RSC Response to the House of Lords Select Committee on Science and Technology consultation on Scientific Infrastructure

The Royal Society of Chemistry (RSC) welcomes the opportunity to comment on scientific infrastructure in the UK.

The Royal Society of Chemistry is the world's leading chemistry community, advancing excellence in the chemical sciences. With 48,000 members and a knowledge business that spans the globe, we are the UK's professional body for chemical scientists; a not-for-profit organisation with over 170 years of history and an international vision of the future. We promote, support and celebrate chemistry. We work to shape the future of the chemical sciences – for the benefit of science and humanity.

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Introduction

Quality scientific infrastructure of all levels is essential for maintaining the standard of scientific endeavour within the UK. There is much to celebrate in the current provision of equipment and facility within the UK, but reductions in capital spending that have resulted since the 2010 Comprehensive Spending Review have led to a danger that scientific capacity, and in turn the UK's capability to attract and retain excellent researchers, is being adversely affected. A review of the current state and needs of UK infrastructure, as well as the future opportunities, would help ensure that the strategy for access to resource is well integrated with the wider national research system and that the UK remains one of the leading scientific nations. In this response, our answers are largely focused upon infrastructure for research, but a national strategy for the UK's scientific infrastructure must also include the provision of modern laboratories and excellent teaching facilities.

Key messages

- Sustained capital funding is essential to the UK's position as a world leader in science and should therefore be formally protected within the science budget ring-fence.
    - Senior researchers have made clear the importance of capital in determining the location of their research group.
- Access to facilities is an integral part of research programmes spanning the whole of the chemical sciences.
- Operational support is crucial for optimal use of scientific infrastructure but can only be provided when appropriately funded. A lack of stable provision for operational costs (for both maintenance and expert technical support) could lead to inefficient exploitation of major capital investment.
- A long-term strategy for UK scientific infrastructure investment is needed with a focus on stability and future planning. Such a strategy should be driven by a landscaping exercise developed in consultation with the scientific community and other stakeholders.

A note on terminology

In this response the terms *large-scale* and *national infrastructure* have generally been used to refer to facilities that are intended to be used on a national scale. The terms *mid-scale* and *regional infrastructure* have been used to refer to facilities that are intended to be used on a regional or inter-university/university-wide scale. In addition, smaller scale equipment has been considered where relevant. These terms have been used to provide a sense of scale and are not intended as hard distinctions.

Current availability and status of scientific infrastructure

What scientific infrastructure is currently available in the UK, do UK researchers have sufficient access to cutting edge scientific infrastructure and how does this situation compare to that of other countries?

1. Access to facilities is an integral part of research programmes spanning the whole of the chemical sciences. It is also key to research areas with which the chemical sciences interface across physics, materials science, life sciences and engineering.

2. Large national facilities in the UK are world class and are as good as or better than similar facilities elsewhere in the world. Two examples are the ISIS pulsed neutron and muon source, and the Diamond Light Source. Other examples can be found on the Science & Technology Facilities Council (STFC) website.[1] In our consultation with members of the chemical science community, researchers report largely positive experiences using large-scale facilities in the UK. However, **significant concern was expressed about potential future funding cuts that could reduce access to these facilities.**

3. For the chemical sciences, in particular, access to cutting-edge mid- and single-lab-scale infrastructure may be more problematic than for large-scale. We received more reports of researchers unable to adequately maintain or upgrade instrumentation at this level than at any other. In 2009, a review of UK chemistry identified that we had excellent mid-level infrastructure,[2] but it now appears that the UK is falling behind the rest of the world in some areas. For example, the UK has just one high-field solid-state NMR instrument above 800 MHz, in Warwick,[3] while France has a network of five, Germany has three, while the Netherlands has one, with a state-of-the-art 1.2 GHz machine in development. A balance of course is required between having many lower-specification machines and a smaller number of high-specification instruments; a decision that should be informed by a national strategy based on a landscaping exercise.

4. Researchers must either go abroad to perform their experiments, or use less cutting-edge home-based technology when facilities are not available in the UK (for example the UK does not have its own free electron laser, which (amongst other things) could be used for XUV/soft-X-ray spectroscopy. Access to non-UK infrastructure often is made available through agreements with institutions within the European Research Area (ERA) and through funding of international facilities by STFC, guaranteeing access for UK researchers and technical contractors.

Is sufficient provision made for operational costs and upgrades to enable best use to be made of the UK's existing scientific infrastructure? Is it used to full capacity; and, if not, what steps could be taken to address this?

5. **We have received reports that current funding models do not make adequate provisions for operational costs or upgrades of equipment.** Large-scale facilities provide access not only to

the instrumentation, but also support for experimental setup and data analysis; costly maintenance of the instruments is also provided. These services are essential for running and maximising output of these facilities, but can be overlooked and underfunded. Further, whilst these needs are met to an extent at large-scale facilities, they are broadly overlooked for mid-scale facilities. This concern was marked as a strong priority in the responses of the research community to an RCUK consultation on a strategic framework for capital investment in 2012.[4]

6. **Limited operational funds at some national facilities have meant that they are not always used at their operational capacity**. However, researchers use the *available* time at national facilities to high capacity, and many are over-subscribed. Most large-scale facilities run a competitive application process based on peer review for access to the instruments meaning that far from all proposals are accepted (see also paragraph 29). This provides fair access for the best research.

7. Operational support is crucial for optimal use of scientific infrastructure but can only be provided when appropriately funded. A lack of stable provision for operational costs could lead to inefficient exploitation of major capital investment. In the STFC Delivery Plan 2011/12-2014/15, it is noted that to maximise the return on UK investment, ISIS and the Central Laser Facility should both operate at higher capacity.[5] We have received reports that ISIS will operate for 120 days this year as a result of a funding shortfall, instead of the optimal 180 days. In addition to reducing research output, **decreasing the amount of time that users are allocated encourages users to perform 'safe' experiments with a higher chance of succeeding**, and therefore a higher chance of publication output. Reducing time pressure would reduce the risk for researchers of investigating more speculative, potentially leading to exciting breakthroughs.

8. There are instances in which equipment—especially that on a small-scale—is underutilised because of a loss of technical skills and knowledge. For instance, when PhD students, postdoctoral researchers or technical staff with the bespoke skills and knowledge to operate a piece of equipment leave an institution often they are not replaced. The mechanisms for preventing such occurrences are not straightforward, but the recent cessation of project studentships may be exacerbating this issue.

What substantial increases in scale would allow new areas or domains of science to be explored (analogous to Large Hadron Collider and Higgs boson)?

9. To plan for future investments in capital infrastructure, RCUK have developed a strategic framework for capital investment "Investing for growth: Capital Infrastructure for the 21st Century".[4] This document was drafted with input from the scientific community and other key stakeholders and identifies (but does not prioritise) potential areas for future investment.

10. In addition to the suggestions by RCUK, the scientific community has indicated that the UK would benefit significantly from a National Compound Bank. This would build upon the compound bank for biologically active molecules developed though the Innovative Medicines Initiative (IMI)[6] and would extend from health to include collections of compounds for other grand challenges such as food, energy and environment. Such an initiative would strongly support the Government's *Strategy for UK Life Sciences*, in particular, by increasing the UK's capacity to research and develop innovative new medicines for the NHS and tackle the healthcare challenges we face.

Long-term needs, setting priorities and funding

What role should the Government play in ensuring that there is an effective long-term strategy for meeting future scientific infrastructure needs?

11. **Focus should be placed on stability and long-term planning.** The international review of UK chemistry in 2009 called for a strategy to sustain scientific infrastructure.[2] This remains a high priority. We recommend that an independent working group, with members from all key stakeholders and chaired by the Government Chief Scientific Adviser, be established to carry out this task. A long term strategy for research funding would assist businesses and researchers in planning their activities in the UK.

12. To be effective, any strategy should be based on a landscaping exercise and be developed in consultation with the scientific community. The RSC supports the Haldane principle, whereby the direction of the science base is underpinned by sound scientific advice and peer reviewed by the scientific communities involved. A role for government must then be to contextualise this principle within a national education and research capacity strategy.

13. The government can further help by ensuring that capital funding through the research councils and through higher education streams are complementary, and that systems are put in place to maintain, upgrade or replace equipment to secure the UK's world class research infrastructure.

What are the long-term needs for scientific infrastructure and how are decisions on priorities for funding usually made?

14. **Investment in scientific infrastructure should be aligned with areas of current, and possible future, UK strength and need.** The RCUK strategic framework for capital investment identifies areas for future investment (see also paragraph 9).[4] It is important that, regardless of the stratagem used for capital investment, the current capacity of the UK is at least maintained and existing facilities' operation costs supported (see also paragraphs 5 and 7).

15. **It is not always clear how decisions on funding priorities are made**. It is clear that where it has worked well there has been a strategic review of current capacity and consultation with the scientific community. For example, Diamond Light Source was developed following a consultation with the scientific community that identified the requirement for a mid-energy synchrotron complementary to the high-energy European Synchrotron Radiation Facility (ESRF) (see also paragraph 4).[7]

16. It is important that funding for infrastructure is not limited to that which supports strategic technologies (such as the 'Eight Great Technologies'[8]) but also provides support for excellence across the breadth of UK research. This wide base is essential in ensuring that we are both able to **nurture world-leading fundamental research and to address specific societal and economic challenges**.

Is it more important to invest in large, national infrastructure or medium infrastructure?

17. **It is important to invest in all levels of infrastructure**. Researchers will often use small, large and medium-sized facilities, equipment and instruments in a single project. For example, studies of protein folding can use low- and high-resolution NMR machines, synchrotron radiation and neutron scattering for complementary but distinct insights into the processes involved.

Since the last Comprehensive Spending Review, a series of additional announcements have been made on investment in scientific infrastructure. How were the decisions on investment

reached and what have been the impacts of this approach to funding scientific infrastructure?

18. ***Ad hoc* announcements do not provide the valuable stability of a ring-fenced budget**. Recent additional funding announcements for research are to be welcomed, and targeted funding can help provide impetus for fields in their early stages. However, it is not always clear why particular sums of money have been allocated or that it is truly 'new' money rather than a reallocation. There are concerns that high quality research, or infrastructure projects, could be passed over in favour of 'hot-topics' with this mode of funding allocation.

19. An example of where capital infrastructure funding was well provided is the EPSRC Core Capability for Chemistry Research.[9] In this the EPSRC worked with Heads of Chemistry UK (HCUK) and the RSC to shape a funding call for a distributed network of mid-scale infrastructure around four key techniques (Mass Spectrometry, NMR, X-ray Diffraction and Atomic level Microscopy). These areas were identified as being of particular need for the chemical science community, and £15m was made available for bidding by universities to fulfil this requirement.

What impact has removing capital spend from the ring-fenced budget had on investment in scientific infrastructure and should the ring-fenced science budget be redefined to include an element of capital spend?

20. **Capital spending is essential and should be formally protected in the science budget ring-fence.** The ring-fence placed around the science budget in the Comprehensive Spending Review 2010 was enacted as a cash freeze on revenue spending. Capital investment, which was excluded from the ring-fence at this time, received a predicted reduction of 41%.[10] Since 2010, all but £330m of capital spending has been reversed, through government investment in large-scale projects, and through investment in the 'Eight Great Technologies',[11] but the long term security of capital for research is unclear.

21. The change in RCUK policy to reduce their contribution to 'mid-range equipment'[12] has placed a significantly higher burden upon individual research institutions as the shortfall must now often be met by the institution. This is further exacerbated by the inability of universities to carry funding over from year to year.

22. **The reduction in capital funding threatens the UK's position as a world leader.**[13] Scientific endeavour requires both capital and revenue expenditure, and **senior researchers have made clear the importance of capital provision in their decisions to move to or stay in the UK.**[14,15] Early career researchers may also find it difficult to establish themselves in the UK with limited access to scientific infrastructure, potentially leading to a **'brain drain' of young UK researchers.** The recently released Science is Vital report on the legacy of the 2010 cash freeze shows a number of sobering viewpoints on this point, but we may not accurately know the impacts of recent decisions until 5-10 years in the future. Decisions made now will have long term impact on UK science.

23. **Sustained and predictable funding, as supplied by the science budget ring-fence, is highly valuable to the science base.** It provides clarity to the longer-term research environment, helping investors to consider their UK investments in R&D. It is also important for institutions, research groups and individual researchers to plan their activities, especially when considering embarking upon ambitious and sustained research projects.

If the current funding level is maintained or reduced, what would be the longer term impacts on scientific infrastructure in the UK?

24. In the lead up to the 2010 Comprehensive Spending Review the Royal Society published a report showing that, over the 2010-2015 period, the UK science base could likely "weather the storm" if held at flat cash.[16] The absolute reduction in capital spending that has occurred since 2010 will have its own consequences as detailed above, but just holding scientific revenue spending at a constant cash value will correspond to a real terms reduction of at least 10% over the spending review period. While some efficiencies may have been accessible initially, it is likely that continuing this trend over a longer period will be **detrimental not only to the science base itself, but also to economic growth.**[14]

25. While the UK is reducing public investment in scientific infrastructure, many of our competitors are increasing investment. A spending reduction over extended periods—in real-terms or otherwise—will lead to a reduction in the competitive capabilities of the UK's science base. The UK's strong science base has a number of economic and social benefits: **it trains a highly skilled workforce, including and extending well beyond scientific endeavour; it acts as a draw for highly innovative international companies; and it provides fertile ground for innovation and economic growth.**[14]

26. Reductions in the UK's funding for scientific infrastructure are also likely to damage the flow of leading academics to and from the UK as many will choose to work in nations with greater access to infrastructure. This is captured in comments by UK researchers in the recently released Science is Vital report on the legacy of the 2010 cash freeze.[15]

27. It is important to recognise that while a 'cash freeze' has its own negative implications, an absolute cut to the UK's science funding would, beyond its material effects, send a strong negative signal to the global community that the UK is not 'open for business'.

Governance structures

Does the UK have effective governance structures covering investment in scientific infrastructure, how do they compare to those of other countries, and are there alternatives which would better enable long-term planning and decision-making?

28. Public investment in scientific infrastructure falls under the remit of several bodies, including STFC, EPSRC, NERC, BBSRC, MRC and HEFCE. This occurs alongside significant investment from a number of charities including The Wellcome Trust and Cancer Research UK. A coherent approach to investment in infrastructure is likely to produce the most effective decisions. This is particularly important for interdisciplinary research that lies at the boundaries of two or more funding bodies.

Are effective and fair arrangements in place for access and charging for public and private scientific infrastructure?

29. Access to national facilities is generally allocated to the best research proposals submitted, as determined by peer review. This provides fair access for the best research (see also paragraph 6). For example, in 2011-2012 Diamond Light Source awarded time to less than 55% of research proposals.[17]

30. Access to STFC funded facilities is generally free at the point of access for researchers funded by UK research councils. An equivalent situation also exists for UK researchers accessing some facilities abroad, but funds are still required for travel and transport of samples. Charges for other

facilities vary, but are generally covered by research project funding if appropriately justified. In practice, where access is difficult or expensive, researchers often collaborate with other scientists who have access to the relevant instrumentation.

Are effective structures in place for funding of medium-sized scientific infrastructure and enabling sharing among Higher Education Institutes and Research Institutes?

31. We have answered this question in combination with the following question. See paragraphs 32 to 35 for our response.

Are regional research alliances proving effective in enabling access to funding for medium-sized infrastructure? Should more be done to support or incentivise approaches to collaborative funding and sharing of medium-sized infrastructure?

32. The reduction of research council capital spending that has resulted since 2010 has made it increasingly difficult for individual institutions to maintain their current levels of capital expenditure. It has become necessary to institute systems by which some equipment is shared either regionally or nationally. The 'level' of equipment that is shared and the manner in which it is shared are matters of great importance, and requires a coherent national approach.

33. Sharing facilities is generally a positive move, but will require time to gain full advantage as problems are resolved and it becomes accepted behaviour. Several regional groupings of universities already have structures in place for equipment sharing (*e.g.*, ScotCHEM, the M5 universities, the N8 research partnership, Equip South West, or the recently announced Science and Engineering South Consortium[18]). ScotCHEM is the best established of these regional groupings and seems to have had a positive effect on chemistry in Scotland.[19]

34. Sharing instrumentation is not as simple as making it available for others to use. It will require investment and support to flourish. It is important to recognise that infrastructure provision does not mean equipment alone, and requires investment in operational costs and user support. Technical support (for maintenance, experiments, and data analysis) is often required for effective use of scientific instruments and should ideally be provided by dedicated technicians. Sample preparation, transport, and financial administration also need to be considered, both for equipment and users.

35. Reduced funding and sharing resources can lead to concentration of resources. The RSC recognises that high concentrations of research excellence can increase the impact of research, but cautions that concentrating too much could weaken the research landscape. There are some excellent research groups operating in important niche areas of science within departments that are not part of the various research council 'framework' universities but require access to large- and medium-scale instrumentation. The breadth of the UK's science base provides strength and agility. Any national strategy for infrastructure investment should consider these factors.

Partnerships

To what extent do funding structures in the UK help or hinder involvement in EU and international projects, and should the level of UK involvement be improved?

36. We have answered this question in combination with the following question. See paragraph 37 for our response.

To what extent are EU and international programmes effective in promoting collaborative investment in scientific infrastructure projects?

37. EU and international programmes can be used to bring together expertise from different member states across their respective strengths under a strategic theme. It is particularly successful for larger initiatives, where the funding capacity of a single member state would not be sufficient to drive progress (*e.g.* CERN). UK involvement in these projects benefits UK researchers and contractors by guaranteeing access to the equipment and associated resources.

What impact does publicly funded scientific infrastructure have in terms of supporting innovation and stimulating the UK's economy?

38. Capital spending influences the decisions of leading academics, many of whom work to commercialise their research outputs. One notable example is Professor Hagan Bayley at the University of Oxford, who recently cited the expenditure on the Chemistry Research Laboratory at Oxford as being instrumental in his decision to relocate to the UK. From there he began Oxford Nanopore Technologies, which is now based in Oxford and recently valued at $1.5bn.[20] Other examples of publically funded infrastructure supporting innovation are the spin out companies that have resulted from research performed at STFC facilities.[21]

39. As well as driving growth, science and innovation provide solutions to the challenges our society faces. For example, neutron scattering at ISIS is being used to investigate how amyloid fibrils aggregate. The information generated at ISIS, in this instance, is contributing towards our understanding of Alzheimer's disease, Parkinson's disease and Type-II diabetes at a molecular level. These are diseases which have an increasing impact upon the UK population and the NHS, and as a consequence, our economy and social well-being.

How accessible is publicly funded scientific infrastructure in the UK to industry and small and medium sized enterprises? Is there room for improvement?

40. Industry is able to make use of publically funded infrastructure,[22] and this is actively encouraged. For example, STFC have an established collaborative R&D programme to stimulate engagement with industry.[5] The ISIS collaborative R&D programme provides industry users with a fast track route for proposals and free access to the equipment.[23] The Diamond Light Source provides free access for companies who publish their results and charges a fee for companies engaging in proprietary research.

41. Regional databases, such as those developed to promote sharing of equipment between universities,[18] may help industrially based scientists gain access to medium-scale resources housed in university clusters, but a national database is likely to be more accessible to industry users.

Are Government policies successful in encouraging industry to co-invest in scientific infrastructure?

42. There are many positive examples of industry co-investing in scientific infrastructure, and several examples are given below. It is important, however, that bureaucratic barriers and confidentiality contracts should be as streamlined as possible to encourage industry to engage with universities and *vice versa*. The time and effort required to gain access to facilities and equipment should not outweigh the value of the results.

43. An example of a mutually beneficial industry–university partnership is between Sasol Technology UK and the University of St Andrews. Sasol Technology UK Ltd. was established in 2002 in St Andrews to carry out medium- and long-term research for its parent company (Sasol Ltd, a global

energy and chemical company) in the fields of catalysis and materials science. They were attracted to the university by local expertise in catalysis, the constructive approach of the university executive, and support from Scottish Enterprise. Both the university and Sasol have benefited from this co-location, through sharing of infrastructure, expertise and equipment. Sasol now provide a steady income to the university for services rendered, invests jointly in people and capital, financially supports a large number of PhD and PDRA projects, and continues to actively participate in the teaching programme. Sasol's interests have diversified and evolved over the years, most recently into energy conversion and storage. The presence of world leading experts at the university was a great facilitator in this transition. This scenario has proved so mutually beneficial, that a lease for a further 10 years has recently been signed.

44. The Catapult programme[24] by the Technology Strategy Board has been a positive step in encouraging co-investment of public and industry funding. Each of the seven Catapults is a physical centre for technology and innovation in a different area of research and development. The High Value Manufacturing Catapult, for example, has attracted investment from Rolls Royce, Boeing and IBM.

45. Research council based initiatives, such as Doctoral Training Centres (DTC) and CASE schemes, have also been successful in attracting investment from industry. Many DTCs engage with industry and there are also specific industrial doctorate centres.[25] Knowledge Transfer Networks are also specifically designed to link industry with academic research and (by association) infrastructure within the University sector.

The RSC would be happy to discuss our response to this consultation in more detail.

Royal Society of Chemistry
Thomas Graham House
Science Park, Milton Road
Cambridge CB4 0WF, UK
Tel +44 (0) 122 3432379
Email: sciencepolicy@rsc.org

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