Institution: EaStCHEM: The University of Edinburgh / University of St Andrews

Unit of Assessment: B8 Chemistry

a. Context

EaStCHEM is a joint Chemistry Research School, created in 2005, supported by two research-led institutions, the Universities of Edinburgh and St Andrews. As a research-intensive school with a broad range of academic expertise, EaStCHEM is firmly focused on addressing the widest range of fundamental and applied research challenges and on maximising its impact.

Impact in chemistry and chemistry-related sectors takes several different forms. Our research strategy is devised to impact on a wide range of non-academic users. These include, but are not limited to, non-academic commercial entities, the Government and other policy-making institutions, non-governmental (NGO) and charitable organisations, and the public at large.

Our research activity feeds directly into economic and commercial impact, which is achieved through a range of mechanisms. Direct exploitation of our research through start-up company formation or licensing is an important component of our strategy. The case studies included with this submission cover a wide variety of these mechanisms, demonstrating how our strategies are being successfully implemented. Impact in this area is maximised through the transfer of our skilled research graduates into industry in the UK and abroad.

An alternative, more unusual mechanism is demonstrated in two case studies where the quality of our research has attracted global companies to locate research facilities at our sites to take advantage of our research and the opportunities it affords for impact on the companies in question.

Impact on the wider commercial, governmental and NGO communities comes from transfer of research know-how, advocacy of scientific issues, engagement with policy makers and key stakeholders in industry, and through a strong media presence, as well as through providing leadership, advice, best practice and consultancy to others. Several of the case studies demonstrate the value of this approach to generating significant impact.

Another important mechanism for impact is Public Engagement; three dedicated outreach officers help us design and administer our varied activities. Their team allows us to engage with people of all ages and backgrounds, and to evaluate the outcomes. This work is vital to the health of the discipline and recognised in appraisals, work-load models, and promotion criteria.

b. Approach to impact

EaStCHEM is an environment where the products of our science are highly valued and translated effectively to benefit society. The following highlights illustrate the successful implementation of our strategies during the REF2014 period:

- We have significant activity in patenting, exploitation, commercialisation, and provision of facilities and expertise. During the REF2014 period our research has resulted in 116 patents, 51 licences and 11 start-up companies, raised £ 2.6 M in facilities use charges, and a number of compounds from EaStCHEM research are now sold through e.g. Aldrich and Sigma (retail value > £50k in 2012), and Umicore (>£400k in 2012 for Nolan's metathesis catalyst sales and licensing).
- Early development of KT initiatives has been enhanced, with the help of three dedicated business development executives (BDEs), through engagement with schemes such as the Royal Society Industry Fellowships (x2), Scottish Enterprise Proof of Concept awards (8 PIs, > £2 M total), RCUK follow on funds (5 PIs, > £4 M), MRC DPFS (Developmental Pathway Funding Scheme) and Wellcome HICF (Health Innovation Challenge Fund) translational grants.
- We have strong interaction with policy-makers, and our research has informed several reports that have been implemented as policy by the UK and Scottish Governments (see case studies).
- We have significant outreach and public engagement activities. One highlight is Pulham's award of an STFC Science in Society Fellowship (2009-11) to promote research in the Centre for Science at Extreme Conditions to the public, with total audience numbers exceeding 7,000, and virtual audiences estimated at ~200,000.
- We have strengthened interactions with Sasol, the South African-based multinational company that based its European Research Centre (25 FTEs) on our St Andrews site due to EaStCHEM's

world-class research in homogeneous catalysis. The resulting collaborations have delivered a positive impact on Sasol, the economy, and knowledge exchange. A similar model has attracted Mölnlycke, a global healthcare company, to locate a research facility in Edinburgh to exploit EaStCHEM IP (see case studies).

EaStCHEM recognises that a broad spectrum of high-quality fundamental and applied research provides the widest range of opportunities for creating impact. We encourage translation of top-class research from EaStCHEM beyond academia (e.g. see the Lithium Battery case study). We strive to innovate in exploiting research in commercial environments, and this has led to unusual mechanisms of impact (e.g. in the Sasol case study) as well as supporting spin-outs, licensing and other more conventional impact forms. Examples of our innovative approach to engagement include two writers and a composer in residence during the REF2014 period, producing poetry, national newspapers articles, chamber music inspired by our research, and a chemistry-based opera.

Working with industry: We have close working partnerships with many companies in the UK and worldwide, achieved by prioritising Knowledge Transfer (KT) as we stated in RAE08. We are extremely open to any mechanism of impact that allows individual academics to work with industry and resources are prioritised to achieve this (e.g. through matching funding). Examples of successful mechanisms that support our strategy are:

1. We use a mixture of in-School business development executives (BDEs) and university BDE teams to remain agile in responding to opportunities. Institutional funding initiatives (e.g. University KT funds, Early Career Researcher (ECR)-targeted start-up support offices, Impact Acceleration Accounts, Shaping Capability Funds, local surgeries with the heads of Knowledge Transfer Networks) are designed to react quickly to researcher needs as they develop ideas to crystallise impact and/or attract outside investment. Several EaStCHEM spin-outs described in the case studies (e.g. Zeomedix, MOFgen, Deliverics) have benefitted from such institutional funding, which was often pivotal in maintaining early momentum.

2. We have engaged extensively with Scottish and UK Government innovation schemes to fund market-driven R&D. For example, we won funding from the Intermediary Technology Institute (ITI, part of Scottish Enterprise) to develop EaStCHEM research into technology that attracted Mölnlycke to locate in the Edinburgh BioQuarter (see case study). We have also promoted a Scottish Government scheme (SPIRIT) that was aimed at enhancing the research agenda in companies, and particularly in SMEs, through stronger interaction with our research base. During REF2014 we have had 16 joint-PhD students with SMEs funded by this scheme.

3. Consultancy is encouraged and supported and the Universities offer training and management for this. For example we offer company internships and 'match-making' by which know-how can be transferred to the industrial sector. Our infrastructure attracts significant use from industry, and generated ~£2.6 M of income during the REF2014 period, and concomitantly, new industrial collaborations.

4. The graduate school training programme includes impact as part of Doctoral and PDRA Training. We recognise that people are the key elements in a successful research-led department, and it is particularly important that students and PDRAs are exposed to and can be involved in successful examples of translation. Training is provided in entrepreneurship, commercialisation, science communication and various aspects of industry, public and society engagement. Support for this is provided by the EU-accredited Institute for Academic Development (IAD) and Centre for Professional Development (CAPOD), with ring-fenced University provision for ECR activities.

5. We strive to ensure that our intellectual property strategy is both strong and flexible – the goal is to increase the exploitation of our technologies, for example by using ‘Easy Access IP’ (see below). At the same time our IP approach is designed to recognise potential entrepreneurship opportunities for exploitation (e.g. spin-outs, licensing) and to support the process to ensure strong patent portfolios that are attractive to investors.

6. We encourage early stage technology transfer projects and we have an excellent record of obtaining funding for pre-spin-outs. For example in the REF2014 period we have received a Royal Society Brian Mercer Innovation Award (Morris), eight Scottish Enterprise Proof of Concept Funds (Bradley [x2], Cole-Hamilton, Greaney, Haehner, Irvine, Morris) worth more than £2 M (that have

already led to four company start-ups), five additional milestone-driven translational projects, which include RCUK follow-on funds exceeding £4 M, ten Research Council/Wellcome Trust Follow-on-Fund awards and three Scottish Enterprise/RSE Enterprise Fellows. Institutional support for these awards is significant and is an important component in the high level of success we have in taking this type of funding on to real impact. We are also extremely successful in attracting other development awards, including TSB and ITI funds, and early stage investment from Angels and private or corporate venture capitalists for our spinouts.

Working with policy-makers: EaStCHEM recognises the importance of expert scientists providing an advocacy role. To this end we explicitly encourage our staff to be involved in mechanisms that impact public and industrial policy. Advocacy to Scottish and UK government in particular is also part of the remit of our national academy fellows (FRS, FRSE, FLSW and members of overseas academies). Yellowlees plays a particularly important role advocating science as current RSC president. Recent examples of impact on public bodies include reports that led directly to changes in energy-efficient transport policy in UK cities such as Scotland's first large-scale hydrogen-bus demonstration in Aberdeen, the largest single European deployment of hydrogen buses to date, worth £30 M to the economy (Irvine), air quality, and NHS policies on medical instrument cleanliness (see case studies). We work with Chemical Sciences Scotland (CSS), a unique partnership of industry, the academic sector, and Government agencies through Tasker (head of the ScotCHEM research pool) and others to advise the Scottish Government on policy with respect to the Chemicals landscape, and help keep the Scottish chemicals sector in the top 2 of Scottish exports (£3.7 bn pa), 15 % of the UK Chemicals industry. The Athena Swan awards to EaStCHEM (Gold and Bronze) and Arnold's Royal Society Rosalind Franklin prize testify to the continuing advocacy work of EaStCHEM to improve equality and diversity in STEM.

Working with the public: Engagement with the public, schools and the media increases the impact of our chemistry; public engagement is embedded in EaStCHEM culture through the funding of PG public engagement career development scholarships and three dedicated outreach officers. Our resident, RSC-funded schools liaison officer works across the region, using cutting-edge research examples to modernise chemistry teaching. We host the largest annual chemistry teachers' conference in Scotland (The Nigel Botting Meeting for Teachers, 150 delegates p.a.).

During REF2014 we demonstrated chemistry research to more than 110,000 members of the public, through 145 school events, 39 public lectures, many at the Edinburgh International Science Festival (the world's oldest and Europe's largest). We developed exhibitions for science fairs at 10 other science festivals, and 6 gallery and museum shows as far afield as Malaysia. Public favourites include 'Energy Challenge' 2013, 'CSI at the Museum' 2012, and the Enlightenment Lectures. We had our own exhibition 'Edinburgh 300: Cradle of Chemistry' in the 2013 Edinburgh Fringe Festival (4900 visitors), and a sell-out chemistry stand-up comedy show.

Pulham won the Tam Dalyell Prize for Engaging the Public with Science in 2011, and an STFC Science in Society Fellowship (2009-11), delivering lectures and workshops to more than 7,000 members of the public as far afield as Hong Kong. Baker instigated the 'Chemistry Map of Scotland', an online resource for schoolteachers and the public. Robertson's 'Solar Spark' has attracted significant RCUK and RSC funding to enable public dissemination of solar cell research, and culminated in the SISER project, which is advising the Scottish government on the 2020 Routemap for Renewable Energy (Scotland), and has been made into an RSC Schools resource.

The University Press and Development officers coordinate with research groups to bring research successes to the media, including national TV and radio, international press, and specialist industry publications, in print, online, and in social media. Examples of researchers who have been highlighted are Alexander (Scottish TV & Russian TV); Shaver (Canadian TV); Arnold, Bruce, Morris, Yellowlees & Zhou (BBC Scotland); Bradley & ECampbell (The Times); Robertson, (The Sun); Love (New Scientist); Arnold (Radio 4); Arnold, ECampbell, Irvine, Morris, Robertson & Zhou (Radio Scotland); Love, (Frankfurter Allgemeine Zeitung); CCampbell, (MIT Tech Review).

c. Strategy and plans

EaStCHEM has a strategic objective to support and embed all aspects of KE (Knowledge Exchange - commercialisation, public policy, entrepreneurship and public engagement) and collaborative innovation in academic life. The strategy is to provide:

- An entrepreneurial environment with a focus on supporting the translation of research into the market place for the economic benefit of society;
- World-class skills development through recruiting world-leading academics and maintaining high-quality courses, facilities and research-led enquiry;
- Cutting-edge collaborative research and high-quality research services and consultancy with external organisations;
- Research that can be translated into high impact public policy and practice, harnessing our academic expertise to inform evidence-based policy;
- Public engagement through building trusted relationships across a range of public and other organisations and maintaining a two-way dialogue with the public;
- A bank of IP and know-how to support existing businesses and new enterprises.

Delivery of the strategy: We encourage all researchers to be involved in KE. We offer support (access to people and funding) and officially recognise impact of all forms through university prizes, appraisals, work-load model, promotions and increments. Operational delivery and development of practice are coordinated through management, monitoring, and reporting, through appraisal, annual EaStCHEM advisory board reports, meetings and benchmarking activities, with individual success stories and good practice examples celebrated and disseminated.

Our three dedicated business development officers (BDEs) directly facilitate a broad range of knowledge translation and mobilisation activities. They help protect IP, identify new companies for collaboration and negotiate contracts. 'Easy Access IP', which streamlines protection and opens access to IP, was embraced early on to increase the visibility of our IP to external partners.

We have invested significant further resource into the promotion of business development, e.g. by providing tailored professional development activities to encourage all staff to engage with the impact agenda, and EPSRC Impact Acceleration Accounts. During the REF2014 period we have continued to embed entrepreneurial spirit by developing even stronger links e.g. with the Knowledge Transfer Networks and the Technology Strategy Board. We target industrial funding as a way of opening up interactions that may eventually lead to impact; using RCUK CASE students and similar mechanisms has afforded 110 industry-linked PhD studentships during the REF2014 period. We are also strengthening our larger-scale industrial interactions. A new position was created for one of our original chemistry BDEs (Sharp) to make a client-facing 'commercial relations team' through which we now have the capability to engage at a higher level with large companies. This is already enabling multiple academic-industrial projects, with larger and more strategic, multidisciplinary aims. Sixteen visits in the last year have already generated funded projects with the US Department of Defense, DSTL (including staff secondment), Defence Research and Development Canada, and UCB Celltech.

Many staff members (e.g. Cole-Hamilton, Heal, Irvine, Mount) are approached directly by policymakers due to their reputation. We facilitate this by strategic use of media coverage of our science and help staff participate in annual 'Science in the Parliament' events, with the Chemistry-themed 2011 event for the Scottish Government and policymakers proving particularly effective at showcasing the breadth of our research. We engage with and organise learned society events and invite politicians, industrialists and stakeholders to these as well as local high-visibility events such as The Enlightenment Lectures.

Our 3 outreach officers and our PG public engagement career development scholars help with administration, development and delivery to enable all researchers to make their outputs publicly accessible, and to monitor the impact of our activities.

Future plans: Our staff, PDRAs, and PhD students generate world-class research outputs that can meet industrial needs and are inspired by new possibilities through working with industrial researchers and technologists: we will continue to use our BDEs to facilitate the interactions that lead to these. In the near term, we will build on the 'Easy Access IP' project to enable new impact by simplifying our engagement with those who wish to exploit our research. We will also build on successes from a 'facilities open-day' held in 2012 that resulted in five new companies engaging with us. Our BDEs are now developing instrumentation open-days where industrialists can interact with our research facilities and their managers. We are targeting SMEs in particular, and we will use a new University initiative for staff to be involved in placements (researchers moving in both

directions) that initiate research that will have impact on smaller companies.

Many researchers take up our entrepreneurship training. We will enhance future training provision with greater specialisation, for example training on how to influence policy-makers, and how to target new Horizon2020 initiatives. We will develop our help for new entrepreneurs (e.g. by continuing to provide incubator lab space and help with sourcing industrial mentors).

The recruitment of Tasker from industry brought invaluable industrialist insight and mentoring and produced a step-change in the way EaStCHEM academics engaged with industrialists (e.g. Tasker has worked on 22 collaborative projects with industry involving 7 countries since 2008 alone). The continued investment in the 'Industrial Chemistry Chair' by the recent recruitment of Vogt will provide continued mentoring for current and new academics in industrial engagement. The regular EaStCHEM research away-days will in the future bring in industrialists and policymakers.

As well as providing specific training for students and staff in how academic research can impact public policy, we will also focus on providing expertise in the breadth of our research areas to Government, taking advantage of the proximity of our Edinburgh site to the Scottish Government, by promoting opportunities to influence government and other bodies and, as required, by taking the initiative in important areas (such as energy/healthcare policy) by holding policy workshops within and beyond EaStCHEM.

Our outreach officers and their team have put in place new monitoring mechanisms to capture and help improve the impact of our engagement activities with the wider community. We will continue to utilise the expertise of these outreach officers to lower the barriers for staff involvement in public engagement activities, especially early career researchers and other staff with little experience in this area, to ensure that the impact of our research is maximised in both quality and quantity.

Operationally, we have brought the CSO of an SME onto EaStCHEM's international advisory board specifically to help direct our strategy in all areas of impact, but with a particular focus on translating our research into the commercial arena. Key staff are being linked to chosen chemistry relevant KTNs to embed KT activities at the research group level, and to monitor our successes.

d. Relationship to case studies

The case studies illustrate successes of our impact strategy in a number of the areas that are outlined above. In particular they represent our contribution to a broad portfolio of types of impact; on the commercial sector and the economy, or on different aspects of public policy. Complementary public engagement activities have highlighted the case studies and their research to the wider public, and this remains an important, on-going deliverable.

We have demonstrated commercial impact using a mix of relatively mature case studies (Albachem and Ingenza) that are based on research completed during the early part of the allowed period but whose impact within REF2014 is substantial, and newer initiatives (the case studies regarding start-up companies Zeomedix, MOFgen, Deliverics) that demonstrate how recent research has benefitted from our Impact and KT delivery strategies during the period, in some cases only a few months after IP protection.

Three case studies (those dealing with Sasol, wound diagnostics and lithium batteries) demonstrate our flexible and innovative approach to developing broader, wider-ranging impact than simply the exploitation of world-leading research. The Sasol and Mölnlycke case studies demonstrate how our research (led by Cole-Hamilton and Mount respectively) has attracted multinationals to locate research laboratories within our sites, precisely to translate our research expertise into impact on their company, and to develop technology derived from our research. Both these studies highlight the importance of physically locating close to our research to embed longer-term impact. The Lithium Battery case study illustrates impact with outstanding international reach, where EaStCHEM research has profoundly changed the types of material used in second generation lithium batteries worldwide.

Several case studies have been chosen to demonstrate our commitment to engaging and informing policymakers for the benefit of society. We show how improvements to NHS health policy on surgical instrument cleanliness have resulted from our research (MIDAS case study) and how better atmospheric contaminant measurement and modelling can enhance public health and influence government regulation (Air Quality case study).