Institution: London South Bank University

Unit of Assessment: 12 - Engineering

1. Unit context and structure, research and impact strategy

1.a. Unit Context and Structure

Our UoA 12 submission embraces research streams across the 4 divisions within the School of Engineering: Chemical Engineering; Electrical and Electronic Engineering; Computer Systems and Informatics; and, Mechanical Engineering, with 48.79 FTE staff. The range of expertise has enabled a viable delivery of applied, impactful, excellent quality and internationally recognised research across our areas of strength with a promotion of interdisciplinary collaboration across these core research areas. Over the last 5 years we have focused to optimise resource use and allocation to guarantee a thriving and sustainable research environment.

Research in the school is carried out through 3 research centres:

1. The **BioE**, (**Centre for BioEngineering)** – Specialising in imaging, nonintrusive and non-contact sensing, radar, applied artificial intelligence, applied anthropology and biomechanics, signal and image processing related to health and energy monitoring applications;
2. The **LCEE**, (**London Centre for Energy Engineering)** – The largest centre in the school performs research on energy generation, i.e. photovoltaics, energy storage, precision and additive manufacturing, materials for energy applications including nanomaterials, energy technologies and project implementation, i.e. heating and cooling and energy modelling; and
3. The **CSRC**, (**Cognitive Systems Research Centre)** – concentrates on areas covering smart internet technologies, cyber physical systems, robotics and automation, data science and machine learning.

To facilitate internal collaborative and interdisciplinary work, Research Centre (RC) members are also encouraged to hold appropriate affiliate membership roles with another RC with circa 65% of staff actively participating in more than one RC.

1.b (i). Research and Impact Strategy

Since the last REF we have strived to create a viable and thriving research environment. Our present and future trajectory follows three main themes:

1. **To be internationally recognised for high-quality research in our chosen areas of strength** (i.e., renewable energy, biomedical applications, materials engineering and robotics) as well as increasing **quality** in the closely related areas of applied bioengineering; material for energy and manufacturing; and distributed and cognitive systems;
2. **Presence and impact:** Creating meaningful national and international research partnerships for translational outcomes; and
3. **Continuity:** Research continuity by attracting high quality PhD students and securing research funding.

The main pillars of our REF2014-2020 strategy aimed to:

1. Improve our global presence for research **quality** in our chosen areas. In support of this aim, considerable **capacity building** took place, employing and retaining high quality staff ranging from experienced Professorial to early career appointments, evidenced below by a major growth (over 60%) in numbers of top-quality academic staff, a focused **facility and estates**

spend (building on previous REF strategy) to ensure staff and students have access to state-of-the-art facilities to execute their research and collaborate effectively with academic and industrial networks. This is evidenced by the enhanced research environment, facilities, organisational structure and management support (*highlighted below and evidenced in section 3*);

2. Focus on **high quality research outputs** evidenced by a 300% growth in outputs and 21% increase of publications in the top 10% of Journals in our UoA *(evidenced by REF 2);*
3. Create a **supportive environment** for staff and research students to flourish in, with a particular strategy to recruit future leaders and support with considerable startup;
4. Create and attract excellent **PhD opportunities** for high quality candidates via dedicated school scholarships and industrially match-funded positions. This is *evidenced by a 9-fold increase in PhDs awarded in 2019/20 compared to 2013/14 as shown below and in section 2;* and
5. Increase the quality and the quantity of **internationally recognised applied and impactful research.** This has been primarily **achieved through research and grant collaboration, grant leads and visiting fellowships** in selected areas of energy, applied materials for energy, manufacturing, bioengineering and cognitive systems. Testimony to the above is the fact that over this REF period, the UoA attracted a total of **£32.7m in** grants/contracts as lead and collaborating institution (a 128% increase since the last REF), **£16.3m** of these were directly allocated to LSBU over the review period (a 69% increase since the last REF - *evidence REF3 and sections 3 and 4).*

1.b (ii). Strategic Aims and Achievements

Progress since REF2014 included focusing on three main research themes of strength to target excellence for 2021 and beyond. We continue to exploit our strong relationships with industrial and academic partners and professional institutions, influencing research agendas (e.g. **Dagiuklas** and team cognitive system work has been noted for Britain's digital future: *Capability Framework and Research Agenda for a Digital Built Britain* document; and **Maidment:** A report on Refrigerant Leakage to the Refrigeration Technical Options Committee; as well as Advisor to the UK Government's Chief Scientific Advisor – November 2018 – present), engaging in fundamental and applied research to meet specific needs related to our research strengths.

The following achievements expand on the five aims listed Section 1.b (i), above:

(1) To improve our global presence for research quality in our chosen areas:
a) Focused capacity building with appointments of 4 experienced researchers at Professorial level, (**Barber**, **Dunn**, **Philbin** and **Upadhyaya**), 18 colleagues at Lecturer and Senior Lecturer levels from a wide range of institutions (in parentheses), including 14 ECRs with high research leadership potential that aligns with research priorities **Battersby (LSBU), Benson (LSBU), Berthaume (Imperial), Buckeridge (UCL), Chaouki (LSBU), Constantinou (UCL), Duan (LSBU), Durand (TWI-partnership), Harput (Imperial), Iqbal (Aalto, Finland), Khamsehnezhad (TWI-Partnership) Memon (Loughborough), Sajjad (St. Andrews), Zhu (Loughborough),** along with 4 mid-career staff appointments, **Cadenas (Kent)**, **Grisan**, **(KCL/Padova**), **Vilches (Brunel**) and **Bleay**, who joined LSBU with over 15 years industrial experience for government bodies in material engineering research that suited our materials engineering drive. Three Associate Professorial colleagues, **Goel (Cranfield)**, **Dagiuklas (Patras)** and **Tokhi (Sheffield)** joined the school, further adding to the school's international research reputation in our chosen fields.

Professorial appointments:
Barber joined from Portsmouth University bringing expertise and international network partners (e.g. GSK) in biomechanics.
Dunn joined from Deregallera Ltd, Caerphilly, where he was Head of Materials research, having previously held a Professorial position at Queen Mary University of London. This distinctive academic/industrial experience has assisted with research focus and partnership finding for the Energy and Materials teams (IUK Battery Management System).

Philbin joined from Imperial College London and leads our Nathu-Puri Institute, a £1.5m centre established through donation, which has allowed Philbin to a) enrich our teaching of engineering management in the school providing students with real-world expertise and b) initiate new partnerships with international institutions, including Chang'an University (China), University of Johannesburg (South Africa) and the Pontifical Catholic University of Paraná (Brazil).
Upadhyaya joined from Brunel University bringing additional expertise and international recognition in advanced materials for applied energy, driving forward the Schools interests in zero carbon opportunities. Upadhyaya holds the first Newton Prize for research in renewable energy impacting high areas of depravation notably in India.

Associate Professorial (AP) appointments:
Dagiuklas joined from Patras University, Greece incorporating Future Internet Technologies with one of the few internationally recognised 5G research centres in the UK **(H2020 SONNET)**, promoting LSBU with key players, such as Nokia, Thales, Motorola, Telefonica and Technicolor.
Goel joined from Cranfield University via a dedicated appointment to revitalise our manufacturing research towards future smart manufacturing and material development (**Co-I EP/T024607/1** and **EP/T001100/1** for sustainable coatings & adhesions).
Tokhi joined from the University of Sheffield augmenting our established research in Robotics research with control intelligence and automation. Tokhi is a key member of the organising committee of the renowned CLAWAR (International Conference Series on Climbing and Walking Robots) Association promoting international network and reputational opportunities.

(b) A focused facility and estates spend Supporting investment in people with parallel selected augmentation in research facilities has been a prime consideration of the School. A total sum of **£4.5m** has been **invested** to enhance facilities and opportunities. This with the aim to develop future higher TRL level research outcomes as well as more grant leadership and collaboration with academic and industrial partners. Highlights included the refurbishment of the materials engineering **LCEE** space to cater for higher TRL level outputs and to accommodate £2m of machine donations along with specialist equipment requests for **BioE** and **CSRC** (**detailed in section 3**).

(2) To focus on high quality research outputs:

SciVal reports that during the REF2021 period, this UoA published (in the General Engineering area) 268 journal articles compared to 80 articles in the previous, REF2014 period (i.e., an increment of over 300%). According to the Source Normalised Impact per Paper (SNIP) metric, 72.8% of these articles were published in the top quartile journals and 48.3% in the top decile, compared to the baselines (previous REF period) of 61.3% and 40% – showing a percentage relative increment, compared to the baseline, of 18.8% and 20.8% for top quartile and decile, respectively. The percentage of articles with international collaborators grew from 40% to 52.6% (giving a percentage relative increment compared to the baseline of 31.5%) and an increment in the number of countries citing our articles from 78 to 96 (giving a percentage relative increment of 23.1%). These achievements have been brought about through a team effort (academic and management), dedicated to making the School of Engineering at LSBU an attractive and productive place to work with an excellent research environment and supportive atmosphere.

(3) To create a supportive environment for staff and research students to flourish:

School research organisation is a combination of bottom-up and top-down activities. The **School Research Committee (SRC)** comprises members from the three research centres, staff at different seniority levels (SL, AP, Professor) and is gender and age balanced (6 female, 7 male staff; 5 staff ≥ 50 years, 7 staff ≤ 45 years). It meets formally once per term, is chaired by the School's Director of Research and Enterprise (DoRE), and members include the School Dean, Postgraduate Research Student Coordinator (PGRC), a nominated research centre head and the Technical Development Manager (TDM). The Director of Operations and Head Technician attend relevant parts of the meeting.

The **SRC** discusses research governance, facility maintenance, mentoring, soft-and hardware expansion, seed funding, general research and impact support activities and postgraduate funding and training/support. It promotes ***vitality and sustainability***, ensuring staff at all levels of seniority benefit from being part of an intellectually stimulating community with state-of-the-art facilities. Heads of Research Centres (HoRCs) act as advocates for their research domain on the SRC and ensure that investments are strategically implemented. DoRE and the PGRC attend termly **University Research Committee** meetings, where school level issues are presented as well as university wide research issues are discussed.

School research communication is disseminated by the DoRE, HoRCs and the PGRC via email or meetings (depending on need), and through dedicated staff/PGR Moodle and Haplo sites. The school web developer works with the University marketing and web team promoting research centre news, assisting with open access and to that social media updates are timely and accessible.

The School has **fortnightly local activities** (seminars, workshops) to highlight and encourage best practices and disseminate research/impact outcome exchanges. The School uses MS Teams research discussion channels to enhance rapid communication and support, especially important during COVID-19 times.

A **Research Open repository** has been in place since 2016, where all outputs are stored for public view. The University also runs an open-access publication fee scheme open to staff and students providing financial support for OA publication fees. Locally the School provides further funds to support colleagues with open access if the university funding has expired.

Locally, open access to research data is managed by each Research Centre. We employ the open-source GitHub service to securely store raw data for each Centre, promoting their availability online (once the related research has been published). Providing data access to researchers worldwide is done via email consent, sharing of data in this regulated way provides the school with appropriate control.

Since 2015, **yearly dedicated funding (£1.5-5k) to assist with self-promotion, international travel and conference attendance** for staff and PhD students was provisioned by the School's management team. It's remit to support staff and students with regular opportunities to promote their work, network and travel to overseas research teams, providing a sustainable development pathway for colleagues.

This resourcing, along with university wide competitive sabbatical scheme and additional networking assistance provided by the University's Clarence Centre for Enterprise and Innovation, have led to **network creation, international recognition** and success. This is highlighted by the lead and collaboration of our staff (notable for female staff **– F** and Early Career Researchers **(ECR)**) on international grants.

Exemplars are as follows:

- ***CryoHub*** (**Evans F**) an EU-funded project to develop and investigate the potential of large scale cryogenic energy storage at refrigerated warehouses and food factories with partners such as Dohmeyer, Germany;
- ***i-STUTE*** (**Maidment and Revesz ECR**) an interdisciplinary centre for Storage, Transformation and Upgrading of Thermal Energy;
- ***ROVER*** (**Dudley F**) an EU ITN with international research and industrial partners from Finland, Italy, Australia and the USA to create market ready imaging and non-ionising wireless medical devices;
- ***ISOPREP*** (**Durand ECR F**). This large European collaboration has 10 partners in 6 countries focussed on recycling technology to facilitate the transition towards a circular economy;
- ***RiserSure*** (**Sattar**) collaborated with international teams such as Mistras Group Hellas Anonymos Biomichaniki Kai Emporiki Etaireia (Greece) to create a non-invasive product to inspect pipes for offshore farms;

- ***ENABLEH2*** (**Ingram and Benson ECR F**) is a H2020 project with 7 partners across 5 countries revitalising the enthusiasm in liquid hydrogen research for civil aviation, with LSBU working on the safety aspects; and
- ***ERDF* CEDaCI** project academic lead (**Andrews F**) investigating sustainable deployment, upcycling of Data centre waste driving companies towards more sustainable approaches.

Other significant examples are the Royal Society and EU Research fellowship successes such as **Goel** (Newton Fellowship from Ben-Gurion University of the Negev) and **Ghavami** and **Dudley (F)** (EU Fellowship from University of Perugia, Italy).

(4) To create and attract excellent PhD opportunities:

To improve the opportunity, quality and continuity of PhD research and supervision, the School management team commenced a programme of full and match-funded scholarships. These scholarships have been regularly offered in the fulfilment of our strategy and received a total £2.47m spend between industry and the School over the past 5 years, resulting in a 9-fold increase (to 31 July 2020 and expected 13-fold at 31 December 2020) in the number of graduates at the end of their prescribed PhD enrolment period since 2015. Companies participating in the match funding partnerships are diverse, from multinationals to SMEs and demonstrate our impact in translational research including projects with, for example, Shell, Biox, Brandmovers, The British Blind and Shutter Association (BBSA), Orxa-Grid, Demand Logic, TWI (Cambridge) and UBT (Italy).

Such fruitful endeavours have resulted in SMEs benefitting from access to university resources (staff and labs) culminating in economic and cultural impact at an industrial level. It has also provided fantastic opportunities with Government Departments (BEIS) and large international companies, GlaxoSmithKline (GSK) and Chinasoft, positioning the School as an authentic and impactful research partner for high quality PhD research.

Successful PhD pursuits have led to unique post-doctoral positions with the same SMEs who now benefit from this mutual investment (time and financial) in highly skilled researchers uniquely aware of their business hopes and needs e.g., Riaz (PragmatIC Semiconductor), Rana (post-doctoral position in medical imaging match-funded by LSBU and UBT) and Dey (Neuville Data through ERDF Low Carbon London network funding shared between Neuville and LSBU).

(5) To increase the quality and the quantity of internationally recognised applied and impactful research via research collaboration and grant's capture:

The respective membership, focus, research impact and achievements of the three Research Centres are summarised below:

(a) The BioEngineering Research Centre (BioE) (Leads: Ghavami/Xiao)

Core Members: Professors Ghavami, Xiao, Barber, Dudley; Associate Professors Goss; Senior lecturers: Vilches, Lishman, Berthaume, Harput, Grisan; Lecturer: Chaouki

Associate members: Zhu, Chen, Kellici; Sajjad, Iqbal, Jahanzad, Memon, Kumar and Duan.

The original focus of the BioEng Centre was to be a **globally acknowledged, high quality interdisciplinary research centre in wireless sensing systems, signal processing and modelling for health and energy** (cross-LCEE) **applications** (Ghavami, Dudley), **material strength, mechanics, and prototyping** (Lishman-ECR, Goss) as well as in **skin bioengineering** (Xiao). The centre has been strengthened by additional expertise in applied biomechanics (Barber, Berthaume-ECR), Image and signal processing (Grisan), embedded systems and digital design for biomedical applications (Vilches) and complimenting research in Ultrasound imaging and signal processing (Harput-ECR). Developed research in house by Goss has focused on nanomaterial mechanics.

Successful exemplars are:

- **Ghavami: WEBOING**: EU Marie Curie Fellowship grant. Dr Gianni Tiberi, a researcher from the University of Perugia applied to spend 2 years working with Ghavami and Dudley to develop his expertise on bone fractures using RADAR. This work has led to a number of proposal submissions and papers as evidenced in REF 4b;
- **Dudley: ROVER** an ITN Marie Curie RISE grant with10 partners across 7 countries: Dudley and Ghavami lead two work packages for beyond state-of-the-art development of Radar and wireless interconnected platforms. These platforms will support new health paradigms employing channel modelling, hardware development and demonstration of wireless imaging, wireless-only gait analysis and their commercialisation strategies, demonstrating the growth in international recognition of the team;
- **Goss PI**: **EPSRC EP/P030203/1 MMEAW**: *Modelling the MEchanics of Animal Whiskers*, led by LSBU is a multidisciplinary project, lying at the interface between structural engineering, robotics and comparative animal physiology. The project aimed to increase knowledge of how whiskers are adapted to their function and apply that understanding to applications in engineering; and
- **Harput (ECR)** won a new research grant from the Royal Society to develop new ultrasound transducer technology: '*Human Ear-inspired Ultrasonic Transducer (HEUT) with a Spiral-shaped Acoustic Lens for 3D Localization of Sparse Scatterers'*.

(b) London Centre for Energy Engineering (LCEE) (Leads Maidment/Upadhyaya)

Core Members: Professors: Maidment, Upadhyaya, Dunn, Evans, Saha, Philbin; Associate Professors: Kellici, Axelsson, Goel and Durand; Senior Lecturers: Constantinou, Aristodemou, Memon, Jahanzad, Holborn, Zhao, Ingram, Benson, Buckeridge and Sajjad: Lecturers: Battersby. Research Fellow: Salimian, Davies.

Associate members: Barber, Dudley, Ghavami, Berthaume, Tokhi, Sattar, Vilches.

The centre originally focused on materials (Kellici, Axelsson, Saha, Jahanzad and Zhao), **pollution modelling** (Aristodemou), **heating and cooling** (Maidment, Evans and Davies) and **fire and explosions** (Holborn, Ingram). Our advanced materials strategy investment culminated in the ARTIC and POLYMERIC Innovation Centres in partnership with TWI. This has brought together academic and industrial expertise to further improve international recognition and broader networks access. In particular, Durand was recruited due to her industrial expertise in materials for energy and sustainability. Fundamental and translation material research expertise brought Upadhyaya, Dunn, Sajjad, Khamsehnezhad and Buckeridge; manufacturing (Goel, Kumar, Memon) and technique development (Bleay), affirms the centre's commitment to international and excellent quality research. Within the fire and explosions area two **ECR** colleagues Benson and Battersby added expertise on hydrogen and fire safety directives with Ingram and Benson succeeding as leading academics for LSBU on a prestigious H2020 grant ENABLEH2.

LCEE researches several aspects of the Energy sector providing the centre with broad impact:

- **Clean & Sustainable Energy Technologies**: photovoltaics (PV) and their scale-up; energy storage and integration with biomass and PV systems; lighting/display devices; clean air and water quality; precision manufacturing, additive and subtractive coatings of functional advanced materials;
- **Energy Materials and Systems**: materials synthesis (2D related, metal/metal oxides and quantum dots) applying to a range of energy harvesting devices e.g., electrochemical batteries and supercapacitors. Collaborations and capacity building structured around these clusters supporting the government target of net zero greenhouse emissions by 2050;
- **Nanomaterials and Modelling:** materials testing and performance evaluation at nanoscale; materials modelling to drive forward the advanced energy/manufacturing materials research for scale up manufacturing;

- **Fire and Explosions:** supports activities on explosion, fire safety and hydrogen hazards for sustainable applications; and
- **Heating and Cooling**: state of the art systems and technologies to minimise demand including advanced heat pumps, 5th generation energy systems, cryogenic energy storage, secondary heat sources and sinks, development of benchmarks and road maps and minimising refrigerant emissions.

Successful exemplars are:

- **Evans: PI CryoHub**, €8m total funding: International leading work coordinated by LSBU on energy storage using liquid air. Funded by the EU (H2020 - IA) and involving 14 partners across Europe;
- **Ingram and Benson (ECR) LSBU PI: ENABLEH2:** EU (H2020 - RIA) involves 7 partners, 3 universities and 4 companies across 5 countries aiming to mature critical technologies for liquid hydrogen-based propulsion to achieve zero mission-level CO2 and ultra-low NOx emissions. LSBU leading the safety and system modelling;
- **Upadhyaya: SUNRISE:** An international multidisciplinary program funded by GCRF/ EPSRC has evolved from one bilateral (Indo-UK) program APEX. It involves 12 partners across UK, India, South Africa and Mexico and has won the Times International Collaboration of the Year 2020, http://www.sunrisenetwork.org/;
- **Andrews PI: (ERDF / Interreg North West Europe a** €3m Interdisciplinary project: *Circular Economy for data centres (**CEDaCI**)* includes designers, engineers, economists, materials experts, recyclers, behavioural scientists with international team consisting of 4 European countries with 10 research and industrial partners; and
- **Durand (ECR): ISOPREP H2020 and SOLARSHARC (H2020 Fast Track to Innovation-FTI**). ISOPREP is based on different underpinning technologies and industrial sectors. This large European collaboration has 10 partners in 6 countries focusses on recycling technology to facilitate the transition towards a circular economy. SOLARSHARC, a European collaboration aims to develop an anti-reflective and anti-soiling coating. This FTI project was successful with performance improvements of 2% (10% enhancement) measured by the Commission for Atomic Energy and Alternative Energies (CEA), France.

(c) Cognitive Systems Research Centre (CSRC): (Leads: Dagiuklas/Tokhi)

Core Members: Professors: Dagiuklas, Tokhi, Sattar, Patel; Associate Professors: Selig; Senior Lecturers: Cadenas, Chen, Child, Duan, Iqbal, Zhang; Lecturer Zhu.

Associate members: Grisan, Harput, Dudley, Philbin, Ghavami, Lishman, Aristodemou, Memon, Chaouki, Axelsson, Aristodemou, Bleay, Davies, Salimian, Vilches and Upadhyaya.

Original CSRC themes pivoted on Applied Systems (Patel, Child, Selig, and Chen) and **Robotics, in particular Non-Destructive Testing (NDT)** where the School partnered with The Welding Institute (TWI) Cambridge to create the London South Bank Innovation Centre (LSBIC) for Non-Destructive Testing (Sattar, Tokhi). Additional investment to create a research-rich digital innovation hub with a global reputation for innovation included adding expertise in smart cities, 5G (and beyond) and distributed systems (Dagiuklas, Zhu, and Iqbal) and Robotic-NDT intelligence/control augmentation (Tokhi, Duan). Collaboration with elite research groups from both academia and the industry in the field via joint research grants at both national and international level has ensued. In the REF period, collaborative research with more than twenty industrial partners has been directed at developing inspection robots for safety critical infrastructure in extreme environments (onshore and offshore).

Exemplars of international success are:

- **Sattar: TANKROB (In-service NDT of petrochemical storage tank floors and walls) H2020 FTI 1/09/2015, Ref: 701007:** 5 partners across 3 countries spanning the entire tank inspection value chain capitalising on previous LSBU demonstration of a mobile robot (RobTankInspec) for in-service NDT of tank floors using ultrasound technology without emptying the tank. **TankRob** prompted rapid product market take-up by maximising the range

of tanks it can inspect and by validating the new system in an operational environment with ATEX certification. LSBU developed the sonar navigation system for the new robot;

- **Sattar: RISERSURE: Rapid Integrity Assessment of Flexible Risers for Offshore Oil and Gas Installations H2020 FTI 1/09/2015, Ref: 730753 E:** 5 partners across 4 countries: RiserSure™, is a product that assesses flexible riser pipes used in offshore oil and gas production. RiserSure uses a novel subsea digital radiography detector to perform sub-sea field trials. LSBU developed the robot capsule, deployed by a ROV, which rotated a Gamma ray source and digital detector around a riser at speeds of 0.03 rpm. Partners are making commercial and manufacturing preparations for product launch; and
- **Dagiuklas: H2020 MSCA-RISE SONNET** involves 2 SMEs and 2 universities from 4 EU countries researching issues in wireless system design, 5G networks and softwarisation, indoor positioning and ray tracing exemplifying a high degree of interdisciplinary collaboration.

(6) Evidence of Applied and Impactful Research:

- Adhering to our University strategy that **our research is applied, and focused for real-world impact and societal benefits**, our local objective **generates measurable impact** by: (i) engaging user-groups/stakeholders in research from the development stage; (ii) promoting existing research across the centres to key stakeholders (including policy groups such as BEIS) and (iii) ensuring staff and students are aware of the needs for planned and evidenced impact through in house training from our REI and Impact manager.
- Industrially matched sources such as: KTP's (5 KTPs from the school receiving good to very good in the last 5 years), industrially match-funded post-doctoral research collaborations (**Dudley** and UBT Italy), PGR university studentships, and Industrially match-funded PhDs e.g., Bond group UK (**Andrews**).
- Engagement in European co-funded industrial collaborations through projects such as the European Regional Development Fund (ERDF) *Access to Innovation* (A2i) and *Simulation for Digital Health* (SimDH) enables the UoA to have direct impact on SME operations. Exemplars of this are **Dudley** and Neuville Grid data Limited applying machine learning for solar farm fault-detection through the ERDF Low Carbon London Network. SME/LSBU match funding: **Ghavami/Dudley** collaboration with UBT Italy on cancer imaging was deemed so successful that UBT have set up a London office to establish a focussed industrial/research partnership.

(7) Exemplars of impactful research collaborations (which also form our Impact case study submissions) during this REF period are:

- **The IUK GreenSCIES project** investigating innovative approaches to deliver ultra-low carbon mobility, power and heat as part of the local energy system in Islington, the West Midlands and in Sheffield City region (**Maidment**). This project has £3m of private funding leading to the development of an international centre of excellence in smart local energy system and provided detailed recommendations to Government;
- **Maidment –** Committee Report to Climate Change on Refrigerant Leakage; Report on Refrigerant Leakage to the Refrigeration Technical Options Committee (**Maidment**); Advisor to UK Government Chief Scientific Advisor – November 2018 onwards;
- **Holborn/Ingram** - Collaborations with Sellafield Ltd have informed and directed a research strategy to meet the challenge of hydrogen hazard management on the Sellafield site making a significant contribution to improving the safety of nuclear decommissioning and drastically lowering the cost of these activities with estimated savings of £100m;
- **Philbin** has created a range of models, processes and analytical tools to measure the impact of infrastructure projects against the United Nation's Sustainable Development Goals (SDGs). This allows SDGs to be measured at the project level and across economic, environmental and social requirements. Application of the results from the research study are being actively used by the Environment Agency to manage impact assessment across its £5.2bn portfolio of infrastructure projects and by the Thames Tideway Project (£4.9bn);

- **Dudley** Inefficient heating in large non-domestic buildings (e.g., high-rise office space and shopping centres) is a major contributor to carbon emissions and climate change. Her work has helped to improve the efficiency of Building Energy Management Systems (BEMS, i.e., the main controlling systems of large building heating and cooling) by using artificial intelligence to improve detection of BEMS faults. Working with Demand Logic Ltd, a UK based SME that produces buildings' BEMS platforms to optimise energy savings), has brought about an improvement in their products leading to:
    - Reduced energy costs spend for their UK and EU clients by 10%-30%
    - About £1.8 million savings in annual energy costs
    - Annual savings of 11,800 tonnes of CO_2 per year since 2016

1.b (iii). Strategic Vision

Over the next 5 years we will continue to grow our translational partnerships and internationally recognised research in the areas described. The School of Engineering will foster and grow our current academic-driven international collaborations with strategic countries such as, IIIT Bombay, India, COMSATs, Pakistan, Al-Khaliffa, UAE, and University of Oulu, Finland.

We will concentrate resources on our existing areas of impact distributed across our centres, aligned with key priority areas reflecting societal and industrial needs (e.g. energy storage, zero-carbon, smart manufacturing and IoT, AI applications related to our centres, advanced materials for energy and sustainability, and biomechanics).

Our aims are therefore to:

- **Promote Staff development**, by providing Cat. A staff with guaranteed one term study leave cycles every 3 years. This support, along with current mentoring, conference/networking provision, PGR scholarship offers will attracted and maintain excellent staff at various career stages, ensuring a long term, agile and collaborative community of scholars. A 20% increase in Cat. A staff engaged in research is targeted over the REF period.
- **Leverage investment for University/Industrial co-creation** through the establishment of a School based Innovation Centre (IC) in partnership with Croydon Council. - The IC will initially focus on our advanced material modelling and smart manufacturing capabilities, allocated space for companies working alongside the School, and to host match funded research partnerships and consultancy. Initial match-funding of £1m has been provided and the IC is supported by the Clarence Centre of Enterprise and Innovation. An increase of 25% research income through Industrial partnerships will be targeted over the next REF period.
- **Alignment of this strategy** with the institutional corporate strategy that is step-changing by increasing (by a factor of 3) the volume and quality of research for 2022 and beyond.
- **We will instill a culture of engagement** where Research Centres permeate into the teaching framework through extra-Curricular engagement with schools, communities and within our UG and PG offering. The promotion of Energy Engineering related Degrees and Higher Degree level apprenticeships – aligning with the University's outreach programmes.
- **Improve our international presence** through further collaborations with elite research groups in our field (improved exposure and citations). A 20% growth in community partnerships will be targeted over the REF period.
- **Continue with focused but cross-centre infrastructural investment:** High Performance Computing for all centre and external client access, Low carbon Battery systems facilities, smart manufacturing lab spaces for Energy Centre teams (LSBU and Croydon sites) and applied biomechanical engineering space expansion.

2. People

Our staffing strategy has 2 main objectives:

1. A recruitment and promotions policy that considers research track record, research fit and research potential.
2. Provide mentoring and support, particularly for those in the early stages of their research career, and development opportunities for all staff, promoting a culture of research in the school.

To achieve the first objective, our staffing strategy focused on recruiting and supporting the highest calibre colleagues at different career stages who share our vision of cross collaboration between disciplines, working with industry and who have an appropriate "fit" to the existing centres, ensuring sustainability.

In the REF period 25 new staff (including 4 Chairs), 3 Associate Professors and 18 Senior Lecturers and Lecturers joined the School of Engineering (SoE); The flexibility to create these permanent roles evolved through retirements, a Voluntary Severance Scheme and university funding to replace and appoint strategically important posts, focusing on research quality and fit to the school. These roles enabled the School's research to be extended to biomedical applications in ultrasound and image processing, biomechanics, energy engineering, materials manufacturing and material modelling.

To achieve our second objective, the School has applied several local staff and PGR student support actions:

Information availability and academic assistance. The university REI team, via the School management team (provides relevant monthly 2-hour talks to all research centre staff with updates regarding (1) promoting research from other LSBU schools that may be of interest to the Research Centres, (2) providing information and support on relevant grant calls, (3) grant writing workshops to support new and existing staff and final year PGRs. The School engages the Clarence Centre team to work with the research centres to understand the Research Centre aims and subsequently provide networking opportunities with related industrial contacts prompting engagement and communication with relevant stakeholders.

Career development support. The appraisal and Annual University Research Audit (AURA) schemes introduced by LSBU are used at the School level to support staff in several ways such as: i) to identify training needs, ii) to review and agree individual targets, support raising output quality using journal subject areas as an objective quality indicator and iii) to help shape the future plans of individual researchers as well as their centres.

The School provides all new permanent academic staff (and those returning from leave) with dedicated PhD funding scholarship (a least 1 home/overseas fees and stipend), access to research centre equipment/lab and access to funding of unique equipment for their needs. New academic staff and those returning from leave have a reduced teaching and administrative load in their first year with no teaching in the first semester. The School's Technical Development Manager (TDM) also provides dedicated support with horizon scanning, partner searching and reach. The TDM also engages with PGR students and supervisors at Research Centre level to ensure she is aware of ongoing research, highlighting synergies, to support colleagues with relevant calls/networking opportunities in a timely fashion.

Mentoring. The School promotes mentoring across all career stages. It is mandatory for new staff and forms part of their development pathway. Mentoring takes place with experienced staff (who have gone through training) supporting newcomers and staff who return after leave, or staff who would like to take on more day-to-day management roles within their Centre or the School. This helps staff focus on their academic and research plans, helping to focus personal development, appraisals and AURA obligations.

PGR supervisor training. All PGR students and supervisors are members of the London Doctoral Academy (LDA). Workshops for all staff at different supervisory levels are managed by the

University's Organisational Staff Development and Training Department as explained in the University statement.

At School level supervisory training is carried out through effective mentoring. A more experienced staff member supports the new supervisor to a) helps them develop a PhD idea, advertise and interview prospective students. Following this the mentor b) ensures that their mentee has all the appropriate paperwork, understands the university PhD processes and highlights any changes. The mentoring supervisor is also requested to assist the ECR in developing an independent research and publishing career feeding into the appraisal process. Acting as second supervisor enables the mentor to help the ECR through student progress meetings and work with the supervisor and student through any issues that may arise.

Enterprise engagement and training is carried out through school's own engagement with industry and our TDM, establishing networking days to promote centre research themes. Here industrial stakeholders are invited to campus for a day of presentations; lab tours, networking and meetings. The Clarence Centre Staff Development Team provides dedicated university level training on pitching, focussed promotion presentations and making your work accessible to non-experts.

Fellowships and International staff appointments. Several personal research fellowships have been won by staff; **Dagiuklas** (H2020 MSCA RISE, Project SONNET, 2018), **Ghavami** (German Academic Exchange Service Fellowship, 2018; JSPS and Keio University Research Fellowships, 2015, H2020 Marie Curie), **Dudley** (H2020 MSCA RISE, Project ROVER, 2020) **Maidment** (Mission Innovation, GreenSCIES) and **Selig** (University of Bologna, Italy, 2015).

Research leadership and independence development is fully encouraged at all career stages through collegiate and collaborative working across international borders. **Saha** (British University in Egypt, £181k funding), **Dagiuklas** (National Technical University of Athens), Lishman (The University Centre in Svalbard, Norway, grant application), **Buckeridge ECR** (Harbin Institute of Technology, University of Limpopo, University of Southern California, Yonsei University, Kyoto University, Trinity College Dublin, several journal publications), **Xiao** (Changshu Institute of Technology, Tongji University Zhejiang College, joint publication), **Memon ECR** (Hokkaido University, Nizhny Novgorod State Technical University, Tianjin University, University of Nairobi, University Kebangsaan, joint publications)

International staff appointments. Exemplars of incoming international staff appointments include Marie Curie Fellows (2018 Tiberi), and EPSRC funded research officers from Algeria and China (2014). Four emeritus professors and 7 visiting Professors have been hosted e.g. Professor Mamdouh Gadalla (British University in Egypt), Prof. Juan Lui (Guangzhou University, China), Professor Eduardo Motta Alves Peixoto (Nobel prize winner, Brazil), Mr. Robert Tozer (international Data Centre lead) and Jolyon Thompson (International ventilation expert).

Sabbaticals. LSBU runs a central sabbatical application process where staff are encouraged to apply for ½ year sabbaticals. Examples of successful sabbatical experiences are Xiao (2018) and Andrews (2017), resulting in grant funding wins (**Andrews**), and new product spin offs for Biox (**Xiao**).

Promotions. The University runs a yearly promotion round. Staff are supported via staff development team workshops and locally by their mentors to understand the requirements and processes to identify strengths and help master any difficulties. **ECRs Iqbal**, **Harput**, **Lishman**, **Buckeridge** and **Berthaume**, **Sajjad** were promoted to Senior Lecturer. **Kellici**, **Goss, Durand** (**ECR)** and **Andrews** were promoted to Associate Professor. **Dudley** and **Xiao** were promoted internally to Professor.

Equality and Diversity Indicators. This UoA is committed to equality, openness and inclusivity, with everyone treated with dignity and respect. In the UoA, women make up 30% of the Cat. A academic staff, 21% of our professorial staff declare themselves as women, and this is 60% at Associate Professor level. Staff who declare themselves Black, Asian Minority Ethnic (BAME) make up to 32% of the returned cohort. The school has a dedicated time at staff meetings to propose or highlight any general EDI issues and the school management team (Dean, DESE and DoRE) has an open-door policy for staff and PGR students (as well as via the student forum) to raise any concerns or to highlight good practice (an email is sent regularly to staff and PGR students about this). Women and BAME colleagues have held managerial roles in the school in the past decade. Director of Education and Student Experience (DESE) (1 BAME woman, 1 man); DoRE (1 BAME man, 1 woman), PGRC (1 man, 1 woman).

The UoA ensures that its Research Committee is well represented and the university places a standard base time for Cat. A staff to do research in its code of practice and the school promotes LSBU's shared parental leave and flexible working policy. Although academic appointments are devolved to Schools, LSBU's central HR helps schools appropriately word their adverts to ensure there are explicit equality statements and that wording does not discourage but encourages potential applicants with protected characteristics, disabilities, BAME, women and those returning from leave to apply.

Research Students:

The 2015 implementation of our full and match-funded scholarships along with promoting our international presence has improved PhD recruitment and graduations as shown in the table below.

	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/July end 20	Total
Male	1	5	5	9	4	7	11	42
Female	1	1	2	1	2	1	7	15
Total	2	6	7	10	6	8	18	57

The 2019/20 graduation cohort saw a 9-fold increase on 13/14 and comprised over 60% female graduates.

School PGR recruitment is managed quarterly, pooling students with larger adverts. Applicants are distributed by the DoRE and interviews take place online or in person. Qualification checklists and project understandings also identify any training needs. All PGR students are provided with individual desk space, a dedicated PC, networked IT facilities, access to appropriate laboratory spaces and are required to register on the online monitoring system Haplo. The supervisory team comprises two supervisors with the main supervisor (Director of Studies) providing the technical input and the 2nd providing complementary technical and general guidance. If the scholarship is match-funded then an additional industrial supervisor may be added.

All PGR students are supported by the London Doctoral Academy (LDA) offering a distinct PhD training program on professional and personal development running throughout the year which students must attend (research management, research skills and techniques, and transferable skills (communication and time management, personal effectiveness entrepreneurship and enterprise engagement).

Locally students are supported through their centre in several ways: financially supporting student "get-togethers" to create a community spirit – this has continued online throughout the COVID pandemic; within Centre presentations to build confidence; group journal reviewing and critiquing with experienced academic staff members. Instrument and Facility training along with health and Safety checks are performed locally with appropriate academic staff and technicians. To ensure PGR students see beyond their own research, bimonthly seminars take place and are compulsory for Engineering PGR students. PhD students must present at the seminar in their 3rd year.

PGR Research Integrity is embedded through internal training and robust internal peer review of papers, plagiarism checking, research data description, collection and storage processes, ethical approval and data storage training. This is also promoted at UG and PG levels with PhD student's speaking at UG and PG project lectures on the importance of what "Honest Research" means to them.

PGR Ethical Approval (EA) training and execution: PGR students are provided with ethics training; EA: understanding the need, requirements and approval workshops; and how to engage with people effectively. At School level EA monitoring is performed on a one-to-one basis with our **School Ethics Adviser (SEA)** (**Grisan**). Following this students and supervisors must declare if their work will require or not require EA (or if circumstances change renew their EA application to reflect changes). All forms are sent to the **SEA** for approval with complex cases sent to the University Ethics panel for approval.

Entrepreneurship and training engender strong interest among staff and PGRs. Match-funded PhDs, ERDF projects (students take on part-time research roles) along with staff/student engagement with the REI and Clarence Centre developing ideas with their supervisor. Exchange programmes such as our Newton-Mosharafa Fund Institutional Links programme in collaboration with the British University in Egypt (BUE) – "Sustainable production of biodiesel from waste cooking oil in Egypt," **Saha** have brought success. Examples are a) Omar Aboelazayem, a joint PhD student between BUE and **Saha** was shortlisted in the top 45 from 800 applicants in the SET for Britain for his research "Biodiesel production from very low-quality waste cooking oil by a single step technology" and has moved towards private investment focus to develop their idea further b) **Salimian** won an Innovate UK ICURE (route to market) award with his PhD student on their research of plasmonic silver based thin films applied to silicon solar cells, resulting in ~10% enhancement in solar cell output.

Student progress monitoring is centrally managed through the Haplo system. This comprises 2 submissions per annum (an automated reminder and alert system is in place). Students present their progress and are interviewed by a panel (comprising the supervision team, panel chair and reviewer). In years 2 and 3 more emphasis by the panel is based on the research outcomes such as publications from results.

The PGR coordinator (Kellici) monitors student progress via Haplo and reports to the School Research Committee. The Schools PGR student voice is led by the PGR student forum held termly within the school and student reps meet the PGR coordinator monthly, promoting a culture of communication between school management, staff and students.

Additional support for PGR students includes:

- School funding to present work at least 1 major international conference
- The support and expectation to submit at least 1 high quality, thesis-based journal paper with open-access financial support.

3. Income, infrastructure and facilities

Research funding portfolio, including future plans

Over this REF period the UoA attracted a total of **£32.7m in** grants/contracts as lead and collaborating institution (a 128% increase since the last REF), **£16.3m** of these were directly allocated to LSBU over the review period (a 69% increase since the last REF). Engineering income came from a healthy mix: EU (16%); Research Council and Royal Academy/Society grants (17%); Government including IUK (43%); and private matched and fully funded research collaborations with Industry (24%). Exemplars for each centre are provided below.

Biome: grants and contracts total **£2.4m (2.56m as Lead Institution (LI) and collaborator (Co))** with successes both at international and national levels comprising EU Fellowships, non-responsive RCUK, enterprise and industrial funding. Highlights include:

- EPSRC: DANCER EP/K002473/1 (**Ghavami/Dudley**, £911k to LSBU)
- EPSRC MMEAW EP/P030203/1 total £460k (**Goss**, £346k)
- H2020 WEBOING: UWB for bone fracture imaging (**Ghavami/Dudley**, £180k)
- EPSRC Piezoelectric Nano-Fibre Acoustic Sensors (EP/M026884/1) (**Vilches**, £230k)
- IUK/TSB: Energy Management and analysis (EP/M506734/1) LSBU academic lead total grant £760k partner with VERCO, Demand Logic and EDSL (Dudley, £210k to LSBU). IUK Intelligent ear protection Innovate UK with (**Dudley**, £200k)
- IUK Sub-Surface Produce Imager with partners NPL and M&SK (**Dudley**, £140k).

LCEE has secured **£9.7m** income to LSBU **(£25.6m as LI and Co)** in international and national research contracts, enterprise and industrial collaborations since 2014.

- EU H2020 project: CryoHub: **Evans grant Coordinator**. Total funded value ~€8m, (LSBU £1.173m).
- EPSRC interdisciplinary centre: i-STUTE, EP/K011847/1 2012-2018 Total value £5.3m (LSBU £1.17m)
- Centre of Flammable Gas management with Sellafield (**Holborn**) (LSBU £730k)
- EU H2020 ENABLEH2 Project - €3.5m (**Ingram/Benson**) (LSBU €619k)
- EU H2020 EVERCLEAN (**Durand**) LSBU £595k
- EPSRC SUNRISE Platform Grant (**Upadhyaya**) LSBU £470k
- InUK GreenSCIES (I and II) - Green Smart Community Integrated Energy Systems, total amount £4m, academic PI **Maidment** (LSBU £400k).
- InTeReg: CEDaCI- The Circular Economy and Data Centres (**Andrews Grant PI**), Total amount €2.9 million, allocation to LSBU £230k
- EU H2020 Clean Sky 2 EFFICIENT Project 2016-2020 (**Holborn/Ingram**) (LSBU €150k)

The **CSRC** has secured over **£4.2m (4.58m as LI and Co)** in international, national grants, enterprise and private funders since 2014, with exemplars below:

- H2020 FTI: RISERSURE **Sattar** (Total to LSBU £650k)
- H2020 FTI: TANKROB **Sattar** (LSBU £474k)
- H2020: FTI WLNPECTOR **Sattar** (LSBU £457k)
- H2020: BATHYSCAPHIC (Robotic Floor Thickness Monitoring of Hazardous Liquid Storage Tanks), **Sattar**, LSBU £255k)
- H2020 SONNET: Self-Organisation towards Reduced Cost and Energy per Bit for Future Emerging Radio Technologies. **Dagiuklas**, (LSBU £230k)
- IUK ROBO-PACK **Sattar** (LSBU £205k)
- IUK FSWBOT **Sattar** (LSBU £205k)
- IUK RADBLAD **Sattar** (LSBU £180k)
- KTP ITECH supplied Ltd., **Patel** (LSBU 178k)
- IUK Autonomous Phased Array Ultrasound Robotic NDT, **Sattar**, (LSBU £117k)
- H2020 SocialTruth **Dagiuklas**, (LSBU £112k)
- IUK Smart Surveillance of a Service Using Fog Computing, **Dagiuklas**, (LSBU £85k)
- Machine-based Learning Consultancy with Lambeth Council (**Chen**, £75k)

Our future plans are to lead more grant consortia, further invest in materials and smart manufacturing, in particular the schools “Nature-inspired Precision Responsive Manufacturing” lab. **BioE** and **CSRC** has planned unique anthro-engineering laboratories combining biomedical, material science and AI. These will focus on biomechanics research, materials development with **LCEE** and affordable measurement solutions for prosthetics and gait analysis tools. We will also focus on our Green energy innovation centre with spending here is approximately £1m over 5 years with another £1m expected from Industrial partnerships.

Investment on selected areas to enhance facilities and opportunities to develop higher TRL level research outcomes for future aspirations to lead on more grants and work with more industrial partners with a total of **£4.5m** spent on facilities and infrastructure.

LCEE received investment of **£2.9m** comprising lab refurbishment, and industrially leading higher TRL equipment donations. The creation of a **"Scaling up and Sustainable Innovation Laboratory"** with equipment donations of a Quantum 2010 In-line pilot system to create of state-of-the-art efficient cells on glass, flexible foils including tandem cell development for over 30% efficiency valued £1.5m [SVS Ltd (UK)] and a Gas analyser System for the teams work on a patented diesel Particulate filter trial for global scale-up (£500k) [BP, UK]. Refurbishment of the **"Thin Film PV Devices**," "**Materials Characterisation"** and "**Optoelectronic Measurement** laboratories with £280k worth of equipment including an XRD (Advanced8-Bruker, £70k) And an Edinburgh Photonic Instrument "FLS1000 Photoluminescence Spectrometer" for steady-state and time-resolved photoluminescence spectroscopy (£160k). Investment in a Nanoindentation instrument (£180k) is a commitment by the school to a unique UK based "**Nature-inspired Precision Responsive Manufacturing**" lab.

The ARTIC and POLYMERIC teams have leveraged equipment through grant income and from the shared use of the LSBU facilities above. Pointed investments include an Elcometer taber [Ecometer Ltd] and a Thermal analysis system [Mettler Toledo UK] at £50k; two Fourier-transform infrared spectroscopy/ cooling System mini chiller [Fisher Scientific] totalling £60k, key enablers in higher TRL level projects ISOPREP and Solarsharc.

BioE research facilities have been upgraded along with a fully instrumented anechoic chamber for antenna, phantom and prototype development with associated characterisation/test equipment (£50k). Dedicated PCB facilities and high-performance computing equipment for applied medical imaging, AI augmentation and non-camera based, non-wearable gait analysis algorithm development (Ghavami/Dudley/Grisan). Ultrasound (US) imaging (High-frame rate US scanner and amplifier (E&I, A150), £50k) along with a dedicated biomechanical lab set for installation in 2021. Investment to July 2020 was **£200k** from LSBU funding.

CSRC investment of **£630k** from LSBU including £350k for the London South Bank University Innovation Centre (LSBIC) on Non-Destructive Testing with TWI Cambridge, used to establish a workshop/laboratory and the Directors and research team's office in TWI. Robotic NDT research gained infrastructure for wireless communications and intelligent control as well as a 3D spatial positioning Faro arm (value £90k) donated by TWI Ltd. Additional investment led to 5G centre research facility valued at £230k.

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

The research strategy has been to improve international presence, support staff to develop networks and to work effectively with Industry. Success highlights of leadership collaborations and contribution across the School are highlighted below:

Leadership of consortia and industrial projects

- **Evans (LCEE)**, coordinates the EU H2020 **CryoHub** project, aiming investigate and develop large scale cryogenic energy storage at refrigerated warehouses and food factories. ~€8.2m shared across 14 international partners EUREC and Dohmeyer (Belgium), CENER (Spain). CryoHub has recently published an assessment of policy and regulatory matters related to the deployment of energy storage technology at EU and national level. The report is the result of research and interviews with industry and policymakers. It also considers how this technology, if deployed at scale, could impact other energy and food industry stakeholder decisions with the possibility of reducing costs and emissions for the user and the wider system. It also evaluates the potential business cases.
- **Andrews (LCEE)** coordinates a **EU InteReg NWE** collaboration worth €3m for a EU Circular Economy Action Plan – **CEDaCI** providing leadership, advice and technical assistance on the Circular Economy and Critical Raw Materials (CRM) to 50 SMEs across North West Europe;

this includes training on use of the bespoke Circular Data Centre Compass (CDCC) on line tool developed at LSBU to support businesses (SMEs, non-profit and public bodies and manufacturers) to increase operational and business sustainability.
    - CEDaCI was selected as a good practice by the European Circular Economy Stakeholder Platform in April 2021.
- **Maidment (LCEE)** is PI of the InUK grant **GREENSCIES**, a waste heat recycling and transfer consortium investigating affordable and meaningful ways to reduce and reuse wastage heat in urban environment using Smart Energy Grids (SEG). Partners include Islington Council and Transport for London (TfL). Concealed underground, the SEGwill provide power inner cities of the future, transforming homes and businesses into sustainable energy districts. GreenSCIES will deliver low carbon and low-cost transport, power and heat to a total of 12,500 homes in the London Borough of Islington and Sandwell in the West Midlands.
    - The new smart energy grid - has now reached design stage
- **Holborn and Ingram (LCEE)** research and leadership have had a significant impact on the safe management of hydrogen hazards, through its collaboration with Sellafield Ltd. This research work has helped Sellafield Ltd to:
    - Support a revolutionary breakthrough saving approximately £100,000,000 for cleaning up the Sellafield site.
    - Designed a process to safely stack and store nuclear waste filled containers which generate hydrogen as a by-product (~10,000 boxes each costing £60,000).

International Research Collaborations with academia, industry and end users

- **Goel** (**LCEE**) is collaborating with the University of Manchester, Queens University Belfast, Cranfield and University of Sheffield on an EPSRC Digitalised Surface Manufacturing (DSM) NetworkPlus award to create networks and collaborations establishing already over 200 academic members registered worldwide including International Centres of Excellence such as SEAM (Australia), GreenSEAM (Canada), NCFlexe (India), NPL (UK) and CIDETEC (Spain).
- **Xiao** (**BioE**) skin bioengineering work with UCL has been transferred into commercial products through the spin-out company Biox Systems Ltd. The University of Surrey also won an Innovate UK Industrial Secondment grant to work with Biox Systems Ltd to conduct mathematical modelling and data analysis for the AquaFlux and Epsilon instruments. Increased sales revenues (~£2.4m since 2014); ~240 machines, over 200 number customer organisations worldwide and a new patent application;
- **Kellici** (**LCEE**) is researching on 2D materials with the Flinders University (Australia), Max Planck Institute (Germany), VITO (Belgium) and the UK Universities of Cambridge, Cardiff, Imperial, Liverpool are informing innovative solutions to global challenges in water treatment, antibacterial resistance and catalyst development for CO_2 utilisation.
- **Salimian** (**LCEE**) work on plasmonic solar cells and field emitting flat panels as a light source for indoor crop growth is being carried out with partners Kelenn Technology, France (Dye-sensitised solar cells and perovskite solar cells), Technische Universität Dresden, Germany, University of Melbourne, Australia, CEA Grenoble, France.
- **Evans/Maidment/Revesz** (**LCEE**) The REAL Zero project with the Institute of Refrigeration, Carbon Trust and 2 industrial partners has been cited in the revised EU FGAS2 proposals on HFC refrigerant use and has provided evidence for the Committee for Climate Change and UNEP's Refrigeration Technical Options Committee feeding the Montreal Protocol.
- **Dudley** (**BioE**) is collaborating with 35 other countries on an EU Cost Action NEWFOCUS to establish optical wireless communications (OWC) as an efficient technology that can satisfy the demanding requirements of backhaul and access network levels in beyond 5G networks. This also includes the use of hybrid links that associate OWC with radiofrequency or wired/fibre-based technologies.
- **Holborn/Benson ECR/Ingram/Maidment** (**LCEE**) with London Fire Brigade have examined the causes and consequences of refrigeration fires in residential dwelling fires in UK and results have influenced policy and the development of safety standards.
- **Holborn/Benson ECR** (**LCEE**) along with Cranfield University, RISE (Sweden) and Airbus via the H2020 EFFICIENT project has resulted in the design, development, and testing of an

environmentally friendly, halon-free, fire suppression system for aircraft cargo holds directly influencing EU plans to safeguard the environment, by completely phasing out the use of chemicals with Ozone Depleting Potential (ODP) in civil aviation cargo holds by 2040.

- **Goel/Upadhyaya** (**LCEE**) Through the Royal Academy of Engineering's Transforming Systems through Partnership program have developed joint courses with the University of Johannesburg in South Africa as well as addressing gender balance in Engineering education in Rural India working with Krishna Institute of Engineering and Technology and India's biggest construction conglomerate Larsen and Toubro Limited.
- **Berthaume (ECR)** (**BioE**) recently formed a collaboration with Mitt Wearables winning an Innovate UK bid (CRN 11026507) to bring upper limb prosthetics to Sri-Lanka.

Consultancies and professional services

The total value of consultancy contracts has typically been £300k pa over the review period. Examples include work for Sellafield Ltd advising on specific plant-related issues **(LCEE)**. Heat recovery from waste with New Heat Development Ltd and environmental impact assessments for TT&E Environmental Consultants, Athens (**LCEE**); rooftop wind turbine performance with Southwark Council (**LCEE**), skin hydration imaging with Glomax Aesthetics (Singapore), Johnson & Johnson (Paris) and DSM Nutritional Products (Switzerland) **(BioE)**; low temperature Si epitaxy for solar cells with Echerkon Ltd **(LCEE)**; Eurofighter wing tip pod cooling and sustainable low carbon and renewable electrical and mechanical technologies for use in the retail sector for Tesco Ltd **(LCEE)**. London Underground testing of PAHU's and development of thermal storage systems for underground carriages **(LCEE)**. Consultancy on Innovate UK grants for a company working on heating products (Vestemi) 2020 **(BioE).**

Highlights of Esteem Factors, Editorships and participation in editorial boards

Assoc. Ed: Multiferroic Materials 2010-; Ed Board: J Ceramics 2010-, Indian J Mat Sci 2012- (**Axelsson**); Ed Board: Materials Research Society (MRS Advances) 2012-2019; Ed Board: J Composite Science 2019 – ; Guest Ed (Special Issue): Frontiers in Mechanical Engineering and Frontiers in Materials 2017; Guest Ed (Special Issue) and Assoc. Ed: Journal of the Mechanical Behaviour of Biomedical Materials (Elsevier): Collagen Mechanics 2016 (**Barber**); Assoc. Tech Ed: IEEE Communications Magazine; Ed Board: IEEE MMTC Communications – Frontiers; EURASIP on Image and Video processing; Signal Processing: Image Communications 2016- (**Dagiuklas**); Ed: J Food Engineering 2005- (**Evans**); Assoc. Ed: IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control (**Harput ECR**); Guest Ed (Special Issue): Mobile Networks & Applications, 2018; Guest Ed: EAI Endorsed Transactions on Collaborative Computing, 2019 (**Iqbal**); Ed Board: Euro-Mediterranean J Environmental Integration 2017- (**Kellici**); Ed Board: Green Processing and Synthesis J, 2012-; Ed Board: Reactions J, 2018 – ; Int Advisory Board: Canadian J Chem Eng 2013- 2017; Guest Ed (Special Issue): Energies J, 2019 – 2020; Member: IChemE Research Publications (Journals) Medals Committee, 2010 - (**Saha**); Assoc. Ed: ASME J Mechanisms and Robotics 2012-; Assoc. Ed: (**Selig**); Ed-in-Chief: J Low Frequency Noise, Vibration and Active Control, 2013- ; Ed Board: International Journal of Modelling, Identification and Control, 2020 - ; Intelligent sound measurement sensor and system (**Tokhi**); Ed Board: J Cosmetics 2013- (**Xiao**); Ed Board: Petroleum & Petrochemical Engineering Journal; Assoc. Ed: Fluid Mechanics Research International Journal (**Zhao**); Ed-in-Chief: Intl. J of Solar Thermal Vacuum Engineering, 2020; (**Saim**); Ed Board: Materials 2020 - Guest Editor: Materials 2020 - (**Buckeridge ECR**); Guest Editor, Special Issue in the journal Sustainability, 2020 –, Assoc. Ed, Engineering Management Journal, 2015 -, Editorial Board Member, Journal of Research Administration, 2013 – (**Philbin**); Editorial Board, Science & Justice, 2010 - (**Bleay);** Assoc. Ed: Journal of Solar Energy; Managing Guest Editor: Progress in Solar Energy (PSE) Special Issue for Perovskite Solar Cells (**Upadhyaya**); Assoc. Ed: Journal of Advanced Manufacturing Systems (**Goel**). Membership of national and international advisory boards and panels includes Mission Innovation Advisor to BEIS; EC expert group member; Australian Government Review; INSPIRE programme, British Council, DelPHE programme (**Tokhi**); Ranking proposals for future funding with Samsung under the Samsung Global Research Outreach (GRO) Programme (2015-2018) **Tokhi**); External reviewer in 2020 on faculty tenure panels for the University of Kentucky and Missouri University of Science and Technology and

external examiner in 2020 for the University of Johannesburg (**Philbin**); Co-chair of the EPSRC funded Computational Collaborative Project in Quantum Computing 2020 – (**Buckeridge ECR**)

Conference organisation and Invited talks

International conference on efficient solar power generation and energy harvesting 2019, Solar Energy PV from 2019 at KIIT, Bhubaneshwar (**Upadhyaya**); Conference Chair for Tomography for Scientific Advancement 2017 (**Barber**); Conference General Chair, CollaborateCom 2019 and 2020 EAI International Conference on Collaborative Computing: Networking, Applications and Worksharing, (**Iqbal**); International Conference on Climbing and Walking Robots and Support Technologies for Mobile Machines, Portugal 2017 (**Sattar**); International Conference on Standards of Assistive Technology and Robots for Health Care 2019, International Conference on Nanomaterials and Nanocomposites 2018, (**Tokhi**); Invited Talks in the International Conference on Photoacoustic and Photothermal Phenomena 2017 and 2019 (**Xiao**); 3 Invited/keynote talks at international conferences including Msnano-20, Conference on Advances in Theoretical and Applied Physics 2020, and International Conference on Material Science and Nanotechnology (**Sajjad**); Invited Presentations at the American Society for Engineering Virtual International Annual Conference, 2020, International Forum on Engineering Management (IFEM), Chinese Academy of Engineering, Jinan, 2019(**Philbin**);Keynote at both ICCC (International Cold chain Conferences) in Auckland 2016 and Beijing 2018, IIR Rankine 2020 Conference - Advances in Cooling, Heating and Power Generation, 2020; (**Evans);** Invited presentation at Chartered Society of Forensic Sciences conference, 2020 (**Bleay**); Invited presentations at LSE Bankside House 2019, Thomas Young Centre, Imperial College London 2018, Workshop on Thermoelectric Materials for Waste-Heat Harvesting, India 2018 (**Buckeridge**); Organiser and Chair of International Conference on Renewable Energy and Vacuum Insulations for NZEB's 2019, and invited speaker in the World Sustainable Energy Days, Austria, 2019, Workshop on How Resilient Manufacturing can solve the unemployment problem in Kenya, 2018 (**Memon**); EC Glass Forum / Tough coatings for a fragile substrate, 2019, Berlin- oral presentation – invited Keynote speaker - Novel nano-additives to enhance the durability of functional surfaces for Glass. MacroGroup UK Young Researchers Meeting, 2019 - oral presentation – Invited Keynote speaker - Opportunities in novel Nano-additives to enhance the durability of functional surfaces for industrial application (**Durand**); Organiser of Symposium ES03: Earth Abundant Metal Oxides, Sulfides and Selenides for Energy Systems and Devices, MRS Fall (2017) (**Dunn**).

Prizes and awards

Highly Commended Award in the "Energy" category for IChemE Global Awards 2014 (**Saha**); 1st prize in the "Materials Innovation for the 21st Century" and the "Increased Manufacturing Value" categories at the ChemEngDayUK 2014 (**Kellici**); Highly Commended award in the Process Safety category of the IChemE Global Awards (2015) (**Holborn**, **Ingram**); H&V News Collaboration of the year 2015, CIBSE best paper, 2015, (**Maidment**); 2015 Emerald Literati Network Highly Commended Paper of 2014 selected by the Editorial team of the Industrial Robot Journal, Emerald publications (**Sattar**); Highly Commended Award for practical innovation by Emeral Publishing at CLAWAR2020 (**Tokhi**); best paper at Sustainable Innovation 2017 conference (**Andrews**); Dstl 'Innovator of the Year' award, 2017, and Chartered Society of Forensic Sciences PW Allen Award (**Bleay**). Highly commended for the 2020 ICHEM E Global award for the ICEMART project **(Durand**). **Goel** was highlighted in ARCHER's 2018 Video Competition Gallery of 2018 revealing new insights into the wear of diamond while rubbing iron. **Sajjad** (**ECR**) has been recognised as one of 2020 emerging investigators in the field of energy and materials chemistry by the Royal Society of Chemistry.

National/international advisory board membership, peer review process participation

Exemplars include EPSRC Peer Review College (**Evans, Maidment, Saha, Goel, Upadhyaya**); Cyprus University of Technology awards (**Evans**); Dutch Technology Foundation STW; FP7 SUNGREEN consortium 2011-15 (**Axelsson**); Member: Hydrogen London Group 2012- (**Holborn**); Advisor to Committee to Climate Change on Refrigerant Leakage, Report on Refrigerant Leakage to the Refrigeration Technical Options Committee, Advisor to International Initiative - Mission Innovation - Affordable Heating and Cooling of Buildings as co-lead with 24

countries worldwide, and Advisor to UK Government Chief Scientific Advisor – November 2018 - (**Maidment**).

Leadership roles in industry, learned societies or professional bodies

Examples include Materials Research Society (elected) 2012-2019, Royal Microscopical Society Electron Microscopy Section Chair (elected) (**Barber**); Member of ISO UK Steering Committee for the development of an ISO on Transport Refrigeration, 2018- **(Davies**); Chair of BSI AMT10-1-Ethics of Robots and Autonomous Systems Committee 2012-; Convenor of ISO/TC299/WG2 – Service Robot Safety 2017-;Chair of CLAWAR Association 2015- (**Tokhi**); Chair, Inst Refrigeration (IOR) Int Refrigeration Committee 2008-, UK IOR international representative to the IIR, 2007–, President of IIR C2 committee (Food Science and Engineering), Vice president IIR CaRe sub commission, and Vice president cold chain in warmer climates sub commission **(Evans**); Director, Air Conditioning and Refrigeration Industry Board, 2013-, Chair IOR research network, 2008-, Vice-Chair Int Working Group on Refrigerant Containment, 2009-, President Inst Refrigeration, 2013-16, Vice President - Commission E2 Heat Recovery and heat Pumps – Intl Inst Refrigeration 2014-, Vice Chair – International Working Group on mitigation of leakage of refrigerants – Intl Inst of Refrigeration, Chair of the IOR Research committee SIRACH 2008- , Advisor to BEIS and co-lead of Mission Innovation Affordable Heating and cooling of buildings 2018 - (**Maidment**); Vice-Chair, IChemE Fluid Separation Special Interest Group (FSSIG) 2011- (**Saha**); Co-founder & Director, Biox Systems Ltd 2000-**(Xiao**); Board of Directors and President of the ASEM (**Philbin**) 2014-; Vice-chairman The IET East Midlands YP 2014 (**Saim**); Forensic Advisor to Dstl , UKAS ISO17025 Technical Assessor for Fingerprint Enhancement Laboratories, and member of the Defence, Safety and Security Subcommittee, IOM3 2010 – (**Bleay**); Member of IEEE 1932.1 Standard 2020- (**Iqbal**).