage with tourism from a social and economic inclusion perspective in the context of the contemporary city. This offered multiple perspectives on the theme including gender, economic, employment, human rights, urban planning, architecture, law and anthropology. A key outcome of this collaboration is a significant bid being developed for submission to the UK wide scheme - British Academy UK under GCRF.

The UOA has collaborated in various international research and KE activities which were supported by external funding (Erasmus+ KLABS project, 2016-2018: Erasmus+ KA107 with the University of Belgrade Serbia, 2018-2020; Erasmus+ staff mobility activities). Within the KLABS project, *Dimitrijevic, Grierson* and *Salama* provided support for the development of MSc courses on sustainability and resilience of the built environment which were successfully established at 6 universities in Western Balkan countries. The project also published 5 books that are used in teaching at the above MSc courses. *Dimitrijevic* co-edited one of these books with academics from TU Delft, Netherlands and IUAV, Venice, Italy. The KLABS project involved extensive KE activities including workshops and quarterly meetings in all partner institutions. The KA107 project with the University of Belgrade, Serbia, involved exchange of teaching at PG level and research visits of two PhD students from each institution. Three joint journal publications are being developed as an outcome of this exchange.

In 2020, we appointed *Professor Tim Sharpe* resulting in networking funding from NERC, engagement in a COP26 low energy demonstration project, and involvement in the National Core Studies funded by the Health and Safety Executive. These projects address pressing research issues related to indoor air quality, building performance and occupants' health, and their integration into professional practice. This clearly aligns with key United Nations Sustainable Development Goals and with the Royal Institute of British Architects (RIBA) 2030 Climate Challenge, which sets relevant targets for practices to meet in the next decade.

Our collaboration with the University's Institute for Future Cities (IFC), a world-leading cross-disciplinary venture linked to the Technology Strategy Board's Future City Demonstrator and City Observatory, was enhanced through a number of activities. These included the joint development of bids, collaboration in the organisation and delivery of the Unit's annual symposia (2015-2020), and collaboration in joint knowledge exchange seminars offered to delegations of urban planners and officials from China, 2016 and Poland 2018, (D*imitrijevic*); and from Kenya, 2015 and the Netherlands, 2018 (*Salama*).

Visiting Professorships and Associated Activities

Visiting professorships in 9 countries have been held by our senior staff, 2 in the UK and 18 in Asian, European, and Middle Eastern universities. Staff have also been assessors on promotion and appointment panels in 16 Universities including 4 in the UK and 12 internationally, and have held 22 PhD external examiner appointments in universities in the UK and 9 universities internationally.

The UOA has also attracted internationally leading researchers and practitioners as Visiting Professors and Visiting Fellows from the UK and beyond including China, Malaysia, and the United States (for example: *Adam, Cunningham, Hakim, Jing-hua, Tomalty, Wilson, Xuyan, Zairul*). This also involved hosting a number of visiting researchers from China, Italy, and Malaysia.

Relationships with Funders, Research Users, Beneficiaries or Audiences

The profile of our staff has increased markedly over the REF period. The unit's staff have contributed to 14 strategic activities that aim to establish national and international funding priorities within the discipline. Examples include:

- *Chen*, Innovation Champion, Construction Scotland Innovation Centre, 2018-;
- *Grierson*, Cosanti Foundation Strategic Plan Steering Committee, Arizona, USA, 2014-17;
- *McGill*, UKRI SPF Clean Air Scoping Workshop on 'Research challenges and state of the art in indoor air quality, health and the built environment', 2020; Scottish Government Evidence in Policy fortnight, 2019; British Council funded UK-China Researcher Links Workshop on 'Childhood Respiratory Disease in UK and China, Chongqing, China, 2018;
- *Sharpe*, MRC funded UK-China AMR Workshop, Shanghai, 2017; Engineering and Physical Sciences Research Council (EPSRC), 2020; Medical Research Council UK Prevention Research Partnership (UKPRP) Information and Networking Event: 2019; EPSRC priority area of Engineering Healthier Environments, 2020.

Contributions of our staff to funding agencies and organisations include:

- Reviews for Research Councils: EPSRC, MRC, AHRC (*college members Dimitrijevic and Sharpe*) and EPSRC, TSB, and Innovate UK (Clarke, *Dimitrijevic.*).
- Reviews for research funders, university research schemes, and National Research Assessment Schemes (equivalent to REF) in more than 10 countries in Europe, North America and Middle East.
- Advice to 4 public organisations and businesses including Zero Waste Scotland in developing guidelines on waste reduction through building design in collaboration with Ricardo Energy and Environment (*Grierson, Dimitrijevic);* Cosanti Foundation Strategic Plan Steering Committee overseeing the development of Arcosanti, 2014/18, Arizona, USA *(Grierson);* KB Strelka on the strategic development of the city of Svobodny, Russian Federation, 2018 (*Porta, Romice*); and the Glasgow Urban Design Panel *(Romice).*

Staff have organised more than 22 KE events nationally and Internationally; been guest speakers at more than 35 KE events involving industries and professional audiences; and delivered invited talks in 16 countries, including 23 lectures These events allowed staff to engage key beneficiaries including leading practitioners from industry, professional organisations, (e.g. Academy of Urbanism, Royal Town Planning Institute, Royal Institute of Architects in Scotland) and academia in the UK, Hong Kong, India, Italy, Malaysia, Qatar, Serbia, Spain, and United States.

Our outreach to the research community in the UK and globally involves 26 keynote lectures in the UK and 33 worldwide, delivered in more than 18 countries. Additionally, we have been members of the organising committees of 48 international conferences in various areas related to sustainability and the built environment, and urbanism and global cities.

Wider contributions to the economy or society

The established reputation of our staff has resulted in:

54 senior advisory roles in national and international societies and funders for example:

- *Sharpe,* UK Government Scientific Advisory Group for Emergencies, Environment and Modelling Group (SAGE -EMG), National Institute for Health and Care Excellence (NICE*)* Public Health Advisory Committee on Indoor Air Quality; Royal College of Paediatrics and Child Health (RCPCH) and the Royal College of Physicians (RCP) working group, *The Effects of Indoor Air on Children's Health Across the Lifecourse*; British Standards Institute (BSI) Retrofit Standards Task Group.
- *Dimitrijevic,* Scottish Graduate School of Arts and Humanities*;*
- *Grierson,* ESRC/NSFC Europe-China grant for collaborative research*;*
- *Salama;* Swiss National Science Foundation).

29 advisory roles to UK and international government and development agencies, for example:

- *Sharpe,* UK Government Advisory Group for Emergencies (SAGE), Environments and Modelling Group*;*
- *Gonzales-Longo,* International Council on Monuments and Sites (ICOMOS-CIF);
- *Salama,* Canada's Social Sciences and Humanities Research Council*;*
- *Agapiou,* W113 Working Commission, Law and Dispute Resolution, International Council for Research and Innovation in Building and Construction – (CIB).

Trustee memberships:

- *Sharpe* since 2015, Chair NHBC Scotland Technical Committee, and NHBC Construction Quality Expert Panel;
- *Porta* since 2016, Research Council of Università di Firenze, Naples, Italy;
- *Agapiou*, since 2017, Architects Professional Examination Authority Scotland; 2016-2018, Scottish Mediation.

16 commissioned reports to government and academic institutions. Examples include:

- Scottish Government report by ZWS, Designing Out Construction Waste: a guide for Architects and Designers (Grierson, Dimitrijevic**);**
- Scottish Government report on decentralised mechanical ventilations in new—build dwellings, Innovate UK Building Performance Evaluation Programme (McGill, Sharpe**),**
- 4 Scottish Government, Innovate UK, TSB**,** Royal College of Paediatrics and Child Health commissioned reports on air quality in home environments (Sharpe).
- Reports for the Korea Institute for Energy Technology Evaluation and Planning (ESRU)**,**
- Expert Report on new postgraduate research degrees at King Fahd University of Petroleum and Mineral, College of Environmental Design, Dhahran, Saudi Arabia (Porta, Salama**),**
- Reports to the National Federation of Cooperative Construction, Italy (Porta),
- Report to the Fund of Integrated Housing Development Institution of the Russian Federation (Porta, Romice).

These engagements have additional benefits as they inform our MSc teaching and PhD supervisions and enable the overall integration of research findings into teaching materials.

Our staff are involved in various capacities with journals at the forefront of research in architecture, urbanism and built environment:

- Lead two international journals and serve as Chief Editor - *Salama* (Archnet-IJAR: International Journal of Architectural Research and Open House International);
- Specialty Chief Editor – *Chen* (Frontiers in Built Environment);
- Associate Editor – *McGill* (Architectural Science Review);
- Editorial Advisory Board – *Romice* (Hogrefe Environment-Behaviour Series);
- Edited 14 special issues of reputable international journals.

Other contributions underpinned by our impact strategy are the provision of research based CPD events and 5 annual thematic symposia, and activities with professional associations covering joint events, judging panels, and industry boards related to the professions of architecture and urban design. Examples are: membership of the RIBA Professional Practice Panel (*Agapiou*); RIBA Conservation Register Accreditation Panel (*Gonzales-Longo)*; and Chairing judging panel for the RIBA President's Awards for Research (*Dimitrijevic)*.

Interdisciplinary Research and responsiveness to international priorities and initiatives

Our interdisciplinary work has resulted in the establishment of the cross-University research cluster 'Socially Progressive Innovation and Entrepreneurship' and to collaboration with staff in the Strathclyde School of Business in inclusive tourism (*Dimitrijevic)*; the Hunter Centre for Entrepreneurship in women entrepreneurial practices in squatter settlements in Cairo (*Salama*)*;* and joint PhD supervision with the Department of Electronic and Electrical Engineering and the Department of Chemical Engineering (*Gonzales-Longo* and *Grierson).* The core research work of *Sharpe* and *McGill* connects expertise in buildings and health. *Dimitrijevic* has led production of two online CPD courses on social factors in innovative civic lighting and on decision-making for place making.

Our commitment to global priorities including social justice, migration and displacement of communities as a result of wars or natural disasters is demonstrated by our interest in internationalising research content and extending our reach to respond to these priorities, especially in housing. This is evident by our aforementioned initiatives that have had an impact on the Gulf Region, China, Malaysia and India.

Our PGR/PhD international cohort from more than 16 countries engage with their supervisors in identifying challenges and exploring opportunities to tackle environmental and social issues in Botswana, Malawi, Nigeria and South Africa, urban fragmentation in Gulf cities, post war reconstruction efforts in Libya and Iraq, and the evolving urban identity in Kazakhstan and the wider region of Central Asia. Recent work by *Grierson* on research for a new earthquake resilient school in the Nuwakot district of Nepal demonstrates further our commitment to respond to international priorities.

Wider influence, contributions to and recognition by the research base

The work of our staff has been recognised nationally and internationally with 14 awards received during the review period including to:

- *Dimitrijevic* (Emerald Literati Award 2019 - Outstanding Reviewer;
- *McGill* (Best Paper Award, International Conference on Sustainability in Energy and Buildings, Cardiff, 2014);
- *Grierson* (Outstanding Contribution in the Closing Panel of the International Congress on Environment and Design, Istanbul, Turkey, 2014);
- *Howieson* (Scottish Edge Wild Card Award 2014 - Scotland's top early stage and high growth potential entrepreneurs;
- *Howieson and Sharpe,* Napier Shaw Medal 2015- highest rated papers of the year on application and research respectively, published in CIBSE's Building Services Engineering Research and Technology journal (BSERT);
- *Salama* (2017 UIA the Jean Tschumi Prize for Excellence in Architectural Criticism, International Union of Architects, Paris);
- *Sharpe* (Saltire Society Innovation in Housing Award with John Gilbert Architects), 2 'A' rated KTP projects (John Gilbert Architects, Building Performance Evaluation of existing dwellings; Cartwright Pickard Architects, to develop innovative tools for applying building information

modelling (BIM) and building performance evaluation (BPE) for application within the build to rent market.

The work of our early career researchers and PGR students has been recognised at University level and nationally through 11 awards and recognitions: 1 award from the Institute of Historic Buildings Conservation; 3 university commendations and prizes from the Advanced Materials Congress in Sweden*; 5* University awards; a National Urban Design Group award; and a Royal Town Planning Institute award for urban design students.

The achievements of our staff have been featured in 9 key media and press releases. This includes: FutureScot – The Times Scotland, November 2017 *(Gonzales-Longo);* The Guardian, November 2014 *(Porta)*; Featured case study on AHRC website and RIBA backed debate – The Edge (*McGill*); News of American Association of the Advancement of Science, August 2017 (*Salama*); BBC – Scotland News and Featured research on AHRC website (*Sharpe*).