Institution: University of Leeds

Unit of Assessment: 15 – General Engineering

a. Context

UoA 15 from the University of Leeds (UoL) comprises a single academic unit, the School of Process, Environmental and Materials Engineering (SPEME). Research in SPEME encompasses the following disciplines:

- **Energy**: energy science, environmental impact and sustainability;
- **Materials**: functional oxides, photonics, non-equilibrium processing of alloys, carbon;
- **Particle Science & Engineering**: process engineering, particle characterisation and modelling.

SPEME's research addresses the industrial and societal themes relating to energy & transport, health & personal care, manufacturing and ICT. Hence the beneficiaries are industries, their customers and supply chains including, energy generation & storage, aerospace, automotive, petrochemical, biomedical, pharmaceuticals, high value chemicals, materials processing and sensing & actuation, nuclear waste management, catalysts, inks & coatings and agrochemicals. Government departments benefit from our research on environment and energy policy.

The School aims to create non-academic impacts from research in all its disciplines:

- **Economic, Environmental Impacts**: Technology transfer to industry through collaboration, consultancy, licensing of innovations, and industrially targeted dissemination activities. Examples of strategic partnerships include P&G and Sellafield Ltd where both research and consultancy feed directly in support of their business need. Creation of new businesses occurs through spin-outs and joint ventures.
- **Impacts on Public Policy**: Informing policy of HM Government departments and other bodies through collaboration, consultancy and dissemination activities. Examples here include (i) input to HM Government, DECC 2050 Roadmap to Carbon Capture and Sequestration, and (ii) impact of hazardous substance release report to the Home Office.
- **Impacts on Practitioners**: Provision of Continuing Professional Development courses to practitioners. Examples include Fire Engineering, Powder Processing, Rheology of Suspensions and Dispersions.
- **Impacts on Society**: Public engagement of engineering research through the media and participation in public lectures/events.

b. Approach to impact

Impact is created through a number of mechanisms at various points in the research & innovation cycle, categorized here as **Engagement**, **Collaboration**, **Dissemination** and **Exploitation** phases. The UoL, Faculty of Engineering and SPEME have developed strategies and initiatives to maximize external impact of research and specific measures have been put in place to address each phase:

Engagement with industry and other potential beneficiaries commences at the start of the research process, to both validate and ensure that well informed and appropriate decisions are made during the course of the research. To ensure that initial engagement is maximised, the School has put in place a number of measures:

- An Industrial Advisory Board made up of 12 business leaders from our target sectors.
- An Industrial Liaison Director, who is a member of the Executive Management Board and Research Committee of the School. His role is to lead the development of strategic partnerships with examples including P&G, Malvern Instruments, Pfizer, Sellafield Ltd.

Valuable and meaningful engagement also results from maintaining good relationships with School alumni who are in key positions within industry, resulting in knowledge transfer opportunities.

Collaboration: SPEME has a policy and strong record of developing research with industrial partners, either directly funded, or through Research Council (RC), UK Government and EU grants, hence the majority of research performed within SPEME is industry led. Examples of this include strategic research partnerships with Sellafield Ltd and P&G where the School has built and retained a close working relationship with these companies over many years, where research feeds directly into the partners' current technology challenges. One such strategic partnership, with Malvern Instruments Ltd (**Wang X**, **Roberts**), directly led to the production of a new instrument on the world market and forms the basis of one of our impact case studies.

Approximately 15% of the School's research has been directly funded by over 60 different industry partners since 2008, **UK based**: Anglo American, BAe Systems, Doosan Babcock, Glaxo

Smith Kline, ICI, Infineum Ltd, Johnson Matthey plc, London & Scandanavian, Malvern Instruments Ltd, Merck, National Nuclear Laboratory, Pfizer, Rolls-Royce, Spirax Sarco, Syngenta, Thales, Unilever and Xaar; **Internationally based**: Abbot Laboratories, Abengoa Solar, Adriatica Industriale, Bao Steel, Danone, Genencor, Henkel, Novozymes, Selex Galileo and Wuhan Iron & Steel. The number of repeat and follow-on contracts from industrial partners is testament to the impact the research is creating within their businesses.

The majority of SPEME's 135 Research Council funded projects during the audit period have involved industrial partners, whilst 45 collaborative projects have been funded by the Technology Strategy Board, including 12 Knowledge Transfer Partnerships (KTPs) facilitated by the University's team of advisors, with a cumulative value of £1.03m. Examples include academic support to P&G (KTP award number 8705), Bristol-Myers Squibb (7537), Drax (7858), Enertek International Ltd (1169), British Glass (8773) and CGI International Ltd (6350).

Dissemination: the normal routes of academic publication (journals, books, conferences) are valid means of dissemination to non-academic stakeholders however members of the School also disseminate the results of their research through a number of other means.

The School has a vibrant programme of Continuing Professional Development, in which short courses are presented to mainly industrial participants. During the audit period, the School organised 77 short courses contributing to the Continuing Professional Development of over 1700 industrial delegates and generating income of £1.8m, with examples including, *Introduction to Colloids and Surfaces* (**Biggs**), *Royal Microscopical Society - Electron Microscopy* (**Brown**, **Drummond-Brydson**, **Scott**), *Energy form Biomass* (**Dupont**, **Jones**), *Chemical Plant Commissioning* (**Fairweather**), *Formulation Science and Technology* (**Hassanpour**), *Powder Sorbants for CO_2 Capture* (**Milne**), *Carbon Capture and Sequestration* (**Taylor**), *Thermal Treatment of Municipal Solid Waste* (**Williams P**)

The School periodically organises events such as 'Industry Days' with the objective of engaging the participants in technology transfer or future research, which will lead to further impact. A number of members of the School have taken part in outreach activities which enhance the public's understanding of our science and engineering research, at both national and local levels, for example, RAEng "*Nuclear Education in the UK*" (**Biggs**), RAEng Ingenious Programme "*Risky Business*" (**Gale**), British Science Festival "*Low Carbon Energy*" (**Ross**), Café Scientifique (a local public engagement forum): "*Nanotechnology*" (**Drummond-Brydson;** December 2009) & "*Piezoelectrics: a moving experience*" (**Bell**; October 2012).

Aided by the University's Public Relations team the School has grasped opportunities to highlight its research in the popular media. For example the press release "*Soldiers turn march into a charge*" (**Bell;** July 2009), which highlighted research on energy harvesting, resulted in a large number of follow on articles in newspapers around the world and four radio interviews on local, national and foreign stations.

Exploitation: as the School's policy is to involve potential beneficiaries, such as industry, Government, national laboratories, etc., in all its research activities, technology transfer is the most common outcome of the culmination of the research cycle.

The University has a central Commercialisation Services (CS) Team based in the Research Innovation Service office (RIS), providing continuity of research and innovation support. The CS team focuses on formal IP protection and later stage commercialisation. The Team includes experienced case managers with technical/scientific backgrounds that align with university research specialisms, dedicated patent & contracts administration and a Corporate Solicitor. IP and case management is driven through a stage-gate decision-making process.

IP management is facilitated by the use of external patent agents for drafting and prosecution of applications, who are selected on the basis of a technical skill set that matches the IP disclosure. There is an annual University budget to cover the drafting and filing of patent applications and the management of subsequent search reports and patent office actions.

Assistance in the assessment and commercialisation of IP disclosures is undertaken through market scoping, due diligence and the creation of detailed exploitation plans. Proof of commercial concept funding includes a University Enterprise Fund (a dedicated internal fund reinvesting a proportion of receipts from equity realisations and licence returns) and access to regional and national schemes. Licensing is managed through a subsidiary company, University of Leeds IP, providing support in partner search, negotiation of licence terms and in-house legal support.

Partnership with IP Group PLC assists in the identification, development and creation of spin-

out companies. IP Group has a campus based office that includes 4 investment managers dedicated to supporting University of Leeds commercialisation activities. IP Group provides development funding and company investment through all stages of business growth. In addition the University works with a range of other venture capital groups and business angels to independently progress company formation and investment (i.e. opportunities that do not match the IP Group investment portfolio). There is in-house expertise in the preparation of business plans, fund raising, company creation and building management teams.

The School has filed 75 patents during the audit period; from which two licenses have been granted to Industrial Tomography Systems Ltd (see Impact Case Study 3). A number of the patents have resulted in the launch of spin-out companies, with ownership shared between the academic founders, the University and third party investors. These are (with incorporation date and 3rd party investors in parentheses): **Glass Manufacturing Services** (May 2010, British Glass Board): Manufacturing, value addition and supply of laser and photonic glasses; **RE Technology Ltd** (May 2011, Throgmorton Street Capital): Rare-earth extraction technology; **Ionix Advanced Technologies Ltd** (Nov 2011, IP Group; www.ionix.at): High temperature piezoelectric materials and devices; **Watermass Ltd** (Nov 2011, NetScientific): Polymer Fuel Cell Technology; and **GlucoSense Diagnostics Ltd** (Sept 2012, NetScientific; http://www.netscientific.net/non-invasive-blood-glucose-sensor): Biomedical and chemical photonic sensors, particularly glucose in blood.

Academic consultancy can also provide a bridge to expand work into research space for the mutual benefit of SPEME and the industrial partner. The focus for SPEME is primarily research applied to real world challenges hence outputs from the School also feed into policy and strategies adopted by HM Government and local authorities. For example, **Pourkashanian** was invited by the Department of Energy and Climate Change to produce a Carbon Capture & Storage (CCS) 'Roadmap to 2050' which describes a shared understanding between Government and key stakeholders of the potential role of CCS in reducing emissions from the power and industrial sectors. **Pourkashanian** was also invited to become an expert member at EU-GCC Natural Gas discussion group whilst, on a local level, **Gale** works closely with Leeds City Council developing the basis of key strategic energy decision making support tools that cities will need in the future where complex systems are used to integrate the technological, policy and socio-technical aspects of energy planning.

In addition to achievements in teaching and research, impact creation is recognized by the University's promotions process, and forms an integral part of the academic annual review.

c. Strategy and plans

The vision for the School is to be recognised as a top-five engineering School nationally and top-forty in the world, and as a model Engineering School for the interweaving of research-led teaching and fundamental knowledge with practical education and impact on societal and world problems.

The School will continue to invest in both personnel and equipment within traditional areas of strength, but will remain agile to adopting new avenues of research. It is expected that with the creation of new Chair positions within the School, supported by new junior academic positions, (see REF5) the breadth and depth of research capability will continue to grow.

To achieve our vision, the strategy used by the School to support non-academic impact includes:

- Review of research activity on a biannual basis, re-shaping as required;
- Continue investing in capability and facilities in areas of strength;
- Develop new vectors of research though industrial and international partnerships;
- Promote interdisciplinary research within the School aligned with challenge driven research;
- Generate new formal alliances with international partners to enhance our global reputation;
- Encourage staff to participate in Government policy making committees;
- Increase adoption of research and innovation outputs through alumni outreach and marketing.

The School will continue with its current policy of promoting the maximum non-academic impact from all its research. For the following five year period our plans include:

- Promoting the outcomes of energy technology and energy policy research;
- Translating the technology demonstrations at the UK Carbon Capture and Storage Centre into large scale implementation with energy providers;
- Maximising engagement with energy generators on research in future fuels (e.g. algal biofuels);
- Supporting licensing of research in functional materials and existing spin-outs and licensees;
- Disseminate findings of our research on nanotoxicity to both users and policy makers and seek

to influence UK and EU legislation on the control of nanoparticles;
- Continue to grow the number and range of our strategic partnerships, e.g. automotive oil & gas and materials processing industries;
- New partnerships within high growth and emerging economies, with a current focus on Chinese industry through tripartite agreements with Chinese research institutions.

The School is a major beneficiary of the recent University initiative to develop *Sector Hubs*. Created using HEIF funds, the 14 Hubs have the specific aim of increasing the University's engagement with stakeholders in key areas of activity. The Hubs are challenge driven, applying research excellence to issues of national and international importance. They provide clear innovation pathways for external stakeholders to access UoL capabilities, maximise the impact of the distinctive knowledge capabilities of the UoL, increase leverage of private and public sector funds and create closer alignment of research output with market priorities. SPEME hosts two Hubs: **Energy** (**Pourkashanian**, www.leeds.ac.uk/info/125086/energy) and **High Value Chemicals** (**York**, www.leeds.ac.uk/info/125083/high_value_chemical_manufacture), and is a major part of the **Digital Technologies** Hub (www.leeds.ac.uk/info/125088/digital_technologies).

d. Relationship to case studies

The following summarises how the case studies have benefited from the School's impact strategy:

Case 1. Particle Shape Measurement: Commercialisation and Applications

This case study demonstrates the value of strategic partnerships with industrial companies in setting our research agenda. Working with Malvern Instruments Ltd (MIL) since 2000, a strategic partnership ('*Intellisense*') was formed between SPEME and MIL in 2005, which sponsored the Readership position of **Wang X** and through this investment (with **Roberts**) developed an image analysis algorithm facilitating the creation of a new type of commercial instrument capable of measuring particle shape.

Case 2. Improving Co-firing Efficiency for Sustainable Biomass Energy

This study illustrates that involvement of stakeholders at the initiation of research, provides a high probability of impact. Driven by CO_2 emission targets, major UK power generators such as Drax and Eggborough have shifted emphasis from coal burning to the use of biomass within their boilers. However, biomass combustion presents many inherent problems (including milling, combustion characteristics, deposition and corrosion within the boiler) and research at UoL has been crucial in helping solve these problems.

Case 3. Global sales of tomographic instruments benefiting process industries

This case study demonstrates a continuing, long-standing relationship between UoL academics and Industrial Tomography Systems plc (ITS) in which innovation from the University is translated into new instruments. In line with the School's strategy full use is made of knowledge transfer instruments such as collaborative research with exploitation being through licensing of a broad patent portfolio over the past 10 years. This mutually beneficial collaborative work is on-going, with research feeding into product development through IP licensing and new developments continuing to emerge into the marketplace.

Case 4. Miniaturization and Improved Reliability of Ceramic Capacitors

Collaborative research with AVX Ltd through the Knowledge Transfer Partnership scheme has resulted in an improvement to the composition and manufacture of ceramic multi-layer capacitor products. These improvements have provided performance and size advantages to customers and have been instrumental in maintaining company competitiveness. The improvements to their capacitor range of products have provided customers with a product performance and size advantage in the marketplace that now commands a premium price.

Case 5. Improved Safety of Fire Resistant Glasses

This is another example of a successful Knowledge Transfer Partnership resulting from the industrial partner (CGI International Ltd) approaching the UoL to gain a fundamental understanding of their fire resistant glasses, with a goal to accelerate the development of new products. This work resulted in the launch of three new, impact certified, fire resistant glass products which exhibited a fire resistance twice that of previous products and has re-established the company's market leadership in 'cut-to-size' fire resistant glass in the UK and Holland.