Institution: University of South Wales

Unit of assessment: B12 Engineering

1. Unit context and structure, research and impact strategy

1.1 Unit context and structure

B12 Engineering is part of USW's **Faculty for Computing, Engineering and Science**, (FCES), having its primary base and most facilities at the main campus, in Trefforest, but with some laboratories and workshops elsewhere.

The Faculty has an establishment of 250 staff. The UoA has eleven professors. Of the 33 people, (29.3 FTE), with Significant Research Responsibility, (SRRs), whose work is being submitted, 14 are at an early stage in their careers as researchers.

The REF submitted in 2014, soon after USW's formation in April 2013, reflected some legacy matters, since addressed, with substantial progress made. 2018 was a major milestone, with a new PVC (Research) in post, the launch of the **Graduate School**, (5b S2.2), introduction of the **Graduate Teaching Associates** (GTA) **Scheme**, (5b S2.2), reconfiguring Institutes as Centres, the **Sustainable Environment Research Centre** (**SERC**), left the School of Applied Sciences, and a Head of Research/Chair of the **Faculty's Research Committee** (FRC), (**Copner**), was appointed. Inherited issues concerning protected time were resolved: now all our researchers have protected time, funded by QR and the University.

The new model is organised around Research Centres, with **SERC** being the earliest, and by far the largest. The **Engineering Research Centre** (ERC), functions as an incubator providing mentoring and support to smaller groupings, such as **Advanced Materials Testing Centre** (AMTeC**),** **Wireless and Optoelectronic Research and Innovation Centre** (WORIC), and the **Advance Control and Network Technology Research Group**, (henceforth NetTec), while they mature, prior to hiving off to stand-alone status, as has already occurred with the **Centre for Automotive and Power Systems Engineering** (CAPSE). These Centres form the core of this UoA.

SERC Director**: Guwy** (https://serc.research.southwales.ac.uk/)
(**Carr, Costa, Davies, Dinsdale, Esteves, Graham, Laycock, Maddy, Massanet-Nicolau, Miedziak, Owen, Patterson, Reed, Zhang**).
SERC includes a range of multi-disciplinary researchers addressing the global challenges of delivering a low carbon economy. Since 2014, strategic research aims were directed at strengthening staff critical mass, expanding research capacity infrastructure, developing the **Hydrogen Research Centre**, and intensifying further engagement with industry. **Guwy** *et al's* article in Bioresource Technology (2014), delivered new techniques for reducing methane emissions in microbial fuel cells for deployment in low carbon wastewater treatment systems, **Dinsdale** *et al*'s paper in International Journal of Hydrogen Energy, (2019), introduced how using electrodialysis in food waste fermentation could increase hydrogen yield and carboxylic acids allowing easier commercialisation and lowering carbon footprint. **Antonelli**'s (2016) patent, US 9376316, demonstrated, for the first time, a viable fabrication and use of Manganese Hydrides molecular sieves for reversibly and safely absorbing/releasing hydrogen at high densities without thermal issues enabling long haul transport and significant heating applications.

ERC Director**: Kinuthia** (https://engineering.research.southwales.ac.uk)
(**Bai, Copner, Harrison, Huq, Li, Liu, Navartne, Oti, Otung, Robinson, Rodriguez, Shao, Tan, Fan**).

In addition to functioning as the UoA's incubator for new research groups the ERC brings together research from a number of different areas:

- **AMTeC** Research Lead: **Kinuthia**

This is also a multi-disciplinary Centre, emanating from on-going research and consultancy work in Civil Engineering, addressing innovation challenges facing the infrastructure sector. AMTeC has widened and enhanced its scope to include cutting-edge research into sustainable cementitious materials, geo-polymers and composite materials such as fibre-reinforced polymers.

- **WORIC** Research Lead: **Copner**

WORIC's expertise in optoelectronics applies to many sectors - telecommunications, sensing, metrology, display, lighting and health. **Copner** *et al*'s latest article in Nanophotonics (2020), proposed and demonstrated, for the first time, the use of layered metamaterials to enhance IR spectral emission (1.4-14μm) of a blackbody creating superior heating efficiencies of up to 30%. WORIC initiated a **Centre for Photonics Expertise,** (CPE), combining academic expertise from Bangor, Glyndŵr, Aberystwyth and USW, all seeking collaborations with industry, to address and resolve technical barriers.

- **Centre for Electronic Product Engineering** (**CEPE)** led by Oleon.

Working with WORIC, CEPE has extended its electrical design capability into technologies requiring innovation and commercialisation. Mentoring provides appropriate support to build confidence in developing ideas and proposals, to grow its own networks, and to develop its research base.

- **NetTech** led by **Liu**

The Group engages in fundamental theoretical research as well as industrial applications, addressing networked control systems, multi-agent control systems, Internet of Things, fuel cell modelling and control, non-linear identification and control, and multi-objective optimal control. **Liu** *et al*'s (2014) article in IEEE Transactions on Automatic Control, describes the first real theoretical foundation for hybrid stochastic retarded systems and stability analysis. Their later article (2015), in the same journal, discusses novel networked predictive control method which successfully utilizes data to model nonlinear uncertain system dynamics, achieving desired optimal control performance and active communication constraint compensation of networked systems, which was previously unresolved by existing methods.

- **Aerospace Research Group** (**ARG**) headed by **Navartne**

This Group (four FTE's plus support), was formed in November 2019 to deliver breakthrough efficiency improvements in electrical motors. A former executive of electrical steels at *Tata Steel*, Mark Cichuta**,** (Visiting Professor), has been contracted to develop new European networks so that effective extended teams can be established to resolve technological design barriers.

CAPSE Director: **Williams** (https://www.southwales.ac.uk/research/research-areas/capse/) (**Bowkett**)

CAPSE is home to Europe's largest battery R&D centre with the ability to measure the performance of over 200 cells simultaneously, and 16 full electric vehicle battery packs under controlled climatic conditions for extended periods. It has developed several new methods for safety testing implementations of ISO standards as well as innovative 'power electronics control' strategies and algorithms, including network management that will be instrumental in all future electric systems control. Sixteen new highly-skilled jobs for researchers, engineers and technicians were created as a result of industrial collaborations.

As with our parent institution, the UoA is 'Committed to growing and sustaining a thriving research culture where staff and students are supported to achieve their fullest potential. Our research informs our teaching, solves problems and has an impact on people, and the economy', and we subscribe to both the UK *Concordat to Support the Career Development for Researchers,* and USW's *Mission Statement*, (5a).

All our Unit's research is underpinned by common values of rigour, integrity and professionalism.

Following on from the last REF, and with a FRC whose remit is to empower researchers, aligning their objectives to the University's *Research Strategy*, (5a), the UoA has established a firm mission to further enhance its industrial and multidisciplinary links leveraging off key innovations, advancing new critical research themes, (e.g. ARG), and developing the skills to execute them successfully, and to share the insights obtained effectively.

1.2 Research and impact strategy

Our overall **AMBITION** is:

To improve the relevance of our research and its impact on people's lives, particularly in the priority areas of environment, economy, and wellbeing policy; this incorporates dissemination, teaching and understanding.

We identified three main **AIMS** as ways of delivering on our **AMBITION**, each comprising a set of **OBJECTIVES:**

1 Empowering the researchers

- Strategic recruiting and appointing.
- Utilising mentoring and other means to increase the number of active and proficient researchers and Research Groups/Centres (across all disciplines), being inclusive of all - from promising novices to experienced academics, mindful of Equality, Diversity and Inclusion.
- Helping each other co-operatively and by better use of processes like 'critical friend', peer reviews of papers and grants.
- Ensuring sufficient protected time for research.
- Continuing to develop postgrad provision, such as Knowledge Economy Skills Scholarships (KESS), and doctoral supervision.
- Better informed research-led undergraduate teaching.

2 More effective resource and facility deployment

- Increasing income and prudent investment in our facilities and resources.
- Optimising and expanding existing resources such as the Library, data bases, laboratories and workshops.
- Establishing a Research Centre Incubator.
- Optimising and expanding commercialisation opportunities – spin-offs, licenses, grants and other financial support.
- Incorporating appropriate and bespoke quality training for PhD, supervision, bid-writing, and commercial opportunities.

3 Enhanced networks and collaboration opportunities

- Encouraging and increasing research visibility and brand through more high-value publications, editorships, patents, government advisories, consultancies and research grants.
- Establishing appropriate contact data bases across academia, industry, governmental agencies and others.
- Building constructive relationships and partnerships of a multidisciplinary nature with funding bodies (e.g. national government, angel investors).

Our current submission is indicative of both our achievement, and intention to grow our research community with its reach and impact. During the assessment period we achieved our identified **Aims** as follows:

Aim 1
The success of our approach to strategic recruiting, and growing-our-own is well illustrated by, *inter alia,* **Navartne,** a member of ERC, who was research-mentored and had the benefit of a critical friend for bid-writing, and, with support, won two Welsh Government (WelshGov) Smart expertise projects - Icore (new efficient motor design), and Dragonfly, (electric propulsion for planes).

Comparable mentoring was provided to other UoA staff, (**Graham, Costa, Laycock, Li, Michie, Owen**). Similar support is also shared with other UoAs of different disciplines within the Faculty, (e.g. B7: **Nieuwland, Hayhurst**). During the covid pandemic, four members from three of our UoA Centres, working together, won a WelshGov award for rapid design and delivery of an innovative oximeter from scratch. With support, and entrepreneurial acumen the same team won a further research grant from WelshGov to deliver covid-detecting solutions.

As we are growing the number of lecturers undertaking research, we have instigated a new recruitment approach whereby we recruit staff who do some lecturing alongside a formal PhD programme. Five people were recruited into such GTA posts in the last 18 months. Specific funded time-limited projects paid for some key researchers (**Huq, Robinson, Shao**), allowed us to recruit others (**Li, Laycock, Michie, Fan**), while some were recruited for their specialised skills (**Miedziak**, **Graham, Owen**).

We have endeavoured to improve teaching at all levels by helping to create an industrial board for the Electronics degree, BEng, and final year projects. We pioneered an Applied Engineering degree assessed only on practical skills (electronics, mechanical, software and optical design), without written examinations. Most of our PhD students are involved in collaborations with industry, many supported through the KESS scheme.

Aim 2
The research income for this REF period has grown to £19.36 m, (5b S3.1), which is being used, alongside University funding, to invest in staff, and to improve resources and facilities.

In 2013-4, we established a pioneering dedicated Research Centre, ERC, with the primary function of mentoring individuals in areas pertinent to research – bid-writing, applying for grants or patents, commercialisation, with training or supervision, as appropriate. Instilling confidence in our novice researchers to promote their own work, will ensure future training becomes more targeted to address individual needs.

SERC's work on waste management, and hydrogen use, has strongly impacted funding themes from BEIS and others, and led to further multifactorial collaborations such as Flexible Integrated Systems (FlexIS), and its 18 work packages addressing carbon capture and hydrogen storage, always taking into account economic and social considerations, featured at COP24, the UN's Climate Change Conference (2018). Reduced Industrial Carbon Emissions (RICE) is another multi-partner European Regional Fund (ERDF), collaboration, as is Smart CIRCLE (Collaboration in Industrial Resource Circular Economy).

In 2016, CAPSE moved to a purpose-built facility on campus, representing a capital investment in equipment. By securing several major, long-term commercial R&D contracts from major original equipment manufacturers, CAPSE's turnover grew from £0.7m in 2017-18 to £2.3m in 2018-19. It also secured a £3.2m ERDF project, Sustainable Energy Storage Solutions (SESS).

In 2016, we instigated open access via PURE (5b S3.2), using our modernised library service. Subsequently, ongoing training has been provided for researchers in the open access compliance requirements of REF.

Aim 3

The ethos of the UoA is to foster collaborations with business, academia and/or government(s), in various capacities. For example, senior staff provide an extensive range of consultancies with several of our researchers (e.g. **Copner**, **Esteves, Guwy**) fulfilling advisory roles with international, European, UK and Welsh Governments, industrial trade associations and agencies, (and further afield, such as Malaysia), bringing considerable influence to policy decisions. SRR's authored 250+ publications, held a number of editorships and applied for 27 patents. Major research grants are detailed in 4a (highlights: Table 2).

Both CAPSE, and CPE, (conceived at USW), were deliberately constructed to increase interaction with, and awareness of, new technology, and to lead impacts in new energy and innovative solutions of industrial/technical problems. CPE works with companies in Western Wales and the Valleys, on a match-funding basis, meeting ERDF targets and contributing to innovation and entrepreneurship by creating new processes, products and jobs around photonic solutions, (including waste reduction), and works closely with USW's Business Exchange to publicise its work through promotional literature, (virtual) networking events, business shows and conferences.

Whereas the examples set out above are indicative of how we have addressed and achieved our strategic **Aims**, our three submitted Impact Case Studies (**Esteves** Anaerobic Digestion, **Esteves** Biogas, and **Maddy** Hydrogen Use), provide further and deeper detail as to how we are achieving our overall **Ambition.**

How our Aims will be taken forward

Following our review of how the above **Aims** were addressed, we now consider that for the future, we will update and supplement those **Aims** with the following:

Aim 1

- Mainstream building confidence in research staff, especially to commercialise their own work.
- Encourage more staff to become members of policy-influencing bodies/Statutory Committees.
- Support applications to join appropriate early career networks, for example, *Welsh Crucible*.
- Link the new Applied Engineering degree and others to Faculty research to better meet workforce needs.
- Assertively review internal barriers to Equality, Diversity and Inclusion (ED&I), at Faculty level.

Aim 2

- Contribute constructively to the customising of a forthcoming facility for Engineering to ensure its serviceability for effective research.
- Provide suitable campus space, (offices, laboratories, workshops), to support spin-offs at the early stage of their development.

Aim 3:

- Focus on developing meaningful relationships with angel investors, entrepreneurs, business professionals and suitable incubators.
- Demonstrate more assertively/share more effectively evidence of the benefits of research investment.
- Continue to engage in collaborative projects, where possible working alongside end-users, and, where appropriate, making use of University-wide expertise in the identified Accelerated Development Areas (ADAs, see 5a).

We are now setting out *via* the FRC new processes to link the staff research with potential commercial opportunities, and to address identified barriers to career development within the UoA.

A short staff survey, (2020), revealed that none were current members of policy influencing bodies such as Statutory Committees. Given that this could be considered a shortcoming, it will be added as an **Objective** to our overall **Ambition** for future REFs.

Additionally, within the UoA, Centres have their own individual **Strategic Plans:**

In the next five years, **SERC** will:

- Continue to work with industry to strategically target hydrogen energy systems, bio-electrochemical systems and resource recovery from waste as areas for investment and development to achieve international excellence and impact on policy-making, the environment and the economy.
- Build on the work of the industrially sponsored PhDs to further the scientific, industrial and environmental impact of our research.
- Specifically target the use of bio-electrochemical technology for advanced water treatment (supported by the Royal Academy of Engineering Professorial Chair), the development of hydrogen energy systems (FLEXIS App Demonstration area, and RICE) and sustainable biological recovery of products from wastes (Smart CIRCLE, BEACON and Sêr Cymru BioPOL4Life – Centre of Excellence in Biopolymers).

ERC undertakes many distinct research activities in its incubator role. The intention is to continue to nurture and sustain the new growth areas to maturity as Research Centres in their own right, with at least one hiving off within five years. As the electrification of the world presents huge challenges - thus opportunities, in innovative motor designs and their applications, **ARG** has the potential to grow in this way. **WORIC** and **NetTec**, both led by experienced researchers, will continue to deliver breakthroughs developing further growth in health solutions and remote communications. **CEPE** will be developed from electronics design to more applications requiring innovative solutions using their skills. Hence we will double our research and commercial income, further augmenting our commercial and societal impacts.

Contracts already secured by **CAPSE** indicate long-term sustainability as turnover doubled again in 2019-20 to over £5m and will create four more high-skilled positions. CAPSE aims to use its new electro-chemistry research team as the bridge between engineering and technology expertise with cell manufacturers. A spin-off company is planned for 2021 to take that expertise into a manufacturing arm, seeking investment from independent venture capital. The new Automotive Engineering and experiential Applied Engineering degrees at USW will provide a pipeline of industry-focused postgraduates to work on projects as a ready-made resource of graduates ensuring sustainability by underpinning the future growth of CAPSE.

2. People

2.1 Staffing strategy and staff development

As an integral part of USW, we subscribe both to the *Concordat to Support the Career Development of Researchers*, and USW's *Staffing Strategy* (5a), as applied to meet our UoA's needs, in keeping with our **Ambition** (5b S1.1), our first **Aim** was to empower our research staff, and our staffing strategy is concerned with *how* we go about doing so.

We set out a list of **Objectives** starting with recruiting and appointing (5b S1.2). During the current REF period, there was minor attrition, mostly due to planned retirements, but overall a significant increase in the number of SRRs being put forward. In 2014, it was **16**; now it is **33**

individuals. We believe that this is indicative of both vitality and sustainability.

Posts were refilled, though not necessarily where the vacancy had arisen, as decisions were informed by need. This resulted in Research Projects being reinforced by the addition of suitably skilled staff bringing fresh ideas and expertise to SERC and ERC, (shown below), enabling cross-fertilization of concepts and mutual support.

- SERC:- **Massanet-Nicolau, Miedziak, Costa, Owen.**
- ERC:- **Fan, Harrison, Huq, Navartne, Robinson, Rodriguez, Shao.**

(Fifteen non-SRR appointments were also made to CAPSE).

We proactively align incoming staff with our overarching **Ambition** and encourage acculturation in terms of setting, and expecting high standards, which we reinforce with appropriate role models, and by team development. Our reputation and regard is important to us. We take especial care of novice researchers, including individuals on Fixed Term Contracts, (FTC's), in terms of their work allocation and time management, and the development of their research armoury (e.g. methodology, bid-writing, applying for grants, commercialisation, taking work through to publication), as well as wellbeing and work-life balance, Health and Safety, lone working, and Occupational Health. We work with people's strengths and take appropriate steps to help build confidence where indicated, thereby ensuring the continuing vitality and sustainability of the UoA.

Line managers are responsible for conducting individual Development and Performance Reviews (DPRs) – a regular system of appraisal and support. Part of this system identifies training and/or upskilling needs. The Athena SWAN submission (2020) identified some issues with the current DPR system which lead to the possibility of career progression or future employment, (which impact FTCs more acutely than others), not being adequately explored. Within the UoA, we are considering additional training for line managers so they can appropriately support the career progression of their staff. Generally, we respond by the provision of appropriate mentoring, training, supervision and support – such as defraying costs associated with attending Conferences. We are amenable to considering sabbaticals and secondments.

We are also considering the provision of a supplementary source of support from Faculty Research Committee, (or a nominee), for early career and fixed term researchers, such as a critical friend/mentor.

The vitality of the UoA is evident in the high level of participation in Conference presentations, keynotes and plenaries, even chairing conference sessions, or whole conferences. Some have made exceptional contributions such as **Maddy**'s keynote speech at the Advanced Propulsion Centre Hydrogen Conference (Cardiff 2018), and **Liu**'s Distinguished Lecture at the 28th Chinese Control and Decision Conference, (Yinchuan, 2016).

In meeting our second **Objective,** we ensure that new starters benefit from protected time and are allocated a suitable mentor (e.g. **Fan** mentored by **Copner**), and we encourage, when the opportunity arises, internal promotions (**Esteves, Patterson, Williams**). This is not inevitably a matter of 'dead men's shoes' as there is provision through the Higher Academic Award Committee (5a), for Chairs to be awarded on application supported by appropriate evidence.

Researchers are introduced to key support staff in the research bid process and have the support of laboratory technicians. Internal investments such as I2S (Impact and Investment Scheme), and SRIF (Innovation Fund), alongside Faculty investments have provided essential support to novice independent researchers and with this we have seen substantial increase (more than double), in the number of bids and income, facilitating and securing a sustainable future.

The University works closely with a network of other HEIs to provide researchers with access to further opportunities to develop their skills. We encourage our researchers to access resources like the **Graduate School**, and collaborative endeavours such as *The Effective Researcher*, and *Leadership in Action.* Early to mid-career researchers are encouraged to apply for membership of the *Welsh Crucible* programme, designed to develop future research leaders and encourage cross-disciplinary research. **Bowkett, Navartne**, **Robinson** and **Patterson** were among the 30 successful candidates selected from across Wales who attended this programme of residential training to help establish collaborations and develop skills appropriate to forge international research profiles. **Robinson** was a member of the *Welsh Crucible* selection panel for the three most recent cohorts.

We support exposure to experts in their field by encouraging attendance at the regular and frequent sessions conducted in-house by invited eminent Visiting Professors.

We encourage existing staff who wish to become researchers, to engage in development opportunities such as doctoral study. Sivanathan, who collaborates with *NPL*, is so enrolled at the moment. Earlier, we cited the example of **Navartne**, mentored in ERC, now heading up ARG (5b S1.2), as illustrative evidence of how our incubator and mentoring method contributes to a healthy and nurturing environment that fosters and sustains the next generation of researchers.

One obvious effect of this is the development of a critical mass, not only *within* the Faculty, but *across* its Centres and disciplines - for example members of CEPE (Oleon, Sivanathan), ARG (**Guo**), and WORIC (**Copner**), recently worked together to deliver on an emergency covid project to develop a ground-breaking oximeter, (**Aim** 1 **Objective** 3). In keeping with our commitment, (as set out in our **Ambition**), to better share the relevance of our work to people's lives, **Copner** was interviewed about the oximeter on UK television news in July, 2020. Likewise, **Esteves** was Adam Walton's guest (Science Café, BBC Radio Wales, January 2020), discussing 'The Problem with Plastic.'

In terms of our own **Aim** to empower researchers, we have demonstrated above how we met **Objectives 1-4**. Meeting **Objectives 5-6** is addressed below.

2.2 Research Students

Teaching teams are strongly connected to their related industries ensuring they bring knowledge of their work to the courses, but, in fulfilment of our fifth and sixth **Objectives**, (**Aim 1**), we believe that by also providing research-led teaching to our undergraduates, that they will aspire to become the postgraduates and quality researchers of the future. We regularly hold Open Days for the curious, (recruiting from at home and overseas), providing support and advice, online and in person, about courses, living arrangements, finances, and other concerns to aspiring students.

Our courses, leading to the award of MEng, MSc, MPhil, or PhD, consist of bespoke elements of hands-on working with industrial partners, involvement in research, and direct teaching, with our renowned researchers taking a lead role. All research students are supervised by a team comprising a minimum of two staff members, at least one of whom is an experienced supervisor (successfully overseen two+ completions). Mentoring and regular seminars are a feature of the support provided. Staff involved in research student supervision undergo regular training on good practice through combinations of workshops and drop-in sessions.

Postgraduates are supported to develop their critical and analytical skills and management experience. Engagement in hands-on and workplace familiarity is encouraged at all levels. Our students have completed year-long placements with a range of companies, including *Tata Steel, 3M, Reneas, Airbus UK, Renishaw, GlaxoSmithKline, Panasonic, Bosch, IBM* and others. Research students are further encouraged to enrol on a newly-created 60-credit module leading

to a Postgraduate Certificate in Research which provides PhD students with a sound framework for developing their research.

The **Graduate School** offers a range of postgraduate degree programmes, including **Knowledge Exchange Skills Scholarship** (KESS 2), supported by European Social Funds (ESF) through WelshGov, providing a funded postgraduate research degree relying on collaboration with an industrtal partner within the WelshGov's priority economic sectors. USW's **Graduate School** supports postgraduate researchers, supervisors and examiners, bringing together individuals from a variety of disciplines into one community for a range of development opportunities and mentoring which includes guidance on PGR degree programmes and regulations, support for the student for the duration of the studies, engagement with experienced research staff delivering creditable, high quality skills development opportunities for postgraduate researchers, supporting and developing supervisors, examiners and viva chairs and providing pathways for experience in external engagement. Advice covers topics such as methodologies, ethics considerations and processes.

Applications to the **Graduate School** are sympathetically but scrupulously considered by the **Faculty Research Doctoral Committee** (FRDC) who, amongst other matters, will ensure that there is sufficient and appropriate supervisory capacity and expertise, and adequate resources within the Faculty to do the student justice.

Research student progress is formally monitored by the University's **Research Degrees Committee/Graduate School Board**, which supports the research team, appoints examiners, and disseminates good practice in the delivery of research degrees to current and future supervisors.

Postgraduate students typically undertake a small amount of undergraduate teaching to develop further essential professional skills, and are encouraged to attend and present at conferences, including annual Faculty and university-wide research workshops, regional events, and major national and international conferences along with several specialist postgraduate conferences (e.g. Postgraduate Combinatorial Conferences). Research students also attend training sessions relevant for their individual needs, internal and external to the University and most postgraduate research students participate in relevant workshops (e.g. grant-writing, how to develop successful Knowledge Transfer Partnerships).

Under the GTA program, individuals complete their PhD part-time over five years. They are employed at 0.4 FTE to complete their doctoral studies in the other 0.6. The scheme is designed to facilitate their paths towards becoming fulltime lecturers and/or researchers.

Currently, there are 70 research students, with a total of 51 PhD awards granted in the period. Funding for our students has been obtained from an extensive range of sources including Engineering and Physical Sciences Research Council (EPSRC) awards, awards from the European Social Fund with an industrial partner, under KESS, (e.g. *Global Laser, Tata Steel, Wales & West Utilities, Flogas, Welsh Water, Bryn Power*), other industrial collaboration (e.g. *Airbus*, *NPL*), and/or self-funded. As with our mission to further progress and develop our commercial links, we encourage all our students to work effectively with their industrial partners to deliver beneficial impacts, and to consolidate their industrial awareness and effectiveness.

Postgraduates are allocated personal desk space with pc's, and appropriate software. Communal facilities are provided, with access to all university facilities as required – workshops, laboratories and library, with technicians' input where indicated.

2.3 Equality and diversity

All staff are required to undertake mandatory ED&I online training.

We are unable to provide data regarding ethnicity or disability as doing so may unduly identify individuals, however we can report that thirteen of our SRRs are from overseas (e.g. China, Portugal, Nigeria, Sri Lanka). Within our UoA, we are particularly conscious of gender under-representation, which is not untypical of the STEM sector, as only 10% of our submitted 33 SRRs are women.

Engineering, like everyone else at USW, subscribes to the University's *Strategic Equality Plan 2020-2024* (5a), to provide 'A safe, welcoming and inclusive community for all our students, staff, partners and visitors,' (Vice Chancellor's Foreword). Some of the Plan's objectives may 'belong' more appropriately to corporate direction, (e.g. closing paygaps), whereas appointment to differential paygrades - and promotion - would be local decisions. Sometimes corporate policies have unintended consequences such as the process for promotion to professor which was seen to disadvantage women (identified in our Athena SWAN submission 2020). This was attributed to unsociable working hours, but had the effect of encouraging able women to go sideways as very senior administrators or lecturers instead, which in turn led to lack of visible role models and gender imbalance at senior levels. The University intends to address barriers to career progression for females in STEM by creating a USW Women in STEM Network with the Faculty Dean as its Executive sponsor.

We are cautiously optimistic about the *next* generation, given that of the *completed* PhDs, 42 were male and 9 female. By July 2020, actively registered, the gender balance was 46 males/24 female, demonstrating not just a steady increase in students, but a considerable improvement in attracting females into a STEM area.

Some of our staff already contribute to ED&I, e.g. **Robinson**, a Female Fellow FIMMM of IOM3, and a committee member of the IOM3 Women in Materials, Minerals and Mining group, who, as a result of a request by the Chief Executive of IOM3, has joined an ED&I focus group at the Royal Academy of Engineering.

While the University is addressing the issues identified in its Athena SWAN work, and founding the Wales Women in STEM Network to further understand the underlying factors influencing the underrepresentation of females in STEM, we are considering, at Faculty level, how we may make positive changes, and referred earlier to ways of supporting managers to support their staff (5b S2.2).

At present, female representation on FRC is circumscribed because membership is accorded by status/job function and as there are relatively few women in such roles,
low numbers tend to predispose to low, or no, representation. Discussion is currently underway to review the FRC's constitution to improve principles of inclusivity, and, better decision-making.

The University is committed to the principle of treating the **Welsh language** on a basis of equality within every aspect of academic and administrative provision, complying with the Welsh Language Standards. As a recent example, CPE produced its own *Eco Code* bilingually and all its publicity literature is available bilingually. As a higher education provider in Wales, USW has obligations in relation to Welsh language provision and Welsh language matters are regularly considered alongside the equality agenda, particularly when conducting Equality Impact Assessments.

3. Income, infrastructure and facilities

3.1 Income

Our second **Aim** encapsulated more effective deployment of resources and facilities. Whilst our prime resource is always our people (see 5b S2), we fully recognise that the physical and expectational environment in which they work is fundamentally linked to performance. We are proud to report that during this REF period, we nearly doubled our total research income from **£10.3m** (2014), to **£19.36m**. During the REF period, **£189,000** was generated from royalties and licences. Our focus and drive towards working more closely with industry, to provide the insights, developments, and solutions that meet their needs, is well illustrated by the increase in UK industrial income from **£2.7m** to **£5.4m**, while our contemporaneous strategic investments in facilities, enabled new hydrogen storage breakthroughs by **Antonelli**, and **Owen**, leading to three patents and a spin-off company, *Kubagen*, **(**established in 2016).

Our commitment to grow meaningful networks across Wales, and beyond, has led to substantial interdisciplinary projects, (academic and/or industrial), funded by the EU (WEFO), totalling **£9.7m**, an impressive increase from 2014's **£3.7m**. A snapshot of research income, by source, is set out below, with full details presented in REF 4b.

FUNDING SOURCE	2012/13 (£k)	2019/2020 (£k)	% CHANGE
Research Councils	1,474	1,861	26.2
EU	3,716	9,760	162.6
Industry	2,735	5,393	97.2
Other	2,340	2,348	0.3
Totals (rounded)	**10,266**	**19,362**	**88.6**

Table 1

Direct industrial activities such as consultancy, test and measurement, are also strategically important as they create effective mechanisms alerting researchers to potential commercial technical challenges, thus maintaining both current vitality and sustainability. 'Coalface' realisation of such challenges lead to real impactful solutions opening new markets and new opportunities.

Some of our typical recent research work is outlined below:

PROJECT NAME	DESCRIPTION	PARTNERS	USW AMOUNT £
Innovative Oximeter	Rapid innovatory collaborative design response to pandemic circumventing suppy chain issues	WelshGov	150k
FlexIS	Renewable hydrogen, storage and syngas use	Cardiff and Swansea Universities, *Tata Steel, N-PT CBC. Pen y Cymoedd Wind Farm.*	3m
RICE	Capturing CO_2 from industrial emissions and converting to animal feed and DH3 omega fatty acids for human use	ERDF funded. Led by ERSI at Swansea, with *Tata Steel* and *Welsh Water.*	1.7m
Smart CIRCLE	Conversion of waste gases, valorisation	ERDF funded with 50% match from	1.9m

	of wastes, fermentates and digestates and development of real-time monitoring and control strategies for bioprocesses	industry, with *Welsh Water, TATA Steel, BPE, Heat Catcher, CSIC* (Spain), *Bryn Power, GP Biotec, FRE-Energy*	
CPE	Provision of photonic solutions to SME's (mostly) in West Wales and the Valleys	WEFO/ERDF. Glyndŵr, Aberystwyth and Bangor Universities.	1.6m

Table 2

Whereas much of our conventional research income concerns R&D Projects, and commercialisation, we are particularly proud of **Dinsdale**'s ten year fellowship to the value of £2.7m (until December 2029), as the Royal Academy of Engineering's Chair in Emerging Technologies.

The amount, range, scope and level of our activity in Engineering, indicates that we are punching well above our weight and despite the likely limiting effects of Brexit on our EU funding source, we have sufficient vitality and sustainability to see us through. Alliances *within* academia is not a new phenomenon, but we take our collaborations further – for us, multidisciplinary interactions within and between academia and industry is a working norm. This approach will stand us in good stead for the future, submitting new proposals, (e.g. to the Industrial Strategy Challenge Fund), building on existing relationships, to develop further links to investor networks with a view to aid the efficacy of establishing new start-ups. Our growth areas such as low and zero carbon energy gases and electrification, novel bioprocesses for a circular economy related to green chemicals, biopolymers, feed and food, place us well for keeping pace with both global developments, (e.g. climate change and biodiversity), and local needs (e.g. green growth and viable employment).

3.2 Infrastructure

The UoA is organised by Centres as described in S1; its infrastructure comprises several intersecting and overlapping elements providing a supportive and nurturing environment, in support of staff development as outlined in S2. We rely on clear processes (set out in documentation), and subscribe to the principles and values set out in both the *Concordat to Support the Career Development for Researchers* and the *Concordat to Support Research Integrity.*

Whereas individualised support regarding innovation and commercialisation, as appropriate, is generally provided *within* the UoA, we share some specific dedicated services:

- The **Research Impact Team** supports academics to develop skills, knowledge and confidence to maximise the impact of their research and promote expertise beyond academia to wider society, the economy, culture and environment. *Research impact* is understood as the beneficial changes the University's research and expertise makes to the economy and wider society, (improving economic performance, increasing the effectiveness of public services and policy, enhancing the quality of life, health and culture). The Team facilitates knowledge exchange, and collaboration with external partners, providing advice and support on IP management and commecialisation. It also supports the development of REF impact case studies and impact projects.

- The **Research Innovation Service (RISe),** offers Research Impact Training, (*via* CPD), providing skills, tools and knowledge to develop impact from research.

- The **Research Infrastructure Team** ensures that the Faculty is supported by a thriving academic/research base, underpinned by various frameworks and systems. The Team helps ensure that our research and innovation activity complies with all ethical, legal, professional and governance obligations and offers strategic and operational support, and management for all aspects of the REF assessments. This Team manages **Pure**, the University's online research information system/reporting tool holding up-to-date records of the work being undertaken by academics - research outputs, activities, impact, external funding applications and awards. This material is our institutional repository, the **USW Research Explorer**, enabling USW to support the REF Open Access agenda.

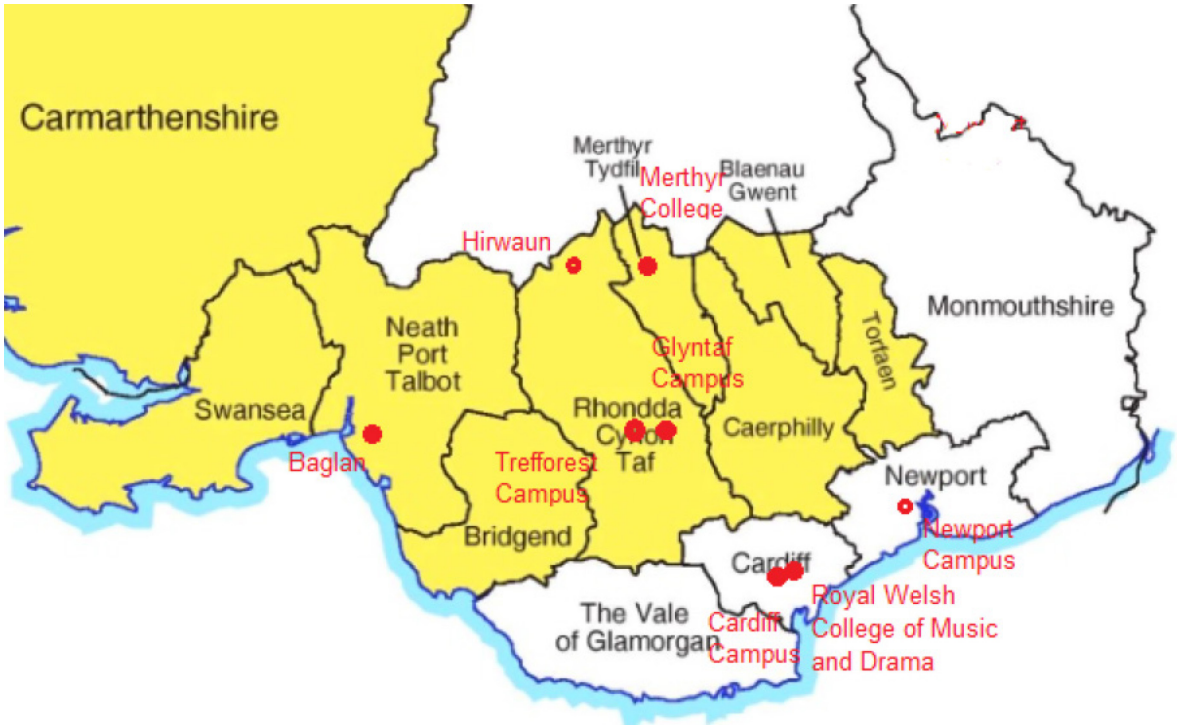
Senior Professors contribute actively to the formulation and execution of the University's high level strategies. **Guwy** and **Williams** are members of USW's **Faculty Research Committee**, chaired by the Head of Research, **Copner.** The FRC is a co-ordinating body, (meeting every six weeks), which operates as a link between the Academic Boards and the Research Centres. Working with the Centres, it helps to set the Targets (income, publications, interdisciplinary networks, PhDs and ECRs), that ensure compliance with the USW 2030 strategy. The FRC has its own standing Terms of Reference and Constitution with vacancies being filled as they occur; in light of insights gained during the REF process, current practices will be reviewed and learning implemented.

Copner is also a member of the **Faculty Executive Board**, **REF Strategy Committee** and the **University Research Committee**, and thus, overall the UoA has significant influence on, and input into, the University's research agenda.

These arrangements and the interworking between them, protect the integrity of our research, and provide a comprehensive, engaged and informed, supportive environment for active and aspiring researchers.

3.3 Facilities

USW is a disparate university operating out of eight different sites across South East Wales, (Figure 1). The UoA is likewise dispersed, having bases in Baglan, Hirwaun, Trefforest and Glyntâf. Distance makes travel inevitable, but wherever possible, staff are encouraged to cycle (lock-up spaces provided), or walk to work, (with shower facilities available on site). Electric vehicle charging points are installed in some car parks.



(Map: *Welsh Government Cartographics* 2006)

Figure 1. **Relative location of USW sites in South Wales**
Baglan, Hirwaun, Cardiff Campus,Glyntâf Campus, Newport Campus,Merthyr College, Royal Welsh College of Music and Drama, and Trefforest Campus

Baglan: A new hydrogen research centre with solar panels providing locally produced hydrogen fuel for the local community.
Hirwaun: Europe's largest battery R&D centre with motor testing facilities, includes numerous climatic chambers, chillers, test facilities, safety rigs, test vehicles, cell and pack testing cyclers (worth £2m+).
Trefforest/Upper Glyntâf: Engineering facilities include 450 m^2 of laboratory space with composite making facilities; additive manufacturing facilities; laser scanner; aluminum casting facility; a fully instrumented wind tunnel; material testing facilities; non-destructive facilities; advanced analytical platform for gas analysis including a Sercon IRMS analyser for measuring the stable isotope ratios of gases and a Hiden HPR-20 process mass spectrometer for gas composition determination; a Waters UPLC mass spectrometer to analyse pollutants such as pharmaceuticals in wastewater complements a range of gas chromatographs and ion mobility spectrometers for the analysis of organic products, together with an embedded and electronics systems lab, as well as new state of the art photonics laboratories with high performance UV holography, coating facilities, and interferometers.

All our staff and PGRs have access to these facilities as well as the fabrication workshops, with support from 30+ technical staff.

Elsewhere, WORIC, via its CPE project, has access to labs across all its Partner HEIs, including the newly installed and commissioned vacuum-coating plant at Glyndŵr.

Researchers can access high-performance computing facilities through HPC Wales. assessments can be undertaken to ensure that persons with disabilities are not disadvantaged. During the pandemic research continued by encouraging everyone to work from home unless absolutely unavoidable, with access to campus facilities subject to risk assessment. The safety and wellbeing of our staff and students is important to us and includes ensuring our premises are covid-secure.

We encourage a good work-life balance and the wellbeing of all our staff and researchers is a priority. We operate a flexible approach to working hours, time off and, (in normal times), we encourage the use of breakout areas, and our extensive leisure and hospitality facilities. These are designed to be multi-purpose and are capable of hosting a wide range of meetings, events and conferences. We have several catering facilities on site as well as a purpose-built Conference Centre, Business Exchange suite, and Students Union. There is nursery provision for the children of staff and students.

We further encourage the cross-fertilization of ideas by fostering inter-disciplinary networking and collaboration and making it easy to attend exhibitions, presentations and conferences as we have funded expenses for such activities. We (normally) hold events – such as Award ceremonies, (see 5a), on site where we recognize outstanding work and achievement; we encourage peer-to-peer mentoring and supportive networks.

Physical copies of books and journals are held in the university's main library while there are significantly more subscriptions to electronic research journals and databases available online.

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

4.1 The Unit's research collaborations, networks and partnerships, including relationships with key research users, beneficiaries or audiences.

The Unit has been, and will continue meeting its third **Aim** of enhanced networks and collaborating opportunities in many different ways. Within this **Aim** we set out various forms of outputs as **Objectives** including high value **publications** and **editorships**. Staff **publications** are listed on **Pure**, (5b S3.2), but many also contribute to the effective sharing of new insights in indirect roles, such as **editorships** of books and journals, (**Bai, Carr, Copner, Davies, Esteves, Huq, Kinuthia, Liu, Maddy, Oti, Otung, Owen, Rodriguez**), and **memberships of editorial** and/or **advisory boards** (**Bai, Copner, Davies, Esteves, Guwy, Kinuthia, Laycock, Liu, Oti, Otung, Patterson, Robinson, Rodriguez**).

In terms of **patents,** the majority of University-owned patents are in hydrogen storage materials and optoelectronics. Our staff applied for 29 patents: **Antonelli** (3), **Copner** (11), **Dinsdale** (1), **Esteves** (1), **Esteves and Patterson** (1), **Li** (9), and **Shao** (3). Many patents have now been assigned to companies like *Hydro Quebec, Renishaw, NPL, Lomox* and *Foshan Huikang Optoelectronics* (a Chinese startup by **Li** and **Copner**). Some patents from the period of 2012-2014 (originally filed in in six different countries), have now been assigned to a Canadian renewable energy company for commercialisation. A further patent family, *Aeriogen* (2014) (**Esteves and Patterson**) has formed the basis for significant amount (+£3m) of collaborative research with *Tata Steel*, *Welsh Water, NiTech Solutions, BPE,* and is now the subject of a spinout company proposal. **Esteves** registered five **Trademarks.**

Several SRRs hold **Government and Industrial Associations/Agency advisory** positions or **consultancies,** among them:

- **Esteves** is the UK Representative in the European Biogas Association's Scientific Advisory Council, and a member of the International Scientific Group for the Swedish Biogas Research Centre, the Industrial Expert Advisory Board for the H2020 Circular Agronomics, the Circular Economy and Innovation Group for Wales, the UK REA Bioenergy Strategy Green Gas Group, and the UK ADBA Cost Competitiveness Task Force.
- **Guwy** is a Fellow of the Learned Society of Wales, and a Chartered Member of both the

Institute of Water and Environment, and the Royal Society of Chemistry. He sits on a number of executive boards including Sêr Cymru, and the National Research Network for Low Carbon, Energy and Environment, and is a scientific advisory committee member for MaREI.

- **Maddy** is the only academic member of the UK Government (BEIS) Hydrogen Advisory Council, and the Green Hydrogen Working Group, with similar positions on the WelshGov Hydrogen Reference Group, and the Low Carbon Vehicle Steering Group.

A synopsis of some of our typical recent empirical research projects with **research grants** awarded, was presented in Table 3, indicating the multi-sectoral nature of our work and the broad range of partners, collaborators and funders – academic, industrial, international and/or interdisciplinary – as well as the income generated. Further illustrations of the **international** aspect of our work are given below:

PROJECT NAME	DESCRIPTION	FUNDERS/LOCATION
IEA Task 34	Biological Hydrogen	Rutherford Strategic Fund with **Australia**
Electrolytic Hydrogen Production	Renewable Hydrogen production	State Grid Corporation of **China**
AF4ENERGY Affordable Energy for Africa - Renewable Energy and Valorisation of Waste Biomass	Low cost efficient anaerobic systems in Kenya	Innovate UK R&D delivered in **Kenya**
AAIBE Chair for Renewable Energy provided to the Institute of Sustainable Energy (ISE) at UNITEN (Malaysia)	Enhance the application of renewable energy as an alternative energy source for Malaysia	AAIBE (The electricity Supply Industries Trust Account) adminsitered by **Malaysia**'s Ministry of Energy, Science, Technology, Environment & Climate Change

Table 3

Three of our eminent professors hold honorary positions elsewhere – **Rodriguez**, whose work *Fundamentals of 5G Mobile Networks* was cited in the European Parliament in January 2016, is an Honorary Senior Researcher at the University of Bradford; **Liu** who regularly works with CAPSE, is internationally recognised. **Thomas Reuters** accorded him the status of highly cited researcher for 2014 and 2015, and **Clarivate Analytics** did likewise in 2016, 2017, and 2018, was a Visiting Professor at Harbin Institute of Technology (2013-19), and has been a Visiting Professor at Wuhan University since 2019; **Copner**, is Visiting Professor at four universities in China – Changchun University of Science and Technology, Xiamen University of Technology, Baoji University of Arts and Sciences, and Foshan University.

While individuals have gained esteem abroad, our networks also demonstrate an extensive range of collaborators and partnerships – many are international, many are industrial and across many sectors, and many are interdisciplinary – with concomitant impact on communities, economy and society.

Some further examples indicating scope and range are given below, with real world impacts/outputs outlining the effectiveness of such partnerships, set alongside:

TECHNOLOGY	COLLABORATIONS	IMPACT
Carbon Capture and Use	*Tata Steel, Welsh Water, BPE, NiTech Solutions, WWU* and *Flogas* (*Smart CIRCLE, BEACON, BEIS Biogrid*) Innovate UK/BBSRC (2016) *ITM Power, Wessex Water, Wales and West Utilities, BPE* and *NiTech Solutions* Swansea University on Reduced Industrial Carbon Emissions (RICE) Project FlexIS - Industrial collaborations with *Tata Steel inter alia* Heriot-Watt and Birmingham University on the Industrial Decarbonisation Research and Innovation Centre (IDRIC) and SME's Cardiff, Swansea, Aberystwyth, Bangor and Glyndŵr Universities, and Low Carbon Research Institute (LCRI)	Innovative processes for converting CO2 from heavy industry to biomethane or carboxylic acid
EU Biomethane policy (see **Esteves** Impact Case Study):	Wales AD Centre, H2Wales, IEE Biomethane Regions, working with *EBA, REA, ADBA, GL Noble Denton*, *DTM*	Introduced changes to EU policy, regulatory and fiscal regimes through input into H&S study and JRC report that led to the EU Renewable Energy Directive criteria resulting in legislative changes, and biomethane incentivisation (>£6b invested), leading to major take-up across Europe and further afield. Biomethane upgrading membrane model to support scale up of the technology culminating in market expansion and increase in turnover for DMT (>£20M/year). Private investment for *NiTech* (>£500k) related to a novel application of their reactor models.

Waste management (see **Esteves** Impact Case Study):	WelshGov and Welsh local authorities, *Welsh Water*, Suez, ADBA, REA ORION EU-FP7-SME (2012-2015) Over 20 industrial partners across Europe. IEE Biomethane Regions with eight partners in the Europe	Shaped WelshGov policy and practice in Wales such that seven Anaerobic Digestion industrial systems were deployed across Welsh communities to better address food separation collections and digestion leading to a yearly reduction of 660,000 tonnes of CO2, and Local Authority savings of £20m+. Wales as a result became the third country worldwide with the highest municipal wastes recycling targets and a worldwide best practice example for food wastes recovery. The Strategy is beginning to be adopted in other UK countries and from 2023, separate food waste collections will be mandated in European countries. Sizing and operation of new infrastructure facilities and optimisation of assets with *Welsh Water* associated with over £140M investment and multimillion pounds of savings a year if technologies deployed throughput the company.
Renewable Hydrogen (see **Maddy** Impact Case Study):	RICE: Neath-Port Talbot Council, Swansea University, Swansea Bay City Deal, *Riversimple, JRE Presreg, SSE, IBM, Cheetah Marine, ITM Power, Novel Reforming of Bio-Liquids Shell (NL), Tata Steel, Progressive Energy, TNO, Johnson Matthey* SWIC, Wales's first hydrogen cluster consist of the following range of companies, authorities and organisations: *CR Plus*, Associated British Ports, *Capital Law, Carbon8 Systems*, *Celsa*	Developed innovative polymer electrolyser membrane (PEM) enabling efficient hydrogen production from fluctuating renewable energy. ITM are commercialising processing from renewables. During the REF period ITM increased world-wide production of RH by 100% and have secured £180M investment. Founding of **SWIC**, which has won £3M of grants.

	Manufacturing (UK), *Confederation of Paper Industries, Connect & Convey, Costain, Dragon LNG, Energy Systems Catapult, Environmental Resources Management, Front Door Communications, Liberty Steel Newport, National Grid Electricity Transmission*, Neath-Port Talbot Council, *Offshore Renewable Energy Catapult, Progressive Energy*, Pembrokeshire County Council, *Rockwool, RWE Generation UK, Sector Development Wales Partnership, Siemens, Tarmac, Vale Europe, Valero Energy, Wales & West Utilities, Western Bio-Energy, Western Power Distribution,* Milford Haven Port Authority	
Optolectronic innovation: OLED Light efficiency **Novel coherent tuneable laser and vibration elimination**	The University of Durham The University of Stuttgart *Lomox* Carbon Trust Oman Government *Renishaw, NPL, Airbus, Boeing*, CERN, Bath and Huddersfield Universities.	Increasing the efficiency of the light output from OLED by a factor of three, leading to substantial carbon reduction. Innovative low cost robust tuneable lasers that enable new vibration-free metrology applications such as photogrammetry of large items in real manufacturing environments.
Low Cost Concrete	UNESCO Governments of Kenya and Cameroon	The cost and environmental benefits of utilisation of soil in infrastructure development far outweighs those of stone or concrete. This novel cement using steel by-products was used in constructing the A420 in Buckinghamshire, UNESCO supported the use of this material for the construction of low cost housing in Kenya and Cameroon, thereby improving quality of life of local people.

NOx reduction	Commercialised by *Engie* (France), and *Global Combustion System Ltd* (Scotland), working with customers in France and Spain.	Melting soda lime glass melting furnaces are major producers of NOx emissions. **Tan**'s auxiliary combustion process diverts part of the fuel from primary burners to areas of recirculating combustion products before burning in the combustion air leading to reduction of 5mm per m^3.

Table 4

4.2 The wider activities and contributions to the research base, economy and society.

USW is a member of the University Alliance, ensuring we are well-placed to make national and international contributions to societies. Our staff contribute directly to our research projects and to the furtherance of research integrity and good practice at Faculty and University level. They also contribute to wider research activities by sharing insights effectively (publications, participation in events and membership of learned societies). A brief summary of such activity is offered below:

EXAMPLES OF ACADEMIC LEADERSHIP	COUNT
Fellowships of learned societies/ professional bodies e.g. FLSW, FRS, IET, IEEE, FHEA, RSC	18
Conferences organised or chaired	3
Workshops, mini-symposia and special sessions organised	2
Plenary lectures	3
Invited or keynote lectures	17
Editorships of journals, books, or other publications (individual/ joint)	36
Member of editorial or journal advisory board	40
National/International professional advisory boards/committees	43
Awards, prizes and similar honours	20
Edited, authored or contributions to books in libraries	35
Statutory Committees	0

Table 5

Some outstanding activities deserve further detail:

- **Kinuthia** was awarded the Royal Society Brian Mercer award for innovation on unfired scaly systems. The deployment of these novel materials into Africa, to provide new homes at lower cost, was supported by UNESCO.
- **Maddy** - was a founding member of the South Wales Industrial Cluster (**SWIC**), (Members listed in Table in 5):
- **Rodriguez** is an IET Fellow and a Charted Engineer with advisory roles on FP7, and CSIM as well as being the founding member of IEEE Technical Subcommittee on Green Communications and Computing.
- **Esteves** was a finalist for the BBSRC Innovator of the Year 2019 under the commercial impact category.

International acclaim, esteem and influence are balanced by not losing sight of our roots, and remaining mindful of how we interact with, support, and develop the communities in which we are situated.

Our HEFCW-funded *Civic Mission Review* documents USW's civic engagement activities and demonstrates how our research outputs are having a direct impact on our local South Wales community. HEFCW 'Higher Education for Future Generations' (2017), referred to the role of the Wales Centre of Excellence for Anaerobic Digestion (**Esteves**, **Patterson**) in reducing the amount of waste sent to landfill, and a further, but particularly apt, example of this aspect of our work is provided by the feasibility study conducted by **Esteves** (2017) into *Recycling of mattress foams and textiles to biopolymer and biogas* on behalf of Rhondda Cynon Tâf/WelshGov with a Small Business Research Initiative.

We take seriously our responsibilities and duties under the Wellbeing of Future Generations (Wales) Act 2015, to improve the social, economic and cultural wellbeing of Wales by thinking in a more sustainable and long-term way about what we do and how we do it.