**Institution: Edinburgh Napier University**

**Unit of Assessment: 16 - Architecture, Built Environment and Planning**

**a. Overview**

Research in Architecture, Built Environment and Planning (UoA 16) at Edinburgh Napier University (ENU) is focussed on working with industry and Government to promote research and innovation of relevance to the wider community. The Research and Innovation Centres are housed in two leading Research Institutes: the Institute for Sustainable Construction and the Forest Products Research Institute and include the:

- **Building Performance Centre:** building and environmental acoustics, noise and vibration;
- **Scottish Energy Centre:** energy performance of buildings and building services, micro-renewables and occupant behaviour;
- **Centre for Offsite Construction:** construction systems, modern methods of construction, with specific expertise on timber systems, erection sequences and lean building;
- **Centre for Timber Engineering and Wood Studio:** innovative use of timber and reconstituted materials in architecture and construction;
- **Centre for Sustainable Communities**: community planning, urban regeneration and smart city development.

Supported by 4 Professors, 2 Readers, 7 Research Fellows and 3 Research Assistants, each of the Centres works in the applied sciences and collaborates with industry, government and the third sector to produce innovations in the design, planning, construction and regulation of the built environment.

**b. Research strategy**

In the RAE 2008, it was stated:

"*over the next five years [this UoA] shall further develop its research nationally and internationally through the Sustainable Development Group* and *Building Performance Group*. *This will be achieved by continuing to focus its fundamental, strategic and applied research on issues relating to the design, planning, construction and regulation of the built environment (urban fabric, buildings and components), so as to assist in the creation of wealth, enhance the quality of life and contribute towards social well-being. The strategy shall capitalize upon the research partnerships developed during the present assessment period and further develop these in a multi-disciplinary environment covering energy consumption, carbon emissions and sustainable development."*

The implementation of this strategy means the 5 Research Centres now provide this multi-disciplinary environment for the UoAs research and innovation. This has been secured during the current period of assessment by the formation of the 2 umbrella Institutes in which the 5 Centres are located. During the current period, the UoA's objectives have been to:

- foster and support high-quality applied and near-market research and innovation, by way of product developments and through system adaptations that in turn lead to patents which regulate the design, planning and construction of the built environment;
- enhance the research environment, leadership and quality of research training, as is evidenced from the investment made in the PhD students and Graduate Training Assistants;
- offer staff the opportunity to present papers at national and international conferences and cultivate an inter-disciplinary partnership approach to research and innovation that cuts across the Research Centres and which capitalises on the opportunity these developments offer to leverage knowledge partnerships;
- embed a culture of enterprise and innovation across the Centres. In this regard the UoA actively encourages staff to always consider the commercial application of their research in terms of the opportunities this offers for KT partnerships. This is demonstrated by way of and through the 18 new innovative construction products the UoA has licensed to UK and multinational manufacturers during this period;
- draw upon a corporate social responsibility strategy to widen the UoA's network and extend the Centres' engagement with key stakeholders. This is achieved by supporting outreach

developments and contributing to debates on the contribution government policies make to the public's quality of life and social well-being;

Progress in meeting these objectives is monitored annually by the University and evaluated alongside other peer group institutions in the UK's research and innovation sector. These key performance indicators cover: research grant awards, KTPs, patent applications, publications in journals, PhDs and knowledge exchange with industry and government both national and international. Since 2008 the UoA has emerged as the national leader in knowledge transfer (KT). No other University in Scotland works with as many industrial partners and government agencies in terms of the research, innovation and key advisory services the UoA offers. Since 2008 the UoA has also received 20 awards recognising the contribution it makes to industry and government. Out of this list of prizes, 13 are for national awards and 6, the equivalent of 30% recognise the international excellence of the UoAs contribution.

The focus of the UoA over the next 5 years will be to:

- continue supporting EPSRC, ESRC and EC programmes that allow the design, planning and construction sectors of the built environment to meet industrial needs and societal requirements;
- further extend the UoA's knowledge partnerships with industry and government via a £3.5 million investment in a new multi-function construction research testing and laboratory facility that commences in 2014 and which interlinks with the forthcoming Construction Scotland Innovation Centre;
- build further upon the positive legacy of research staffing and collaboration by the Scottish Energy Centre, particularly in relation to building retrofit, energy performance gap analysis and occupant behaviours. These align strongly with government initiatives (2020 Climate Group and Retrofit Scotland) where staff serve on these groups;
- expand the existing international linkages from 32 countries to 45 by building on current leading edge projects in France, Brazil, Russia and North America;
- enhance the success of the EPSRC and EC funded programme within the Centre for Offsite Construction by investing in the production of timber engineering software distributed internationally to approximately 16,000 engineers;
- draw upon the EC's Smart Cities and Communities Programme to further the Centre for Sustainable Community's research into the urban design and planning of digitally-enabled infrastructures capable of saving energy, reducing carbon emissions and adapting to climate change. This will be achieved by drawing upon these scientific and technical innovations as a way for the built environment to adapt to climate change and transfer the knowledge needed for the public to sustain these developments.

**c. People, including:**

**i. Staffing strategy and staff development**

The European Commission (EC) HR Excellence in Research Award recognises the University's commitment to support the career development of researchers at Edinburgh Napier. The University gained the award through a detailed analysis of the existing policies, followed by the development and implementation of a robust action plan. The resulting strategy for "Effective Researcher Development" is endorsed by the University Research and Knowledge Exchange Committee, Research Degrees Assessment Board and the Academic Strategy and Enhancement Committee. This strategy focuses on the development of early career and established members of staff involved in either student supervision, funded, or contract research. This is supported by a "Researcher Development Framework" that maps career development against training programmes and which matches them with the needs of the researcher. The value of these programmes has been recognised nationally through a THE award in 2010 for Outstanding Support of Early Career Researchers (Edinburgh Napier chaired the award-winning team, the Universities Scotland Research Training Sub-committee). The University Code of Practice on Research Integrity and Ethics complements this concordat by providing for day-to-day ethical issues researchers encounter, including issues such as authorship guidelines and informed consent. Researcher development conferences have also been held on topics such as *'Supporting Researchers at Edinburgh Napier'*, '*Fostering inter-disciplinarity in learning, teaching and research at Edinburgh Napier*' and '*Linking research and teaching to enhance learning'*. The University is also committed to the principles of Athena Swan which promotes gender equality for women in

Science Engineering and Technology (SET) research. The University also hosts and provides funding to support the Scottish Resource Centre for Woman in SET which works closely with Construction Skills, government and construction industry organisations.

The implementation of the Researcher Development Framework and Code of Practice within UoA 16 has been successful in establishing 4 new Professorships, 1 Reader, 4 Research Fellows and 2 Research Assistants, by way of staff promotions and through a series of new appointments. This staff profile is further complemented by a series of 28 funded internships for graduates and postgraduates within the Research Centres of which 93% are now in employment in industry or other HEI Research Centres. The University now formally recognises industry and government-related research activity as part of their professorial promotions. Two of the UoAs new Professorships have been awarded on this basis. These have the remit to promote high quality research impact by way of industrial applications and through the work they undertake to set government standards. One of these Professorial posts has been awarded a BRE Trust Fellowship in recognition of this research impact.

**ii. Research students**

Research student degrees are governed through the School of Engineering and the Built Environment and at Faculty level. Each student is allocated a supervisory team from the research centres consisting of three academics - a Director of Studies (DoS), a Second Supervisor (SS) and an Independent Panel Chair who comes from outside the research focus area. Regular supervisory meetings between the DoS, SS and student are held. The panel meets formally twice a year to monitor developments and produces a report on progress which is approved at School level and reported to the Faculty Research Degrees Management Group. This group monitors the progress of each student across the Faculty against a clear timetable of expected outputs and passes key information to the University Research Degrees Assessment Board.

This arrangement has been successful in enhancing the Unit's PhD completion rates. In addition to producing 8 PhD completions during this REF period and a further 15 registrations, it has enabled early career researchers to gain higher degree supervision experience and students to work in a field of expertise they are recognised for. The University has also put £200,000 into the funding of the UoA's PhD studentships during this REF period. The University Research Degrees Assessment Board (RDAB) approves the appointment of the research degree examination panels. It in turn devolves quality control to the Faculty Research Degrees Management Group. This Management Group scrutinises the composition of supervisory panels and ensures appropriate resources are available. A Faculty-wide programme of research training has been established for all PhD and other research students. This covers the essential issues and milestones over the three years of study (full-time and part-time equivalent) and ties in with the record of postgraduate development and skills audit that is maintained by each PhD student.

Training and skills development is delivered through several mechanisms:

- the centrally-delivered Researcher Development Programme of professional development activities aimed at enhancing research practice;
- School-based training events and fortnightly research seminars for students to present their work to staff and students from all Centres;
- Faculty-based training programmes for research students

This model allows provision of generic and subject-specific skills to be delivered across the University in a tailored manner. From the commencement of their candidature research students are encouraged to participate in appropriate national and international conferences to disseminate their research work. For example; in 2011-12 the Research Centres directly funded over 60 knowledge exchange presentations at national and international academic or industry conferences. As research students progress through their candidature they are encouraged to publish their research work in relevant refereed journals. Most research students have a good publication record by the end of their candidature. The University's Researcher Development Programme is open to all researchers regardless of career stage. Through a co-ordinated, cross-University approach to education, training and professional development it ensures that research students are integrated into the research community. The University also provides specific induction sessions for research students, allowing them to plan out their own professional development and

to network with the wider cohort of students. The University's "Supervising Research Degrees" Course has been formally recognised by the Staff and Educational Development Association.

**d. Income, infrastructure and facilities**

In terms of income, UoA 16 has generated approximately £3,500,000 of research funding between 2008 and 2013. This has been secured from a variety of sources including: the UK's EPSRC, ESRC, Technology Strategy Board (TSB) and Knowledge Transfer Programmes (KTP), EU Framework 7 and INTERREG budgets. This has leveraged a further £1,100,000 in industry demand-led applied research funding and a further £530,000 in industry funded test laboratory infrastructure and equipment.

**Research Councils:**

- LfWWs (Learning from What Works in Sustainable Community Development). Funded under Economic and Social Research Council's (ESRC's) **Sustainable Communities Programme** (£60,000) 2007- (Sept) 2008. Edinburgh Napier directed this project, the partnership included Salford University. (Total fund £92,000). RES-182-25-0004.
- SURegen (Sustainable Urban Regeneration) Funded under Phase 2 of the Engineering and Physical Sciences Research Council (EPSRC): **Sustainable Urban Environment Programme** (£290,000) 2008-2012. Edinburgh Napier was responsible for diagnosing what users need from this decision support system. This included Salford University, University of Manchester, Dundee University and Cardiff Metropolitan University (Total fund £2,400,000). EPSRC Ref: EP/F007213/1.
- EPSRC: £125,999, 2010-2012 for a project entitled "**Structural Optimisation of Timber Offsite Modern Methods of Construction".** This generated novel technical solutions and innovative products that form the timber closed panel system solutions of the future. The project engaged with multiple industry partners leading to new structural engineering software launched at Ecobuild 2013.

**Government:**

- Dept of Energy & Climate Change (DECC): **Acoustic noise measurements of air source heat pumps**. 2010-11. (£56,000). This unique multi-field trial research project led to specific guidance now incorporated into planning guidelines (The Town and Country Planning (General Permitted Development (Amendment) (England) Order 2011) for permitted noise levels and distance factors to adjacent residential properties.
- Dept of Environment, Food and Rural Affairs (DEFRA) – **Attitudes to Environmental Noise from Concerts**. 2009-10. (£113,000).The project provided in-depth concert noise measurements and interviews of over 1,700 residents near major open air concert venues. Results were then applied into the UK Code of Practice used by all local councils for permitted concert noise levels.
- Scottish Government (SFC SPIRIT Award) - **Low Carbon Housing** (LCH) - £455,000, 2010-13. Investigating technical compatibility for LCH for energy, structural and acoustic requirements. This project leveraged a further £2.2 million in ERDF and industry KT / contract projects and assisted in supporting the development of over 280 new products and systems for industry.
- Scottish Government – **Review of the Offsite Construction Sector** - £40,000, 2011-12. This reviewed the growth of the sector and 17 key companies. The project outcomes then leveraged £10 million of government investment into the Greener Homes Innovation Scheme leveraging a further £15 million from housing associations and industry for 13 new build construction sites.

**Industry:**

- TSB: **Building Performance Evaluation** - £25,258, 2011-2012. The Quarries Sheltered Accommodation post occupancy study. An 'as-built study' of building energy efficiency. Edinburgh Napier University – Scottish Energy Centre, collaboration with Misia Jack Consultancy, Assist Design Architects and Dunedin Canmore Housing Association. Total funding allocated: £37,885
- TSB: Knowledge Transfer Partnership (KTP) £106,466. 2011 – 2014. Development of a nanotechnology solution for the **Retrofit of Older Properties**.
  Edinburgh Napier University – Scottish Energy Centre, A. Proctor Group Ltd.
- TSB: July 2010. £36,750. Research project entitled "Concierge" under the Technology

Programme Integrating **Smart Meters into Systems in Smart Homes**. Tayeco Ltd, Edinburgh Napier University – Scottish Energy Centre and Dunedin Canmore Housing Association. Total project cost: £98,845

- **Hybrid Racking** Scottish Enterprise – SCORE Funding, £75,000, 2009-2012 to work with industry partners Oregon Timber Frame Ltd, Cullen Building Products Ltd and ETA Fixings UK Ltd in quantifying variables that affect the racking performance of timber platform frame walls by means of calculation and laboratory testing in order to derive optimised system solutions. This work has been intrinsically linked with the British Standards Institution and the development of a unified Eurocode design methodology for timber frame racking walls.
- A series of three Forestry Commission funded projects (totalling £75,000) under the collective title: **Durability Grading of Larch** (2005-08). Edinburgh Napier University set up and led the projects. Project partners were: TRADA Technology, BRE, Imperial College, Forest Research and CSIR (Durban, South Africa).
- **Development of Timber Cladding Systems** (2009) funded by SCORE (£60,000). Edinburgh Napier University set up and delivered the project on behalf of Russwood Ltd in Newtonmore.
- **Development of a Standard for Dried Timber Pallets** (2013) funded by TIMCON (£22,000). TIMCON is the membership organisation for timber pallet producers in the UK.
- **KTP Programme with Diageo**: £181,513; Duration: 2008 - 2011.To optimise the design of the traditional Oak whisky casks to improve maturation performance and reduce whisky loss; to develop a novel cask that is less costly to manufacture, reuse and store. The programme was awarded the highest grade of “Outstanding”.
- **KTP Programme with Simpson Strong-Tie**: £145,202; Duration: 2008 - 2012).To develop a structural element for the timber frame market that provides efficient racking resistance to multi-storey timber-frame buildings and facilitates design for large openings. The programme was awarded the highest grade of “Outstanding”.
- **KTP Programme with Icopal-Monarfloor**: £202,000; 2009-12. To develop thin membrane isolators for thermal and acoustic drivers in low carbon housing. Led to 3 patents and 9 products and generated over 50% of company turnover by year 3. The programme was awarded the highest grade of “Outstanding” and has been shortlisted for UK KTP Final Awards 2013.

**EU funded projects:**

- EC (INTERREG IVB) funded project on **Smart Cities**: €300,000, 2009-2012. Edinburgh Napier directed the academic component of this project. This included: Amsterdam University, the Free University, Amsterdam, Turin Polytechnic, Groningen University, Agder University, Osterholtz University, Karlstad University and Mechelin University (Total fund €3,400,000).
- EC (INTERREG IVI) funded project known as **CLUE** (Climate Neutral Urban Environments): €180,000, 2012-2015. This project is directed by Professor Niles Brandt, from KTH, Stockholm. Edinburgh Napier leads the benchmarking component of the Climate Neutral Urban Environment developments this project shall implement. This work is also supported by Delft University (Total €2,000,000).
- Contract Research Projects funded by the EC’s Institute of Technical and Prospective Studies (IPTS) on **EXGOV and eInclusion** (€12,500): 2011-2012. Collaboration with the Cities of Barcelona, Berlin and Tallinn (Total fund €25,000).
- Contract research funded by the European Investment Bank (EIB) as part of an investigation into the potential of **Smart and Sustainable Cities** to act as a vehicle for restructuring the European Regional Development Fund (£10,000): 2011-2012. Collaboration with Mazares, WSP and Jones Le Salle (Total fund €60,000).
- **EracoBuild Star Project**: (Sustainable Thermal and Acoustic Retrofit) £65,000, 2012-2014. This UK project (£255,000) focuses on retrofit technical compatibility for dwellings between energy efficiency improvements and other technical standards. BRE Scotland - Lead partner, Housing Directorate, Scottish Government, Historic Scotland, Institute for Sustainable Construction, Edinburgh Napier University, Edinburgh, UK – subcontract partner. This is part of a 3 country partnership. Total fund: €1,598,869 involving Passief Huis Platform (PHP), Belgium, Lund University and Faculty of Engineering, Sweden.

- **CIC START ONLINE -** European Regional Development Fund (Lowlands and Uplands Scotland 2007-2013 programme) and SEEKIT programme of Scottish Government. 2011-2013. Various KT contract and consultancy support projects aimed at energy efficient solutions in the built environment. The Scottish Energy Centre based in this UoA undertook the most projects of any of the 9 HEI partners. Total funding £48,000.
- **Exposure Trial of External Timber Cladding** (£145,000 funded by the EU Northern Periphery Programme and national co-funders). This was part of a larger trans-national project running from 2004-08 and spanning Scotland, Norway, Iceland and the Faroes. Edinburgh Napier University delivered the exposure trial as a research contractor to the project.
- **Development of British Standards for External Timber Cladding** (£20,000). This project (2012-13) was funded through Edinburgh Napier University's Wood Products Innovation Gateway (WPIG) project supported by the European Regional Development Fund, and national co-funders.

**Infrastructure:**

Edinburgh Napier University provides all the infrastructure support for research that would be expected from a modern university. There is a Vice-Principal responsible for research and an Assistant Dean who leads research and innovation strategy within the faculty. The University has invested over £850,000 towards research staff and facilities in this UoA. The University-wide Research Office provides staff with support for obtaining and managing externally funded research activities. Support for knowledge exchange (KE) activities is provided centrally through the commercialisation office and at faculty level where business development managers work with staff to exploit opportunities for KE.

During 2008-13 the University supported the UoA in a strategic partnership with the Building Performance Assessment Centre where large scale test rigs for structural timber and full scale apartment buildings were constructed with industry partners. Industry laboratory test infrastructure investment was £530,000 and the UoA Research Centres invested over £120,000 towards specialist test equipment. The Building Performance Centre provides specialist research for noise, vibration, acoustic product testing, air tightness and thermographic equipment. State-of-the-art Bruel and Kjaer monitoring equipment for environmental noise is provided in addition to a multi-channel PULSE system for vibration analysis in buildings. The Scottish Energy Centre offers renewable and micro-generation technologies. This Centre has made key contributions in the area of photovoltaics and infra red thermographic expertise, now integrated with hygrothermal analysis and modelling capabilities and widely applied in the construction sector. The Centres for Offsite Construction and Timber Engineering provide a climate controlled timber testing laboratory equipped with the latest testing and data acquisition machines including torsion tester, two large racking frames, large beam testing rigs and a range of acoustic non-destructive testing equipment including field tools, as well as drying and conditioning facilities. The Centre for Sustainable Communities assembles open source software platforms for inter-operable public service delivery and subsequent integration of these technologies into the e-learning, knowledge management systems and digital libraries that not only underpin the morphological, socio-demographic and cultural transformation of the built environment, but which also support improvements in the quality of life.

**e. Collaboration and contribution to the discipline or research base**

**Professor Smith** is Director of the Institute for Sustainable Construction and serves on a range of government-industry bodies including: the Industry Leadership Group Construction Scotland on behalf of Universities Scotland and the Robust Details Standards Committee (UK). He is also Chair of the: EU Cost Action TU0901 WG3 (involving 29 EU countries with Canada, Australia and New Zealand), Scottish Government Sustainable Procurement Group, external reviewer for the Belgian Government Science Policy Unit 2008, external assessor for the TSB's "Retrofit for the future" programme, invited member of the ISO-NP16717 Draft Working Group and a BRE Trust Fellow. He has also attended invited meetings and given presentations to the Secretary of State for Energy, Secretary of State for Scotland, Scottish Cabinet Secretary for Housing and Infrastructure, Scottish Minister for Energy, Enterprise and Tourism and Scottish Minister for Local Government and Planning. He has given over 30 industry invitational presentations at major conferences and company meeting. He has also given such presentations to the Italian Government (2010),

Swedish Timber Industries (2011) and British Chambers of Commerce in Hong Kong (2013). He is a founding member of the Edinburgh Centre for Carbon Innovation and serves on the Partnership Advisory Board with the University of Edinburgh and Heriot-Watt. He has also given evidence to the Scottish Parliamentary Committee on Energy (EET, 2012 & 2013) and in 2010 organised “The journey of Lego now and into the future” exhibition at the Edinburgh Science Festival for families and children. In 2013 he was nominated by 10 other Scottish Universities to lead the £10 million Construction Scotland Innovation Centre proposal.

**Professor Deakin** has collaborated with leading academics in the Universities of Amsterdam, Turin, Manchester, Salford, Stockholm, Delft, Thessaloniki and Karlsruhe since 2008. Industrial collaborators include: IBM, Microsoft, Mazares and WSP. He has also collaborated with the UK Central Government and Cities of London, Manchester, Edinburgh, Amsterdam, Barcelona and Malmo. This collaboration has led to publication of 5 books, 3 special issues of journals and over 20 articles on Smart and Sustainable Cities. He currently sits on the Editorial Boards of 4 Journals, has sat on the Scientific Committees of 5 International Conferences and Chaired 3 of them. He has also been on the Stakeholder Committees of the World Smart City Forum and EC’s Smart Cities and Communities Programme. In addition to acting as a reviewer for the Swiss, German, Italian and Finnish National Research Funding Councils, he is also a regular contributor to the press (Times, Guardian, Telegraph and Financial Times) on Smart and Sustainable City developments.

**Professor Kermani** is one of UK’s leading contributors to the development of timber engineering and is one of the few leading experts in this field. He is the co-author of Europe’s most authoritative book on Timber Engineering "Structural Timber Design to Eurocode 5". He is the appointed Principal Consultant to several leading UK and European structural and timber engineering firms and manufacturing industries including: Simpson Strong-Tie, Norbord, Finsa, Metsa Wood, Egger, and Weyerhaeuser. He has collaborated with standards agencies, local authorities and consulting engineers, construction and forest industries, research institutions in UK, European and North American universities. His collaborative research with academics includes, Lulea University of Technology, Sweden, University of Trento, Italy, Universidad Da Coruna, Spain, University of New Brunswick, Canada, North Karelia University of Applied Sciences, Finland and University of Applied Sciences, Germany. He sits on the editorial/advisory boards of 5 journals. He has also been reviewer/referee of national and international research proposals, including The Technology Foundation STW, Netherland; The Natural Sciences and Engineering Research Council, Canada; The Innovation Partnerships, Enterprise Ireland; Leverhulme Trust, EPSRC, UK; and COMET (Competence Centre for Excellent Technologies), Austria.

**Professor Currie** retains strong professional links with external organisations and is a Fellow and Past Chairman of the Institute of Energy, Chairman of the Energy Institute Accreditation Panel, Member of the Engineering Council - Engineering Accreditation Board, Co-Chairman of Scotland’s 2020 Climate Group and recently founded ‘Retrofit Scotland’. As well as chairing numerous academic accreditation panels both in the UK and abroad, he holds current External Examination posts with both the University of Strathclyde and University of the Highland and Islands. He regularly meets with Scottish Government Ministers to share knowledge and expertise on energy and fuel poverty and has been invited to chair and speak at numerous events including the Hong Kong Green Building Council, the Cross Party Group on Construction and Scottish Federation of Housing Associations amongst others.