Institution:

CARDIFF UNIVERSITY

Unit of Assessment:

UoA 16

a. Overview

Research in the Welsh School of Architecture (WSA) is organised across three groups:

- **Architectural Science Group** (ASG)—chaired by Eames with Ampatzi, Bleil de Souza, Gwilliam, Jones, Knight, Lannon, Patterson, Pearson, Poortinga, and Tweed;
- **Architectural History and Theory Group** (AHTG) chaired by Kite with Davis, Hardy, Kite, McVicar, Odgers, and Prizeman;
- **Design and Practice Research Group** (DPRG) chaired by Forster with Jabi, Lupton, McVicar, Prizeman, Salter, and Wulf.

Group membership also includes Research Assistants and PGRs. The groups organise the School's broad portfolio of research and scholarship, while research centres address specific topics and provide an interface for external collaborations:

- **Low Carbon Research Institute** (LCRI) led by Jones (Chair), directed by Pearson—addresses topics in the development of sustainability and a low carbon agenda;
- **BRE Centre for Sustainable Design of the Built Environment** (SuDoBE) directed by Tweed—specialises in research concerning people and the built environment;
- **Practice, Research and Advancement in South Asian Design and Architecture** (PRASADA) directed by Hardy—focuses on historical traditions of the Indian subcontinent, including their relevance to contemporary design, particularly temple architecture;
- **Design Research Unit Wales** (DRUw) directed by Forster—engages in architectural design projects that address key topics in contemporary architectural design, including low carbon design, landscape and placemaking; and
- The **Centre for Research in the Built Environment** (CRiBE), directed by Jones, offers consultancy services, drawing upon the School's diverse and interdisciplinary research expertise. It also provides support with project and financial management to other centres and is often the first point of contact for external organisations. In this role, it is well placed to deliver impact through engagement and dissemination.

All of the groups and centres are represented on the School's Research Committee and there is collaboration across the centres, particularly between the LCRI, SuDoBE, and DRUw.

b. Research strategy

The School's research strategy is to foster excellence in key areas of the architectural and built environment research agenda. It focuses on **low carbon and sustainability**, **quality of life and well being**, **future cities**, **history and theory of architecture and the creation of places that enhance people's enjoyment of the built environment**. Since RAE 2008, the strategy has been to focus on specific topics and address them with a broad mix of disciplinary backgrounds. The School has grown its research on low/zero carbon built environments at building/urban scale; built capacity through the LCRI and SuDoBE; developed design research through the DRUw; extended research on the cultural and religious dimensions of architecture, including non-western traditions; and engaged in collaborative research with other disciplines, e.g., environmental risk perceptions and public health with Psychology and Medicine.

The variety of approaches, methods and topics of enquiry creates a rich **interdisciplinary environment** that encourages staff to collaborate within and beyond the School. It contributes to the intellectual development of the broader discipline using technical, socio-technical, humanities and design research paradigms, drawing on a combination of project-based and individual scholarly research. Our staff come from a wide range of backgrounds, including architecture, but also engineering, natural and social sciences, and economics. This diversity has come about through **planned expansion** of the research portfolio and recruitment of appropriately qualified

staff. This interdisciplinarity is reflected in the School's success in attracting research income from different sources and in the diverse range of research outputs. Since RAE 2008, **research income has more than doubled** to £10.5M over the (longer) period of assessment.

Research on low/zero carbon built environments

This is the School's **largest growth area since 2008** and has been pursued by the LCRI, SuDoBE and DRUw research centres. Research in this area has resulted major grant awards, research outputs, measurable impact and actual buildings with recognised low carbon achievements in operation. Each centre provides a different focus. The LCRI creates **innovation in energy systems** and **building fabric** and the **social changes** that are required to realise a low carbon future. SuDoBE develops knowledge about people and the built environment. DRUw merges the resulting knowledge with wider architectural concerns to produce designs and completed buildings that fulfil the exacting criteria set by real clients and occupants. Working across these centres, Poortinga's research on health and the built environment links with other research in SuDoBE, while his work on public attitudes to energy and climate change informs the debate on energy transitions; and Knight's studies of the design, inspection and operation of air-conditioning in non-domestic buildings addresses the realities of providing comfortable and energy efficient buildings. This work has strong links with industry and is described as one of the impact case studies.

LCRI and SuDoBE have developed the capacity to generate funding, outputs and impact in key areas of **energy transitions**, **smart energy regions** and **building performance evaluation**. The LCRI secured funding of £19M from the European Regional Development Fund (ERDF) with matched industry funding of £15M. The LCRI is based in the School and oversees a programme of research with six Welsh Universities supported by this funding. Initial funding of £5.2M from HEFCW led to strategic appointments of Professors Pearson (Director) and Eames (Research Chair.) Subsequent Research Council funding has enabled an interdisciplinary programme of sustainability transitions research, encompassing work on past and prospective transitions in energy, urban environments and transport systems. Evidence of achievement includes: participation in, and leadership of, national research consortia (see Section D); a seminar series attended by staff from Welsh Government and other Schools; and important outputs, such as the monograph by Pearson on UK Energy Policy 1980-2010. These new interests fit well with established expertise on socio-technical issues related to energy and the built environment in the School. Research in the LCRI has resulted in three new and significant collaborations:

- SBEC (Sustainable Building Energy Centre)—funded by Tata Steel, LCRI and Welsh Assembly Government. SBEC's focus is on accelerating the development of low and zero carbon solutions for the built environment using steel in combination with other materials. The building, designed by DRUw, is leased to the LCRI, bringing together researchers from WSA and Tata, to collaborate on energy generating building envelopes research.
- The SPECIFIC consortium led by Swansea researching the feasibility of developing buildings as power stations.
- SBED (Sustainable Building Envelope Demonstration) project, led by the School in partnership with Tata Steel, demonstrates the work of SPECIFIC and SBEC via eight building applications.

SuDoBE secured funding from EPSRC, TSB and the European FP7 programme for research projects and support for PhD students from BRE, EPSRC CASE and Knowledge Economy Skills Scholarship awards. Its research has developed a focus on human interaction with built environment technologies and on evaluating building performance from the users' perspective.

Research in architectural history and theory

The AHTG is a growing team of researchers with strengths in relating theoretical issues to practice and 'making', within its varied cultures and contexts. Two senior appointments (Prizeman and Davis) have brought expertise to the Group that complements the portfolio of humanities and design related research and links to ASG and DPRG. Prizeman's work on **sustainable building conservation** brings together environmental professionals to balance the interests of **heritage and energy conservation**. Davis' work on **regeneration and resilient cities, urban form and governance**, connects cultural contexts to urban modelling in ASG. Hardy's research on **Indian Temples** has led to his developing a conservation plan for ruined temples at Ashapuri (WMF-

funded) and acting as architect for a new temple near Bangalore. The Group has produced important monographs, such as Kite's books on **Adrian Stokes and John Ruskin**, Hardy's studies of the **Hindu Temple**, and Prizeman's book on **Carnegie Libraries**.

Design research activity

Design has grown to be an important area of research in its own right as well as an integrator for results from ASG and AHTG. The School created the Design and Practice Research Group (DPRG) in April 2009 to develop design research. This group provides a home for DRUw which, in this period, has built in excess of £17m of buildings, winning an RIBA Award, a Civic Trust Award, an Eisteddfod Bronze Medal, the CIOB Award for Research 2010l and the Cardiff University innovation Award 2010. Other notable successes in design research include Salter's **Walmer Road houses**. This work, with its focus on materiality, complements TSB funded research on Low Impact Systems and Building Materials carried out by DRUw, which resulted in the **innovative timber construction system, Tŷ Unnos**. DRUw also designed the **LCRI Tata SBEC building**.

Collaborative research with other disciplines

The School is strongly interdisciplinary in its makeup. It also engages with other disciplines across the University and beyond. There are strong collaborations between researchers working on the **historical analyses of energy transitions** (Pearson) and in the AHTG (Davis). The AHTG participates in Humanities Connect, a Cardiff University initiative that encourages and supports innovative and collaborative research across the Humanities at Cardiff. It acts as a forum for events, research strategy and cross-school themes, both internally and externally. The work on **human interaction with the built environment** in SuDoBE draws on phenomenology (Tweed), which also features in research in history and theory within the School (McVicar). Poortinga has long-standing links to psychology and medicine with his work on **environmental risk perceptions and housing & health**. Research in ASG addresses more than technical issues and engages with researchers in social sciences and geography in three EPSRC funded projects: *Carbon, Control and Comfort (EP/G000395/1)*, *Re-Engineering the City 2020-2050 (EP/I002162/1)*, and *Conditioning Demand (EP/H051082/1)*. Through the LCRI the School works with engineering schools at Cardiff and Swansea, Chemistry at Bangor and Glyndwr, and hydrogen research at Glamorgan, linking, for example, **building integrated photovoltaics** (PV) with new PV developments (Glyndwr), power electronics (Swansea) and energy storage (Glamorgan). **The LCRI has established four low carbon research centres** in Tianjin University (2010), Chongqing Municipality (2011), Nanchang University (2011), and South China University of Technology, Guangzhou (2012). These centres are collaborating with the School on guidance for sustainable low carbon urban master-planning and building design, on joint research proposals and facilitating student exchange between Wales and China.

Future plans

We will continue to develop four main research themes: **low carbon futures, people and buildings, architecture and its cultural context, and design research**. The three current research groups work well as organising structures to manage research and promote interdisciplinary collaboration. The ASG, which has doubled in size since 2008 and includes more than 40 funded staff and research assistant/associates, contains four Special Interest Groups (SIGs): low carbon and energy transitions (Eames, Pearson, Jones, Lannon), modelling and simulation (Jones, Lannon), building performance evaluation (Tweed, Knight, Jones, Poortinga), and people and the built environment (Poortinga, Tweed). We plan to introduce further Special Interest Groups across group boundaries and that will include colleagues from other UoAs in the College of Physical Sciences and Engineering and across the University.

The LCRI will build on its work on the low carbon built environment, linking the built environment to future energy supply options. It has recently embarked on a new £2.9M project, Smart Operation for Low Carbon Energy Regions (SOLCER), which focuses on combining technologies in energy supply, energy demand reduction and energy storage. The LCRI will continue to target key areas of low carbon energy transitions, with a strong focus on Research Council (mainly EPSRC & ESRC) and Horizon 2020 funds (e.g. WSA leads the 27-country Smart Energy Regions COST Action [Jones] and the Wales Higher Education Brussels European Research Low Carbon

Coordinating Group [Pearson]). We will continue to foster the sustainability transitions research, to consolidate our reputation as an international centre in this emerging field.

SuDoBE has secured continued support from BRE following its initial five-year agreement. It will continue to address issues around relations between people and the built environment. It is involved in research funded by NIHR (Poortinga, Tweed) on health and comfort in dwellings low-income households and deprived communities receiving energy upgrades. We see this area acquiring increasing importance as energy prices continue to rise.

The Architectural History and Theory Group aims to grow its strength in:

- research on responsive and **sustainable urban realms** and public spaces (Davis);
- exploring the interplay between concept, representation, and experience in the histories, construction, and conservation of architecture (Kite, Odgers);
- applying intimate knowledge of South Asian architectural traditions to interpretation of canonical texts, theoretical and actual reconstruction of lost built heritage, and new designs (Hardy).

The progress made in developing a design research portfolio, which began in the RAE 2008 period, will remain a priority for future development. The DPRG aims to:

- continue the trajectory of establishing design as a research discipline in its own right (Salter, Forster);
- develop further the testing of ideas, materials and systems through **real life prototyping** and **advanced digital making** methods (Forster, Jabi); and
- develop further the area of **sustainable retrofit and conservation** (Prizeman, Forster, Tweed).

Two areas have been identified as Special Interest Groups to enrich interdisciplinary research:

- the School's growing expertise and interests in cities and urban modelling, which is already evident in the work of the LCRI (Jones, Lannon), combined with research on urban retrofit and energy transitions (Eames), resilient cities (Davis) and user-centred urban design (Tweed); and,
- the confluence of interests and on-going research into retrofitting traditional buildings (Tweed), **architectural conservation** (Hardy, Prizeman, Forster), and construction (Forster, McVicar).

The School aims to play a leading role in the University's plans for interdisciplinary research, University Research Institutes and the developing £250M Innovation System.

c. People, including:

i. Staffing strategy and staff development

The School follows the seven key principles of the **Research Concordat** in its recruitment and support for appointed research staff. Since 2008, the School has made seven strategic appointments. Our strategy has been to: (a) strengthen leadership and expertise in socio-technical approaches to built environment research (Pearson, Eames, Bleil de Souza); (b) extend our current expertise in sustainable cities (Eames, Davis), health and well-being in the built environment (Poortinga), and energy modelling (Bleil de Souza, Ampatzi); and, (c) develop new lines of research in architectural conservation (Prizeman). Four of the appointments are researchers at the early stages in their careers. Professor Pearson joined the School as LCRI Director in 2010. He has attracted EPSRC funding to investigate transition pathways, carbon capture and storage and public attitudes to changes in the UK energy system. Professor Eames was appointed as Research Chair of the LCRI in 2009 and has secured large grants from EPSRC on urban retrofitting and on hydrogen. Dr Bleil de Souza was appointed (2008) as a Lecturer in the School after completing a BRE-funded PhD on energy modelling. She has secured and completed an EPSRC award under the First Grant scheme, and provides a focus on the use of simulation tools in the design process. Dr Ampatzi is an ECR who completed her Masters followed by a BRE-funded PhD at WSA and brings a focus on energy storage to the School. Both of these appointments consolidate and extend existing expertise in ASG. Dr Davis' recruitment in 2012 as a Senior Lecturer with an interest in urban regeneration and the resilience of cities provides a further link between the AHTG and sustainability research in ASG. Dr Prizeman, also appointed as a Senior Lecturer in 2012, brings insights to DPRG from her background as a practising architect with a commitment to developing theoretical understanding of the conservation of buildings. In

2008, Dr Poortinga was appointed as a Senior Lecturer in 2010 based full time in the Welsh School of Architecture, but maintains strong links to Psychology through jointly funded research projects. Federico Wulff joined the School in 2013 as a Marie Curie Research Fellow and is working closely with Dr Davis on cities and regeneration.

The School is committed to helping staff achieve their full potential at all stages of their careers, and benefits from Cardiff University's commitments to training and development through the *Investors in People* framework and the *Research Concordat*. The School is committed to initiatives to enable all staff and students to achieve their potential, and is working towards an Athena Swan Silver Award with a committee reviewing evidence and changing processes, led by a senior team, including the Head of School. The School is rolling out a recently developed **Workload Model** to ensure equity and balance. There are development courses, including workshops on postgraduate supervision, leadership, project and performance management, for all research active staff and these are frequently used (over 140 course attendance registrations by School staff in the period).

All staff benefit from internal appraisal procedures that review research progress against agreed objectives and identify support needs. Recovered indirect costs are returned to investigators (currently 25%) for reinvestment in strategic travel, equipment, and PGR support. Staff have access to additional funds through the Research Committee which provides an individual allowance of £750 p.a. to support their research. Bid preparation is supported by **Internal Peer Review**, which offers proposers early feedback from experienced colleagues. Linked to this, the School has introduced a mentoring scheme for junior researchers. The University supports early career researchers through the *Cardiff Futures* programme, which is a competitive programme designed to support early career academics to develop their career path and to explore how they might contribute to shaping the future of our University. The programme also seeks to promote collaborative working across disciplines. Four staff (McVicar, Gwilliam, Bleil de Souza, Ampatzi) have benefitted from this initiative and four (Bleil de Souza, Lannon, Patterson and Poortinga) have benefited from the University's *Leadership and Management Development Programme*, for which the University won a Times Higher Award. This programme is aimed at staff with existing experience in research and helps them move towards the next stage in their research careers. Professor Kite has been successful in securing a year of leave through the University-wide competitive Research Leave Scheme, which offers £10k for teaching cover and £3k for research related expenses, to carry out research on a monograph, *Light's Dark Brother: the story of architecture and shadow*.

In 2010, the School introduced dedicated **research weeks** four times per year. These encourage staff to focus on research with minimal distraction from teaching and administration. Mini conferences are held twice a year, at which papers from the different research groups are presented alternately to encourage staff from different disciplines to listen to talks outside their area of expertise. Research seminars take place all year round. In 2012, the School launched a Working Paper series to promote the work of its researchers in a timely way. An "Energy Transitions" seminar series has grown from new interests in transition pathways and socio-technical aspects of energy in the built environment. The series, organised jointly with Cardiff University's Sustainable Places Research Institute, has invited speakers from across the UK.

The School operates a Research Ethics Committee to oversee the conduct of research involving human subjects. The Committee consists of representatives from the School staff, a PGR student, one representative from another school and one from outside the University.

Staff support through the provision of equal opportunity

The support offered to researchers is discussed by the School's Research Committee and approved by the School Executive, which includes the Director of Staffing. Implementation of the School's recently developed Workload Model includes time for PGR and RA supervision, funded research projects, generation of research outputs, engagement with research beneficiaries, management and "citizenship" in their research group and School-level research activities (for example, seminars and away days). All RAs are affiliated with a primary research group, and are encouraged to participate in their group meetings.

These provisions are complemented by University level support, including networks for female

research staff and for research leaders. The University received an award from the *Times Higher* for its research leadership programme in 2010 and has also been recognized for its *HR Excellence in Research* by the European Commission.

ii. Research students

The School has maintained a high level of PGR successes, graduating 27 students in this period. This has been achieved by developing more stringent review procedures for registered students, providing training for supervisors, accessing funding for PhD research and clear marketing of research interests on our web pages. The School has secured competitive studentships from AHRC, BRE Trust, EPSRC CASE Awards and a Knowledge Economy Skills Scholarship (KESS).

Each PGR student has two supervisors. A panel, consisting of the Director of Postgraduate Research Students, the relevant research group chair, and the first supervisor, reviews progress every six months. For annual reviews, the University's *Research Degrees Code of Practice* requires submission of a current research plan and a substantial piece of written work (e.g. a thesis chapter) and an interview with a panel. The interview produces a documented outcome and, at the end of the first year, a progression decision. Training and development needs are analysed on an annual basis. Much of the training is provided by the University's Graduate College, offering courses that contribute to the efficient management of research studies but also to personal development and future employability. PGR students in the WSA have attended more than 540 courses in the current period. Students are allocated £500 each year to be spent on a conference trip or an item of research equipment subject to approval. Students are invited to attend the regular research weeks and run a PGR seminar series and annual conference for staff and students.

The University provides funding for interdisciplinary academic activities through the University-wide Graduate College, which brings together postgraduate research students from different subject areas. These funds, which are awarded competitively, were won by students Kenan Zhang in the WSA with Xuezhi Liu (from Engineering), to set up a forum and organise a series of seminars to examine 'Flexible Energy Delivery System'. The school also runs a low carbon summer school for potential PhD and PGT students.

d. Income, infrastructure and facilities

The income for the period was £10.5M, which represents an increase of 260% over RAE 2008. The School attracted 21% of its research income from RCUK as well as significant support from UK Government sources (65% of income). In addition to the Welsh European Funding Office (WEFO) award (£19M) listed above, significant grant successes in this period include:

- £2M (total) EPSRC/E.ON consortium, *Transition Pathways to a Low Carbon Electricity Sector* (2008-2012), with partners at Bath, Imperial, Loughborough, Strathclyde, Surrey, UCL, UEA: EP/F022832/1 (Pearson, £259k));
- £2.5M (total) EPSRC, *Realising Transition Pathways* (2012-2016), with partners at Bath, Imperial, Loughborough, Strathclyde, Surrey, UCL, UEA: EP/K005316/1 (Pearson, £341k);
- £1.7M (total) funding from NIHR for various projects (Poortinga, Tweed and Lannon);
- £2.7M (total) from EPSRC for the collaborative project, *Re-Engineering the City 2020-2050: Urban Foresight and Transition Management*, with partners from Salford, Cambridge, Oxford Brookes, and Durham (Eames, Lannon, Tweed, £2.7M);
- £2M (total) from EPSRC/EOn for *Carbon, Control and Comfort: User-centred control systems for comfort, carbon saving and energy management* with UCL (lead), Durham, KCL, Loughborough, Greenwich, De Montfort, and Leeds Metropolitan universities (Tweed, £392k);
- £600k (total) from EPSRC and EDF for *Conditioning Demand: Older People, Diversity and Thermal Experience*, with Manchester (lead), Lancaster and Exeter (Tweed, £161k);
- €3.3M (total) for the pan-European iSERVcmb project, funded by the Intelligent Energy Europe (IEE) scheme, working with SME's, multi-nationals, schools, universities and professional bodies in the UK and Europe—the largest award from the IEE programme (Knight, £445k);
- £2.8M (total) EPSRC with SPECIFIC/Swansea, for Buildings As Power Stations (Jones, £116k);
- £20k (total) British Council grant in collaboration with Illinois Institute of Technology, Chicago, Illinois; The University of Illinois at Champaign-Urbana, Illinois; The Art Institute of Chicago,

Chicago, Illinois; and Carnegie-Mellon University, Pittsburgh (McVicar, £20k).

The School has support staff (1.5 FTE) for digital illustration, web design and maintenance and photography. There is administrative support (1.8 FTE) to organise research-related events and the School also has a post (0.5 FTE) dedicated to supporting communications and media. All researchers in the School have direct access to and support from the Advanced Research Computing facility at Cardiff University. This delivers capability and capacity for large-scale simulations, data analysis, storage and visualisation and is one of the largest and efficient academic supercomputer facilities in the UK.

e. Collaboration or contribution to the discipline or research base

The School leads and contributes to key research networks, notably the LCRI's role in leading a group of universities across Wales, which has created a template for similar centres in China, and SuDoBE's role as one of the BRE's University Centres of Excellence. These are models of collaboration, having engaged with researchers across the University, Wales, throughout the UK and internationally, particularly in Europe, China, India and the Middle East. The School is also engaged with the University Research Institute on *Sustainable Places* (PLACE), and runs its own dedicated meetings and seminars that are open to university colleagues and others.

At national level, the School provides professional leadership by liaising directly with Welsh Government and chairing committees: E.On International Scientific Advisory Board (Pearson); Advisory Board for the Carbon Trust's Carbon Trust Standard (Pearson); Welsh Building Regulations Advisory Committee (Jones); and, Sustainable Living workstream for the Wales Low/Zero Carbon Hub (Tweed). The School (Eames, Pearson, Poortinga and Tweed) also works with UK Government including the Treasury, DECC, DEFRA, and DCLG. The LCRI involves industry—Tata Steel—directly, but also includes others as "enterprises assisted" to boost the local economy. National interdisciplinary collaboration takes place through funded research with UCL, Cambridge, Durham, Loughborough, Reading, Greenwich, KCL, Bath, Salford, Manchester, Exeter, Lancaster, De Montfort, Swansea, Oxford Brookes, and Leeds Metropolitan in projects Communication in Urban Civil Engineering Projects (Tweed and Lannon). European FP7 funding has supported collaboration with industry and NGOs across Europe, including VTT (Finland), SINTEF (Norway), Technalia (Spain) and EKK (Estonia). The School (Knight) has led two IEE funded projects (HARMONAC and iSERVcmb) involving industrial collaborators—CIBSE (UK), REHVA (Europe), SWEGON AB (France), Camfil Farr and SKANSKA. The Ashapuri Indian temple project (Hardy) is in collaboration with the School of Planning and Architecture (SPA), Bhopal. Contributions to the research base can be summarised as:

- innovations in low energy systems and facades through collaboration with Tata Steel via the LCRI SBEC Research Centre in Shotton, North Wales;
- working with industry internationally (Atkins Dubai, Hyder Hong Kong, Kopitsis Zurich) on applying low carbon research through major design projects (case study impact);
- understanding of socio-technical issues surrounding energy transitions and urban retrofit;
- new methodologies for building performance evaluation—co-heating of low energy buildings, accurate thermal comfort surveys, and benchmarking procedures (NHBC);
- new knowledge about Indian temple architecture supporting renovation and new designs; and
- new knowledge and understanding of the work of key figures, such as Ruskin and Stokes.

Keynote addresses include PLEA (Tweed); Allchin Symposium (Hardy); Tianjin International Forum for Heritage Protection (Jones) and INSITE13 (Tweed). Editorships undertaken by School staff include *Energy Journal* and the *Journal of Natural Resources Policy Research* (Pearson); *South Asian Studies* and *Journal of History and Social Sciences* (Hardy); *arq* (Kite, Odgers, Gwilliam); *International Journal Building Simulation* (Jones) and *Indoor and Built Environment* (Jones). Awards received by School staff include: RIBA Honorary Fellow 2011 (Salter); Japan Society for the Promotion of Science Invitation Fellowship (Poortinga); and for research based designs (Forster)—Margam Environmental Discovery Centre (RIBA, 2010), and Trevithick Library (Standing Conference of National and University Libraries Award for Small Project 2011).