

# fst *journal*

The Journal of The Foundation for Science and Technology

Volume 21 Number 7 March 2016 [www.foundation.org.uk](http://www.foundation.org.uk)

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**Sir Paul Nurse:** Putting research at the heart of Government

**Professor Philip Nelson:** Making the most of the opportunities

**Gareth Davies:** Communicating clearly to Government and the community

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**Iain Conn:** Scotland's position in the energy market

**Gary Haywood:** A role for shale gas

**Professor Rebecca Lunn:** Balancing our energy portfolio

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## The future of the Arctic

**Lord Teverson:** Responding to a changing Arctic

**Jane Rumble:** Increasing our engagement

**Dame Julia Slingo:** Charting the changes in the Arctic ecosystem

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*FST Journal* redesigned in 2015 by IOP Publishing's Design Studio, under the art direction of Andrew Giaquinto.

IOP Publishing provides publications through which leading-edge scientific research is distributed worldwide and is central to the Institute of Physics, a not-for-profit society.

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ISSN 1475-1704

Charity Number: 00274727 Company Number: 01327814

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## Harnessing the potential of big data

The UK has an enormous opportunity to reap major benefit as it evolves into a data-enabled economy, but must implement best practice now, especially in systems engineering, to maximise productivity and minimise security risks, according to a report from the Royal Academy of Engineering and the Institution of Engineering and Technology.

*Connecting data: driving productivity and innovation*, says that harnessing the power of data analytics – big data – and linking key datasets reliably in real time has immense potential to drive innovation and enhance UK productivity, which is currently lagging 17% behind the average across the G7 economies. However, good practice is currently not widespread or consistent enough across and between each sector of the economy.

[www.raeng.org.uk/news/news-releases/2015/november/uk-companies-in-danger-of-missing-major-opportunity](http://www.raeng.org.uk/news/news-releases/2015/november/uk-companies-in-danger-of-missing-major-opportunity)

## UK could lead in forensic science

The UK could become the world leader in forensic science, Sir Mark Walport, Government Chief Scientific Adviser, says in his themed annual report, *Forensic science and beyond: authenticity, provenance and assurance*.

The UK has a long-standing reputation for being at the forefront of forensic science innovations, including developing DNA fingerprinting and profiling. But the power of analytical science and its many applications has the potential to deliver benefits to society that go far beyond the criminal justice system.

The report draws on evidence provided by experts in several fields. The review starts with forensics – the use of analytical science to assist the courts – but then moves on to explore the many ways in which we can use analytical scientific tools, combined with the approaches and skills of forensic scientists, to assure the authenticity and provenance of products and services.

[www.gov.uk/government/publications/forensic-science-and-beyond](http://www.gov.uk/government/publications/forensic-science-and-beyond)

## Serious mental illness linked to early death

Research led by the RSA Open Public Services Network (OPSN) and Mind has uncovered new information on the degree to which local areas are meeting the physical health needs of people with serious mental health illnesses (SMI). People with SMI are less likely to be sent for crucial physical health tests: 6% less likely to have blood pressure tests, 9% less likely to have a screen for cervical cancer and 15% less likely to have a cholesterol check.

A new composite measure produced by the RSA OPSN network has identified 18 areas that have a statistically significant difference between tests for people with SMI and the whole population. These data shed new light on the fact that people experiencing serious mental health illnesses are more likely to die younger.

In an accompanying report, *Getting*



*the message on mental health: From public data to public information*, the RSA's Open Public Service network explores this and three other key questions to map the difference between the total population and people with serious mental health conditions.

[www.thersa.org/mentalhealth-report](http://www.thersa.org/mentalhealth-report)

## What role does the EU play in UK research?

The Royal Society has published the first of three evidence-based briefing reports about the role that the European Union (EU) plays in UK research.

*UK research and the European Union: The role of the EU in funding UK research* brings together the most up-to-date facts and figures about the finances, while also clearly outlining how EU research funding works in the UK.

The report is intended to play a part in

informing the debate ahead of the UK's in-or-out EU referendum, due before the end of 2017. The following two briefing reports will explore the influence of the European Union on researcher mobility and international collaboration, and the influence of EU regulation and policy on research in the UK.

[www.royalsociety.org/topics-policy/projects/uk-research-and-european-union](http://www.royalsociety.org/topics-policy/projects/uk-research-and-european-union)

## UK faces an electricity generation crisis

The UK Government's policy to close all coal-fired power stations by 2025, combined with the retirement of the majority of the UK's ageing nuclear fleet and growing electricity demand will leave the UK facing a 40-55% electricity supply gap, according to a report by the Institution of Mechanical Engineers.

The *Engineering the UK Electricity Gap* report claims that plans to plug the gap by building Combined Cycle Gas Turbine (CCGT) plants are unrealistic, as the UK would need to build about 30 new CCGT plants in less than 10 years. The UK has built just four CCGTs in the past 10 years. In addition, in 2005, some 20 nuclear sites were listed for

decommissioning, leaving a significant gap to be filled.

According to the report, the country has neither the resources nor enough people with the right skills to build this many power stations in time. It is already too late for any nuclear reactors to be planned and built by the coal 'shut-off' target of 2025, other than Hinkley Point C.

The report also highlights that a greater reliance on interconnectors to import electricity from Europe and Scandinavia is likely to lead to higher electricity costs and less energy security.

[www.imeche.org/docs/default-source/position-statements-energy/imeche-ps-electricity-gap.pdf](http://www.imeche.org/docs/default-source/position-statements-energy/imeche-ps-electricity-gap.pdf)

## Historic and wide-ranging climate agreement concluded in Paris

An historic agreement to combat climate change and unleash actions and investment towards a low carbon, resilient and sustainable future was agreed by 195 nations in Paris in December. The Paris Agreement for the first time brings all nations into a common cause based on their historic, current and future responsibilities.

The universal agreement's main aim is to keep a global temperature rise this century well below 2 °C and to drive efforts to limit the temperature increase even further to 1.5 °C above pre-industrial levels. The 1.5 °C limit is a significantly safer defence line against the worst impacts of a changing climate.

Additionally, the agreement aims to strengthen the ability to deal with the impacts of climate change.



To reach these goals, the United Nations says that appropriate financial flows will be put in place, thus making stronger action by developing coun-

tries and the most vulnerable people possible, in line with their own national objectives.

"The Paris Agreement allows each delegation and group of countries to go back home with their heads held high," said Laurent Fabius, President of the Conference of the Parties (COP 21) UN Climate change conference and French Foreign Minister. "Our collective effort is worth more than the sum of our individual effort. Our responsibility to history is immense," he added.

Christiana Figueres, Executive Secretary of the UN Framework Convention on Climate Change (UNFCCC), said: "It is an agreement of long-term vision, for we have to turn this agreement into an engine of safe growth."

[www.cop21paris.org](http://www.cop21paris.org)

## Researchers boost public engagement

Eight out of 10 (82%) researchers carried out at least one form of public engagement in the past year, according to a new study commissioned by a consortium of 15 UK research funders, including the Research Councils.

The study – *Factors affecting public engagement by researchers* – found that participation in public engagement was higher among researchers in the arts, humanities and social sciences (AHSS) at 88%, than in science, technology, engineering and mathematics (STEM) at 78%. AHSS researchers were also more likely to value it as a core component of

their role (52%, against 37% of STEM).

However, since the last study into this area in 2006, the number of STEM researchers who value public engagement as a core component of their role has risen from 28% to 37%. The proportion of STEM researchers who would like to engage more with the public has also increased from 45% to 53% and they also feel better equipped to engage with the public than they did in 2006 (up from 51% to 63%).

[www.wellcome.ac.uk/About-us/Publications/Reports/Public-engagement/WTP060031.htm](http://www.wellcome.ac.uk/About-us/Publications/Reports/Public-engagement/WTP060031.htm)

## Guide to biological and toxin weapons

IAP (the global network of science academies) has published, in partnership with the Royal Society, the US National Academy of Sciences and the Polish Academy of Science, a review of scientific and technological developments that have implications for the UN Biological and Toxin Weapons Convention (BWC). This is to ensure that the most up-to-date scientific advice in the area of biosciences is available to assist policy makers in preparing for the 8th BWC Review Conference, which takes place in December 2016.

Biosciences are developing at an unprecedented rate and the move from 'concept' to 'application' is becoming ever simpler, with costs continuing to fall. This has both positive and negative implications for the BWC. Technological barriers to acquiring and using a biological weapon have been significantly eroded since the Seventh Review Conference (2011). The 'bio-economy' has grown and is therefore itself a potential target for attack.

[royalsociety.org/topics-policy/projects/biological-toxin-weapons-convention](http://royalsociety.org/topics-policy/projects/biological-toxin-weapons-convention)

## New £20m UK-India fund backs research on food security

A £20 million UK-India fund has been created to support research that addresses critical food security challenges.

Four Virtual Joint Centres in Agricultural Nitrogen will be established between leading UK and Indian researchers to deliver innovative research over the next three years, which will contribute to the sustainable use of nitrogen fertiliser in Indian agriculture.

This represents a £10 million investment from the Newton-Bhabha fund, delivered in partnership by the Biotechnology and Biological Sciences Research Council (BBSRC), the Natural Environment Research Council (NERC) and the Department of Biotechnology India (DBT). This collaboration will help meet the challenge of sustainably producing enough food for a growing population whilst reducing pollution and greenhouse gas emissions.

The value of joint investment in UK-India research has grown from less than a million in 2008 to now over £200 million, demonstrating the Research Councils' commitment to working towards the goal of making the UK India's partner of choice for research collaboration.



## An effective forum for debate

John Enderby



Professor Sir John Enderby CBE FRS is the Editor of *FST Journal*. He was Professor of Physics at the University of Bristol from 1976 to 1996. He was elected a Fellow of The Royal Society in 1985 for his pioneering studies into the structure and properties of liquids and amorphous materials. He served as a Vice-President of The Royal Society from 1999 to 2004. One of his responsibilities was the Society's publishing activities. Sir John was President of the Institute of Physics in 2004. He is now a consultant to IOP Publishing.

As this is my last editorial before handing over the *Journal* to my successor, I thought it might be interesting to look back at some of the issues I was able to raise in my capacity as Editor.

In the November 2010 issue, I wrote about the Millennium Development Goals (MDGs). These were a result of a special World Summit held in 2000. To quote from the editorial: "With only five years left until the 2015 deadline, UN Secretary-General Ban Ki-moon called on world leaders to accelerate progress in order to achieve the eight anti-poverty goals." How well has the international community performed since 2010?

In writing his foreword to the final MDG Report (2015), Ban Ki-moon states that this initiative has produced "the most successful anti-poverty movement in history". He goes on to say that for all the remarkable gains, progress has been uneven and that the world's poor remain concentrated in some parts of the world. In terms of the indicators of success, consider just three of the goals as illustrations of the problems that remain.

Goal 1 was to eradicate extreme poverty and hunger. Globally, the figures are impressive. Extreme poverty has declined significantly over the past two decades. In 1990, nearly half the population of the developing world lived on less than \$1.25 a day. Today that proportion had dropped to 14%. However, over 800 million remain in extreme poverty and a similar number of our fellow humans still suffer from hunger.

Goal 2 aimed to reduce child mortality. Again, the global under-five mortality rate has declined by more than half and now stands at 43 deaths per 1,000 live births. Nevertheless, in sub-Saharan Africa, the rate remains stubbornly high at 86 per 1000, twice the global average.

Goal 6 aimed to combat HIV/Aids, malaria and other diseases. By June 2014, 13.6 million people living with HIV were receiving anti-viral therapy compared with only 800,000 in 2003. The global mortality rate for malaria has fallen since 2000 by 58%.

Impressive as these figures are, HIV and malaria continue to be of concern. In 2013, there were around 2.1 million cases of HIV infection and in 2015 alone, there were over 200 million cases of malaria with nearly half a million deaths. Malaria is still endemic in 97 countries with 3.3

billion people at risk, some 80% of them living in just 17 countries. In short, and as the General-Secretary recognises, while the global figures look promising, the situation for the least-developed countries remains problematic.

### Sustainable Development Goals

A successor programme to the MDGs was agreed at a meeting of the UN in September 2015. It will build on the lessons learnt and is now referred to as the Sustainable Development Goals. Several new goals have been added to the existing ones. These include efforts to:

- reduce inequality within and among countries;
- make cities and human settlements inclusive, safe, resilient and sustainable;
- ensure sustainable consumption and production patterns;
- take urgent action to combat climate change and its impacts;
- conserve and use the oceans, seas and marine resources for sustainable development;
- promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.

The Editor of *FST Journal* in 2030 might wish to review the progress of this ambitious programme as well as the extent to which the original MDGs have been achieved.

### Open access publishing

As someone who has a long-standing interest in scientific publishing, I was very happy to write (December 2012) an editorial on the Open Access (OA) model proposed in the Finch Report. Janet Finch and her colleagues came down in favour of 'Gold' OA where authors (or their funders) pay an Article Processing Charge (APC) in order that the article is available for all to read.

There are huge variations in APCs and this leads to difficult choices for both authors and funders. According to Pinfield *et al*<sup>1</sup>, current APCs can vary from £82 to £5,280. Even within a single publishing house, there are significant differences. For example, the highly regarded journal *Cell* published by Elsevier charges \$5,000. Yet it levies just \$500 for *Case Studies in Structural Engineering*. As it is now generally accepted that

the sums available for Gold OA are finite, some sort of rationing is inevitable.

The Royal Society of Chemistry's 'Gold for Gold' is an interesting initiative. In essence, institutions which sign up receive a number of vouchers to cover the APC (£1,600). The number of vouchers depends on the amount the institute pays in subscriptions to RSC journals. For example, a payment of £24,000 generates 15 vouchers. However, the distribution of these vouchers is left to an administrator within the subscribing institution. Thus, there is a system of rationing which has to be carefully managed.

One of the unforeseen consequences of the author-pays model has been a growth in so-called 'predatory' publishers, who produce counterfeit journals to exploit the open-access model in which the author pays. According to Professor Jeffrey Beall, the growth in such publishers over the past few years has been dramatic. He identified 693 as potential, possible, or probable predatory OA publishers in 2015 compared with 18 in 2011. Beall also points out that well-known journals have been hijacked by predatory publishers. The *MIT Technology Review* was a victim of this, with authors being misled into thinking that the APC they paid ensured publication in this highly-respected journal.

Professor Beall is a librarian at the University of Colorado and is a long-standing critic of Gold OA. Defenders of the system, while applauding Beall's work on predatory publishers, argue that such fraudulent activities do not, in themselves, invalidate the overall benefits of properly funded, free-to-read, high-quality journals.

### A place for the Arts

An editorial published in February 2012 entitled 'Arts, Humanities and Social Sciences must be supported' evoked considerable interest in the wider community. I was inspired to write this editorial by a remarkable statement made by General Sir David Richards. He had seen a series of short plays badged under the title *The Great Game* which depicted the turbulent history of Afghanistan. His regret was that he saw these plays after being deployed to that troubled country. Sir David is quoted as saying that the insights gained through this series of plays would have influenced his military decisions.

Arts and Humanities are, of course, of considerable value in their own right. Great novels, poetry, art, and theatre bring pleasure to countless millions. In terms of the UK, they contribute directly to the nation's GDP as well as its balance of payments, particularly through tourism.

However, the central theme in that editorial

was the need to maintain a healthy and vibrant community of scholars trained in the Arts. It seemed to me obvious that before we embark on interventions such as humanitarian aid, new medical therapies, or conflict resolution (involving diplomacy, military action or both), a proper understanding of the economic, historical, political, social and religious backgrounds is essential. Such understanding draws heavily on the skills of our colleagues in the Arts, Humanities and Social Sciences.

In 2006, during the Global War on Terrorism, a *New York Times* reporter went to Washington in an attempt to ascertain the extent to which American officials understood the ideologies underpinning Islamist terrorism. The reporter began with a simple question: could senior counterterrorism officials identify which groups were Sunnis and Shias and where they tended to be located?

Remarkably senior officials and lawmakers had, according to the reporter "not a clue". Sectarian tensions between Sunnis and Shias are even more pronounced today than they were in 2006. The questions that the *New York Times* raised seven years ago remain highly relevant.

### A word of thanks

It has been a great privilege editing the *Journal* and I thank all the contributors for their acceptance of copy deadlines and the minor editorial changes made to their submissions. Special thanks are due to Simon Napper, the Production Editor who does much of the day-to-day work.

Over the years, he has been ably assisted by Judy McBride, Simon Clarke, Alison Gardiner, James McQuat, Charles Wenz and Wendy Barnaby. My colleague at IOP Publishing, Andrew Giaquinto and his team, did the most wonderful redesign of the journal (*pro bono!*) in order to reflect, in its appearance, the exceptionally high quality of its contents.

Above all, I must thank our Chief Executive, Dr Dougal Goodman, for all his help and support. As Lord Selborne said at the recent Christmas event, Dougal is the Foundation of Science and Technology. Such successes as the *Journal* has had are due in large part to his excellent choice of speakers as well as his amazing powers of persuasion, particularly in the ability to acquire, free of charge, the services of former Permanent Secretaries to undertake tasks such as note-taking and to help in the identification of major issues in the debates. □

<sup>1</sup> S Pinfield, J Salter and P Bath: <http://eprints.whiterose.ac.uk/83525>

General Sir David Richards is quoted as saying that the insights gained through a series of short plays badged under the title *The Great Game*, which depicted the turbulent history of Afghanistan, would have influenced his military decisions if he had seen them prior to his deployment there.

# SPENDING REVIEW

The Chancellor of the Exchequer, the Rt Hon George Osborne, presented his Autumn Statement, which included the results of the Spending Review, to Parliament on 25 November 2015.

## Balancing sound public finances and great public services

Addressing the House of Commons, the Chancellor said he could confirm that the four-year public spending plans he was setting out were forecast to deliver a surplus, “so we don’t borrow forever and are ready for whatever storms lie ahead”.

He argued that it was false to claim that Britain had to choose between sound public finances and great public services. “If you are bold with your reforms you can have both,” he said.

To achieve the desired surplus, though, the Spending Review has resulted in cuts in virtually every Departmental budget, but a number of the programmes they run have either been protected or in some cases augmented.

### Business

In his speech, the Chancellor committed the Government to the same level of support for aerospace and automotive industries, not just for the next five years but for the next decade.

Spending on Catapult centres will also increase. He also promised to protect the cash support given through Innovate UK by offering £165 million of new loans to companies instead of grants. He noted that “France has successfully done this for years.”

The Chancellor argued that “in the modern world one of the best ways you can back business is by backing science. That’s why in the last Parliament, I protected the resource budget for science in cash terms. In this Parliament I’m protecting it in real terms so it rises to £4.7 billion. That’s £500 million more by the end of the decade – alongside £6.9 billion in the capital budget too.”

He reminded his audience that the Government is funding the new Royce Institute in Manchester, and new agri-

tech centres in Shropshire, York, Bedfordshire and Edinburgh.

He added that £75 million would go to a transformation of the famous Cavendish laboratories in Cambridge.

In his speech, the Chancellor also announced he was setting aside “£12 billion we promised for our Local Growth Fund and I am announcing the creation of 26 new or extended Enterprise Zones, including 15 zones in towns and rural areas from Carlisle to Dorset to Ipswich”.

Investing in long term economic infrastructure was a goal of this Spending Review, with a doubling of spending on energy research. Spending on Catapult centres will also increase with protection for the cash support given through Innovate UK.

### The National Health Service

In regard to health, he said that patients will see more than £5 billion of health research, in everything from genomes to anti-microbial resistance, a new Dementia Institute and a new, world-class public health facility in Harlow.

He acknowledged that one part of our NHS had been neglected for too long – mental health (a subject addressed on several occasions by the Foundation for Science and Technology). He promised £600 million in additional funding – meaning that by 2020 significantly more people would have access to talking therapies, perinatal mental health services, and crisis care.

### Transport

Although the Department for Transport’s operational budget will fall by 37%, transport capital spending will increase by 50% to a total of £61 billion. This is to fund “the largest road investment programme since the 1970s”.

This will mean that the construction of HS2 to link the Northern Powerhouse to the South can begin. The electrification of lines such as the Trans-Pennine, Midland Main Line and Great Western Railway can also go ahead.

### Energy and climate change

Investing in long-term economic infrastructure was a goal of this Spending Review, he said, and “there is no more important infrastructure than energy”.

The Chancellor announced a doubling of spending on energy research, with a major commitment to small, modular nuclear reactors. In addition, the Government was supporting the creation of the shale gas industry by ensuring that communities benefit from a Shale Wealth Fund, which could be worth up to £1 billion. Support for low-carbon electricity and renewables will more than double, he added.

The development and sale of Ultra Low Emission Vehicles will continue to be supported – but in light of the slower than expected introduction of more rigorous EU emissions testing, the Government is to delay the removal of the diesel supplement from company cars until 2021.

Mr Osborne reminded MPs of the UK’s support for international efforts to tackle climate change, including the Paris COP21 talks which were to take place the following week. The Government would, he said, increase support for climate finance by 50% over the next five years. □



# RESEARCH COUNCILS

The Government invited Sir Paul Nurse to undertake a review of the Research Councils, to explore how they can support research most effectively. His report was debated at a meeting of the Foundation for Science and Technology on 12 January 2016.

## Putting research at the heart of Government

Paul Nurse

### SUMMARY

- The Research Councils deliver high-quality research in a cost-effective way.
- However, they need to develop further to maintain their leading role in today's world.
- Research Councils UK should, as 'Research UK', take on a strategic role for the whole research community.
- Research UK would advise Government on policy for science.
- A separate ministerial committee could provide a platform for high-level interaction between Government and the research community.

The goal of the Review<sup>1</sup> was to investigate how the Research Councils could support research in the most effective ways – securing excellence, promoting collaboration and developing agility to best contribute to sustainable growth.

An advisory group was established which covered the breadth of UK research endeavour. We met regularly for much of last year. A second reference group, which was consulted on particular questions, had international reach. So, unusually for a Government review, we had access to scientists familiar with research in the USA, in Germany and New Zealand. Within these two groups there were four Nobel laureates.

Although the review was aimed primarily at science, it recognised that research covers all the academic disciplines, not only the natural sciences but the social sciences, the arts and the humanities. The Review covers the whole field of academic endeavour.

Why do research? To gain and generate knowledge of the natural world and of ourselves. It enhances our culture and civilisation, as well

as producing knowledge that can be developed into useful applications. It also leads to, for example, a better quality of life, better public services, improving health and protection of the environment.

Decisions on what research to carry out should be made by those who are expert in that particular area – this underpins Haldane's 1918 Principle. Research requires high-quality peer review.

An effective discovery and translational research agenda requires a culture that gives freedom to the individuals trying to generate knowledge, alongside a culture that captures knowledge to turn into applications.

### The Research Councils

The starting point for the Review was that the Research Councils have done extremely well over many years. They are admired throughout the world. They have achieved their objectives very efficiently. They deliver high-quality research in a very cost-effective way. They promote good research training. They contribute to our economy. They engage with the public and provide advice.

Yet, in my view, Research Councils are overstretched. They have too many things to do. There needs to be more focus on strategic thinking. They need to have the time to be leaders in their community. They also need to be better at addressing cross-cutting, multi-disciplinary research issues – especially those concerned with emergencies.

There is a need to establish budget-setting between Councils, but currently no clear way of choosing between competing demands.

A single, unified, strong voice is needed in



Sir Paul Nurse FRS FMedSci led the Review of the Research Councils. Sir Paul is a geneticist and cell biologist who has worked on how the eukaryotic cell cycle is controlled and how cell shape and cell dimensions are determined. He is Director of the Francis Crick Institute in London, and has served as President of the Royal Society, Chief Executive of Cancer Research UK and President of Rockefeller University. He shared the 2001 Nobel Prize in Physiology or Medicine.

Research Councils are overstretched. They have too many things to do. They need to have the time to be leaders in their community.

speaking to Government about science. Having seven Research Councils with different views and voices is not the best way to do that.

Some of the issues identified in the Review can be dealt with straightforwardly, particularly those concerned with ways of working, focussing more on operational detail.

### High-quality peer review

High-quality peer review of research is crucial. There has to be a rapid grant-awarding process and a transparent process that reports outcomes. There has to be diversity across the board. Different ways of supporting research have to be found that cover research at all levels – pilot level, project level, programme level or major strategic level.

Early-stage career researchers must get support early. The entry point, the age at which independence is achieved, is gradually increasing, to a point where the most creative period may be lost. We have to be able to promote youth, although always remembering those of more advanced age still have contributions to make as well!

Flexible doctoral programmes need to be developed, so that people are not excluded just because they are in the wrong place at the wrong time. In general, systems which are too inflexible degenerate.

Good linkages must be maintained across the entire research community. That means there needs to be time to make and foster connections. There has to be an appropriate balance between reporting to BIS and being researchers.

Finally, invest in excellence wherever it is found. Sometimes new ideas pop up outside of the great academic centres and that aspect of diversity should be recognised too.

### The wider landscape

How should the Higher Education Council for England (HEFCE) and its dual-support system interact with the Research Councils? The charitable research sector is also vital. It is providing £1.5 billion to the life sciences every year.

Then there is Government-funded research in its own Departments which is often not well-connected to the whole research endeavour. Commercial research is more difficult to assess because to some extent it is confidential.

Finally, there is international research. We are an island, but we should not be isolated – we have

to think how best to engage with Europe as it provides the critical mass to increase our agility. A point which is often missed is that if we increase our mobility across Europe then we have a bigger critical mass, closer to that of the USA.

There is a responsibility to horizon scan across the world, not simply for new applications but for any new developments so that we are not left behind. This responsibility I have put with the Research Councils.

All of this requires high-quality leadership – I cannot emphasise this enough. Those in senior positions should not simply be good managers, they need to be leaders in science.

Some of the necessary changes can only be delivered if there is a reform of governance and structures. This is to strengthen strategic thinking across the board, as well as within individual Research Councils, and in order to move science closer to the heart of Government. Greater sharing of best practice is required across the organisations, as well as better coordination in general across the research landscape.

To achieve this, the Review proposes two major changes. The first is at the level of research councils and involves new cross-council arrangements. The second concerns new cross-Governmental arrangements.

### Research UK

The key to the first change is the evolution of Research Councils UK (RCUK) into a formal organisation which speaks with a strengthened and unified voice about science to Government. It should also take responsibility for cross-council agendas and strategy. That will simplify operational issues and reduce the administrative burden.

I have suggested a change of name to 'Research UK' to indicate both that its responsibilities are heavily concerned with the Research Councils, but also that it has wider responsibilities to the research community. The Chief Executive of Research UK should be the accounting officer collectively for all the Research Councils and the objective there is to reduce the administrative burden on the individual bodies.

Research UK will report to a single oversight Board and the Chief Executive should be a distinguished scientist who is not only managerially effective, but is also a leader – and seen to be a leader. The oversight Board should have an independent Chair with members appointed by Ministers and would report to the Department for Business, Innovation and Skills (BIS).

Board membership would include independent, non-executives who are scientific leaders

Some of the necessary changes can only be delivered if there is a reform of governance and structures to strengthen strategic thinking across the board.

familiar with the research landscape. That board should include the BIS Director-General, who would link with other Government Department research, and with the Government Chief Scientific Adviser (GCSA). Depending on the final structures, there could be representation from HEFCE and Innovate UK, although this may be more appropriate at the executive level.

The Executive Committee, supported by a relatively small administrative core, would be chaired by the Chief Executive, would have all seven heads of the Research Councils as well as the research functions of HEFCE and of Innovate UK.

Crucially, the Board and the Executive Committee of Research UK would have responsibility for advising government on policy for science. This is different from the role of the GCSA who provides scientific input on policy. Until now we have not had a clear route for advising on policy for science.

The organisation would work through a single Chief Operating Officer who would be responsible for delivering activities across the Research Councils. Having a single person in this role will increase efficiency.

A single data management system would provide a one-stop mechanism for enquiries about all UK science research activities and how they can be accessed. So a company, for example, could request information about a topic of interest and it will be given details of research going on, how it can be accessed, what grants might be available, etc. It is known that companies find it difficult to penetrate the present complexity, so this approach would simplify the process.

Cross-cutting research would be supported through a common research fund. This would deal with multi-disciplinary issues, which are always difficult to deliver, such as emergencies and cross-cutting societal needs. This facility would also provide a mechanism to discuss any reallocation of budget from one Research Council to another: at the moment there is no place to discuss this. The individual Councils still need to control their own funding in order to do their job, but some proportion of money should be vested at this higher level.

Research UK is where research strategy can be generated, so as to produce a strong, common position for interaction with Government. That is a really crucial role for this new body.

Overall responsibility for ethics and conduct in science would also be part of its remit. As the House of Lords noted some 15 years ago, scientists have to earn their licence to operate. That means we have to conduct science in a proper manner – and be seen to do so.

**A single data management system would provide a one-stop mechanism for enquiries about all UK science research activities.**

The creation of Research UK has implications for individual Research Councils, but it is crucial that they maintain their present integrity, even though they will no longer have accounting officers. They must remain disciplined and focussed, close to their research communities. They will have to maintain budgetary control and run an effective research endeavour, maintaining a capability to employ researchers and facilities. One way of maintaining this structure would be to keep the Royal Charters.

### **Cross-Government structures**

The second major recommendation is the establishment of a new cross-Government arrangement that will put science more squarely at the heart of Government.

Responsibility for the research effort currently sits with Ministers in BIS. However, other Departments and Ministers need to be engaged with the research community as well. Science impinges on all aspects of our lives and on all aspects of Government operations. There is a need to understand and accelerate the impacts of science and technology on the work of Government and this necessitates a greater engagement between policy-makers and the research community.

While Research UK provides a strong scientific voice to Government, a new Ministerial committee will provide high level, political interaction between experts and scientists on the one hand and our elected political representatives on the other. It will help the Government respond to new scientific research and disruptive technologies, as well as maintaining Government's overall capacity for research. It could be chaired by a senior Minister who has a cross-cutting Cabinet perspective, with the Minister for Universities and Science as well as other Ministers who have responsibility for delivering the science agenda as members of the committee. Relevant senior officials would also need to be in attendance.

The Council of Science and Technology, which at the moment advises the Cabinet and the Prime Minister on science issues, could form an independent advisory group for such a Ministerial committee. This would add a valuable additional resource for ensuring a successful UK research endeavour. □

<sup>1</sup> [www.gov.uk/government/publications/nurse-review-of-research-councils-recommendations](http://www.gov.uk/government/publications/nurse-review-of-research-councils-recommendations).

# Exploiting the opportunities

Philip Nelson



Professor Philip Nelson FREng is Chair of the RCUK Executive Group and Chief Executive of the Engineering and Physical Sciences Research Council (EPSRC). He previously served from 2005-2013 as Pro Vice-Chancellor of the University of Southampton, with particular responsibility for Research and Enterprise. He also served as Director of the University's Institute of Sound and Vibration Research and Director of the Rolls-Royce University Technology Centre in Gas Turbine Noise.

The Research Councils, taken together, constitute a large undertaking. Each of the Councils is established by Royal Charter. Altogether, there are about 770 staff involved in administering the operation, including the processing of grants applications, and a further 450 staff supporting the delivery of programmes. There are also about 8,000 staff in a range of institutes directly involved in undertaking research.

Research Councils UK (RCUK) is the strategic partnership between the seven Research Councils. Each Council is a partner organisation of the Department for Business, Innovation and Skills (BIS). A number of the Councils run institutes, such as MRC's Laboratory for Molecular Biology and NERC's National Oceanographic Centre. There are many other centres supported by the Councils. For example, the EPSRC has 115 centres for doctoral training.

Together, the Research Councils had a budget of £3 billion in 2015. About 2,500 businesses are collaborating with the Councils at any one time, 1,000 of which are SMEs. The Research Councils between them, for example, support around 30,000 researchers at any one time.

The UK does not spend as much on R&D as many of its competitors. Having said that, the Government showed strong support for science in the last parliament and we remain grateful for the knowledge that our allocations will go up, in real terms, over the next five years.

## A focus on excellence

Productivity is very high in terms of citations produced per pound spent – we outpace the rest of the world on that basis – and with 1% of the world's population we produce 16% of its most highly-cited papers. So UK research is both productive and of high quality and this, in no small measure, is due to the past work of the Research Councils.

The whole ethos of RCUK is excellence with impact. History shows that some of the greatest discoveries have come from letting talented researchers follow their intuition. At the same time, there are societal challenges we must also address. We must get the balance right between supporting basic research and responding to society's challenges.

Developing skills, leadership and infrastructure is absolutely critical. We are providing PhD-qualified individuals to build the success of

## SUMMARY

- The Research Councils deliver world-class research extremely cost-effectively
- The current framework of seven Research Councils with their own remits should be retained
- RCUK supports moves to a more integrated voice for science to government
- Changes should be carefully thought through and should not stifle innovation
- The Research Councils engage closely with their own communities and those links need to be protected in any new structure

the economy – it is critical for the future of the country that we can continue that very strong programme of doctoral training.

In my career I have seen significant progress in supporting innovation, ensuring that we turn great science into economic wealth, not only in traditional industries but right across the creative sector too.

Impacts are wide-ranging, from flood prediction to policy alleviation. Some, 6,679 case studies were submitted to the Research Excellence Framework (REF) in 2014. These illustrated the benefits provided to the economy, society, culture, public policy and services, the environment and quality of life.

EPSRC carried out a study of 1,226 case studies submitted to the REF. The £7.8 billion spend during 1993-2013 was associated with £80 billion of economic activity during the period 2008-2013. Investment in science does produce economic benefits in addition to its broader societal impacts.

The Research Councils have an increasingly important international role, too. We have offices in Brussels, Beijing, Washington and Delhi: again we are trying to make connections across the world in order to leverage our really strong science base. This is still more important following the announcement of the Global Challenges Fund by the Chancellor in the Autumn Statement, through which we will help research in developing nations that meet official development assistance (ODA) criteria.

The Research Councils engaged fully with the Review. There were three meetings between Sir Paul and the Research Council Chief Executives. We also made a number of points direct to the Science Minister, Jo Johnson. We argued that retain-



ing our existing seven, strong, science and business-facing identities was important. Quite how we do that is a matter for discussion, but the principle is very important.

We felt the Haldane Principle was also critical and we referenced the 2010 Government statement of this which is clear and helpful. It is also very important to have clearly delegated authority and accountability for the independent management of research funding, for transparency and pre-determined, multi-year investment.

I have not met anyone who does not think the dual support system is a good thing and we also emphasised that in the letter to the Minister. Peer review is very important too and is central to our effective operation.

The Chief Executives of the Research Councils had already begun an initiative called 'Research Councils Together', focussed on delivering operational efficiency, with core 'common operations' like finance, HR and IT.

While certain things remain properly associated with each Council, there are also some other potential areas which could be pooled. This process is underway and will be delivered irrespective of any other decisions.

We completely accept we need to increase our capability to fund multi-disciplinary research as science progresses, although there are already many examples of successful initiatives.

Our Royal Charters define the legal personality of our organisations. Research Councils are corporate bodies whose council members have corporate responsibility, rather like the directors of a company. So we have very strong governance. The council members are eminent individuals who contribute enormously to the success of the organisation.

There is also a very large, wider community that contributes to the operation of the Councils – those who do peer review, and those who sit on strategic advisory networks, etc. EPSRC for example has an estimated community of 10,000 investigators and it is vital that they are represented in advisory networks.

The Review seeks to give a more unified, strategic voice to the Councils. But there is still much to be discussed and decided in terms of the detail. For example, there is a possibility of having Innovate UK as part of this structure, or the quality-related (QR) part of HEFCE. Many things have yet to be finalised.

There are, undoubtedly, significant opportunities and some of these are set out in Section 4 of the Review. Stronger strategic thinking offers better engagement with Government and there are proposals for operational policies that are more effective, simplified and common. We support moves

in that direction. But we have to ensure that such changes do not stifle innovation. Research Councils have been responsible for a number of successful innovations and that should continue. No-one wants to end up with a plethora of incomprehensible schemes, but nor should new approaches be overlooked. We should also be wary of increased bureaucracy through the imposition of another layer that just adds more complexity.

We have already acknowledged the need to support multi-disciplinary research more effectively, but this should not be at the expense of our core disciplines. Good, inter-disciplinary research is not possible without strong core disciplines.

Long-term budgeting, planning and investment, flexibility and agility – all of these things go with an allocated budget. So we need to be clear about the degree to which the budgets of different Research Councils will be fixed.

### Issues of governance

The Review mentioned strengthened Research Council leadership: it is difficult to disagree, but we should not simply discard the existing strong governance arrangements. The Councils are dispensing large amounts of public money, so it is important to be confident they remain well-governed.

Better coordination with other stakeholders across the research landscape, including Innovate UK and HEFCE, is certainly desirable. We already have good relationships with them, but perhaps the formal structures could be improved and further thinking is required here.

With regard to HEFCE, the separation between research and teaching needs to be considered. Innovate UK has a mission beyond the higher education system, so let's not forget that either. Their mission is to stimulate growth across the economy, and in doing so to work with industry and business. There is a risk that putting them in the same family could result in a loss of focus on their core function.

Finally, of course, big changes can sometimes threaten business continuity so such changes have to be managed extremely carefully. That is to ensure that the process and the goals are thought through in detail in order to mitigate any risk.

There must be a proper appraisal of the options in terms of the proposed new governance structures. This involves considering the alternatives – what is legally possible – and assessing these options so as to ensure that current excellence is not inadvertently compromised by organisational change.

Our policies are informed through engagement with stakeholder communities. We are all comfortable about the way our missions develop through conversations with those communities. We must not lose that input. □

Good, inter-disciplinary research is not possible without strong core disciplines – it is as simple as that.



# Communicating clearly to Government and the community

**Gareth Davies**



Gareth Davies is Director General, Business and Science at the Department of Business, Innovation and Skills. He was previously the Executive Director and Chief Economist in the Cabinet Office, responsible for civil society, innovation and analysis. Over the last decade he has worked in Downing Street as the Prime Minister's lead adviser on welfare reform, and has been Head of the Prime Minister's Strategy Unit.

In Government, the fundamental importance of science, both as a public good and of itself, as well as its economic and social impact, is now broadly accepted. Support come from the highest levels, right across Government, both politically and among officials.

Following the Comprehensive Spending Review, there is confidence on the next five years' funding, which gives a base for implementing some of the changes set out in Sir Paul Nurse's Review of the Research Councils.

The Government has welcomed the Review. It continues the legacy of the Drayton and Waldegrave Reviews.

In a time when there is so much change in the system, it is important to emphasis what is not changing. The UK has a world-class science system. No one in Whitehall doubts that. The proposed changes are about building upon that which is why the focus on excellence is so important. Therein lies the importance of the Haldane Principle, our system of dual-support and peer review. While the number of citations per pound invested is not a perfect indicator, it does give a good indication of the quality and the impact of our research.

One of the essential elements of our research funding is the mechanism of dual support. I know of no debate, internally or externally, about moving away from this and the more certainty we can provide on this, the better.

The critical importance of blue skies, discovery research is recognised across the system as is the balance between quality-related (QR) support and the Research Councils' more direct funding. So the work of implementation during the next year or two will make sure the touchstones build on the existing foundations of the UK's world-class system.

The Government also recognises that subject experts should be responsible for funding allocations within their subject disciplines. Here we recognise the way Research Councils have been able to bring together world-class researchers, getting them to commit time to both peer review and in determining where best to allocate budgets.

## SUMMARY

- The importance of science is recognised across Government.
- The Government welcomes the Nurse Review.
- Government needs to hear a strong, single voice of science.
- Balancing funding for multi-disciplinary societal challenges with discovery research in separate sector will be a key role for the new overall research body.
- The appointment of Chief Scientific Advisers to all Government Departments is an important step forward.

## Implementing change

What has surprised me over the last 12 months is the amount of time that eminent scientists are spending on non-scientific issues. Time that is being spent on the grant processes, around the reporting back to BIS, the natural governance systems required of a publicly-accountable body – these can be very onerous. It seems crazy to bring together leading scientists and ask them to spend time worrying about buildings, IT systems and shared services. This is not an effective use of their time. That is something that needs to change.

## A unified view

One of the things I have found hardest to do in the last year is to be able to advise Ministers on the relative strengths and weaknesses of the UK scientific endeavour in different fields and disciplines. There is a huge amount of data and it is very difficult to bring that together to achieve a consistent, coherent feel to the wealth of publicly-funded research, let alone the charity-funded research and the R&D spend that goes on in businesses. It is a patchwork vision at best and more needs to be done to bring this all together. With Research UK we may be able to tackle this.

In relation to multi-disciplinary work we know there is a gap. Yet, it cannot simply be resourced at the expense of sectoral expertise on basic research. Societal challenges like obesity,

terror and climate change touch on the physical sciences, behavioural sciences, economic history, etc. We need the specialist knowledge, but also the ability to bring all the insights together and focus them on these big scientific and societal issues – which is, after all, the reason taxpayers are funding public science.

There is a ‘value for money’ question for taxpayers. The UK’s economic position has meant cuts on public spending for the last five years and further fiscal prudence over the next 10. I keep reminding my colleagues in BIS that we are only half way through parts of the programme. Obviously we would always like to have more money for science and scientific research, but it is beholden upon us to ensure best value for money from that research. I have touched on some of the global challenges we face, but even within this country, research needs to address priorities like flood defence and resilience.

### Moving forward

The Government recognises the benefits of a single, strong voice for science to Ministers in Whitehall, but also one that can make the case for science to taxpayers and the wider community – as well as internationally.

While it is important to hear from the individual sectors, a strong, single voice can cut through the sometimes competing different voices of the seven communities. That will be extremely helpful in making a case to Whitehall. Frankly, there are difficult messages that Ministers need to hear about continued investment in science and they need to be conveyed clearly and powerfully.

There are a number of other considerations – not least those affecting the Higher Education Funding Council for England (HEFCE). The Higher Education Green Paper also raised very important structural questions about the implications for QR – the other half of dual support.

There is a strong case for a single focus for research funding in this country, with a single understanding of the research landscape and where the research priorities should be – and advising Ministers on that basis. However, the question arises of how to provide assurance about the division between QR funding and Research Council grant funding.

The Chancellor also said at the time of the Spending Review that he wanted to integrate Innovate UK into this new research body. This builds on Professor Ann Dowling’s work on business/university collaboration. How can this country ensure that investment in scientific research is then translated into both further ideas and into innovative applications? For we need this in order to provide the productivity and the

growth which will continue to fund scientific endeavour in years to come. However, that is only part of Innovate UK’s work and its wider role in encouraging collaboration between businesses must also be safeguarded.

Of particular importance is how to balance common needs and the benefits of standardisation on the one hand with the special needs of individual disciplines on the other. How do we ensure the continuing success of some of our incredibly prolific institutes, for example?

### A strong scientific voice

I also support the idea of a strong voice of science in Whitehall. I think in some ways it is a strength rather than a weakness that the interest in science is dispersed across Whitehall. To confine its influence to one Department would be a weakness. The fact that we now have strong Chief Scientists in all Whitehall Departments is a powerful step forwards and the dialogue between the Chief Scientific Advisers and the Research Council network will ensure there is a strong, open dialogue between the research communities and the scientific communities in Whitehall.

One area where more work is needed is connecting scientific endeavour into the policy-making community of Whitehall. This happens in some areas, but not strongly enough in my view. Whitehall needs to be able to access the excellent world-class research we know is already there. There must be on-going discussion and debate, rather than one-off research grants for specific projects. □

## FURTHER INFORMATION

### The Nurse Review

[www.gov.uk/government/publications/nurse-review-of-research-councils-recommendations](http://www.gov.uk/government/publications/nurse-review-of-research-councils-recommendations)

### Higher Education Green Paper

[www.gov.uk/government/consultations/higher-education-teaching-excellence-social-mobility-and-student-choice](http://www.gov.uk/government/consultations/higher-education-teaching-excellence-social-mobility-and-student-choice)

### Dowling Review

[www.raeng.org.uk/policy/dowling-review](http://www.raeng.org.uk/policy/dowling-review)

### Higher Education Funding Council for England

[www.hefce.ac.uk](http://www.hefce.ac.uk)

### Research Councils UK

[www.rcuk.ac.uk](http://www.rcuk.ac.uk)

### Innovate UK

[www.innovateuk.gov.uk](http://www.innovateuk.gov.uk)

There is a strong case for a single focus for research funding in this country, with a single understanding of the research landscape and where the research priorities should be.

### DIVERSITY, ETHICS AND THE WIDER WORLD OF RESEARCH

*Professor Dame Jocelyn Bell Burnell DBE FRS FRSE FRAS FInstP joined the panel for the discussion periods. Dame Jocelyn is President of The Royal Society of Edinburgh and a visiting professor of astronomy at the University of Oxford.*

I particularly like the emphasis on diversity, meaning a full breadth of research activities. The research community, at least in Britain, has tended to have fashions and bandwagons. If a particular piece of research is not one of those favoured areas, funding can be a struggle. So this is a welcome change of emphasis.

I am disappointed there is no mention of major ethical issues. Questions like 'Should this research be done?' or 'Is it too dangerous if it falls into the wrong hands?' or 'Should this research be done – is the British public ready for it?' are difficult but need to be addressed.

The suggestion that the Research Councils should have a bigger role and better links with European research programmes is welcome. But the wider world needs to be considered too. As an astrophysicist, I am also interested in countries like China, Australia, and South Africa where the world's largest radio telescopes are being built.

I have concerns about bringing the HEFCE QR component into closer association with the Research Councils through Research UK. An ambitious Chief Executive of Research UK at some point in the future might be tempted to abandon the dual-funding distinction.

Speaking as President of the Royal Society of Edinburgh, the relationships between the Research Councils and the devolved governments need a great deal more development. Recall that the 'E' at the end of HEFCE stands for England. There are funding bodies in Wales, Scotland, and Northern Ireland as well – they are all different and need to be taken into account.

## The debate

Key issues raised by the audience included questions on oversight, focus, and public engagement.

The ambition to develop a more effective dialogue between the research community and policy makers at Ministerial level within central Government is welcome. A Committee of the kind proposed could, for example, help to shine a light on Departmental research budgets that had not been protected in the same way as those of the Research Councils budgets. It could bring a much wider perspective on the collective science and research endeavour across central Government, reinforced and supported by a more broadly-focussed Research UK and the independent oversight body. It would be vital for success that the Treasury buys into the new arrangements.

Questions were raised about the likely effectiveness of the proposed oversight committee – previous experience of such structures is not promising. Is there a risk that independent advice from senior leaders in science could be diluted by corralling them into such a structure? Even if it does maintain an effective arms-length relationship from Government, will Research UK have sufficient teeth?

The Chief Executives of the Research Councils are to become subordinate, in effect, to the Chief Executive of Research UK. If Research Council posts are seen to be downgraded they will not attract people of sufficient stature. And will the voice of, say, social science be squeezed out if Research UK becomes a single voice?

Drawing elements of the responsibilities of HEFCE into the new structure may put the system of dual funding at risk and lead to the break-up of HEFCE.

It would be wrong to blur the focus of Innovation UK by locating its functions in a body with an emphasis on discovery science. Industry continues to feel a sense of full ownership of Innovation UK – and that means keeping it separate from Research UK, though not necessarily excluding some form of observer status. The voice of translational research must not be lost in these new arrangements.

There is a need for a stronger direct engagement between Research UK and the public, with the emphasis on improving public understanding of science and building a dialogue which would inform and support research priorities. The regional agenda and the importance of 'place' in key Governmental strategies is another factor which should be taken into account – for example in relation to processes such as peer review.

There is an opportunity to develop stronger links between Research Councils and public sector research establishments (much of whose work is close to the discovery agenda) with more formal engagement on specific issues.

At present political leadership is focussed on specific issues – nuclear and fuel poverty – and is failing to communicate the full facts about wider energy issues to the public.

# RESEARCH PARTNERSHIPS

The Dowling Review of Business–University Research Collaborations provided the theme for a meeting of the Foundation for Science and Technology on 7 October 2015.

## Creating the climate to excel at innovation

Ann Dowling

### SUMMARY

- Public support structures for collaboration and innovation are too complex.
- Researchers need more opportunities to engage with business throughout their careers.
- Pump-priming could have a substantial impact for only a modest outlay.
- Local Enterprise Partnerships need support to deliver their innovation mandate.
- The UK has the potential to excel in collaborative research and innovation.

My remit in undertaking this Review<sup>1</sup> was to examine how businesses could be encouraged to connect with UK universities through strategic research partnerships that deliver benefits for the collaborators and also the country as a whole.

Collaboration has been a key feature of my own career. Some of my most rewarding and successful research activities have come from interactions with industry. I have seen at first hand how working with industry can enrich a research career.

In carrying out this Review, I had excellent support from both my review group – drawn from experts with broad experience across disciplines and sectors – and the secretariat at the Royal Academy of Engineering. Despite the tight timescale, over 200 written submissions were received from a very broad spectrum of stakeholders. In addition, around 200 individuals took part in the meetings we held across the country.

The Review team analysed a rich seam of evidence related to both the barriers and the success factors. Perhaps not surprisingly, there was much common ground among businesses and academics.

### Complexity

The sheer complexity of the support structures for collaboration and innovation was striking.

While some of this is understandable (innovation is a complex, non-linear process), this complexity acts as a barrier to engagement by companies, especially SMEs. It is extremely difficult for those firms not accustomed to collaborating with universities to work out just how to do so.

The Review's overarching recommendation is that Government should reduce complexity in public support for collaboration. Where this is not possible, every effort should be made to 'hide the wiring'.

This should be done by providing users with an interface which is simple and coherent, directing interested parties to the information they need without exposing them to the full complexities at play.

It should be made absolutely clear, though, that simplification must not be used as an excuse for reducing public support for collaboration. Improving coherence and reducing complexity are quite different from just making cuts.

### People

Another central message from the report is that people are at the heart of any successful collaboration: strong, trusting relationships between people in business and academia form the foundation for success. While this may seem self-evident, it is absolutely fundamental to improving the environment for collaboration.

Contributors to the review were full of enthusiasm for the inclusion of impact in the Research Excellence Framework (REF) – one said it was the best thing that had happened to him in his whole career! Yet the perception persists that academics who pursue collaborations with industry do so in spite of, rather than because of, their universities.

This country still suffers from the attitude that research undertaken as a result of engagement with users is of lower status or quality than 'pure' research. The Review team felt strongly that we need to move on from this. Research inspired by challenges faced by users is just as intellectually



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## KEY MESSAGES OF THE REVIEW

- Public support for the innovation system is too complex.
- People are central to successful collaborations.
- Effective brokerage is crucial, particularly for SMEs, and continued support is necessary for activities that help seed collaborations.
- Pump-prime funding would stimulate the development of high-quality research collaborations with critical mass and sustainability.
- Technology transfer offices need to prioritise knowledge exchange over short-term income generation, and further work is required to improve approaches to contracts and IP agreements.
- Government strategy on innovation needs to be better coordinated and have greater visibility.

challenging as research inspired by other academics and can be truly excellent.

One of the best ways of tackling this issue is to improve the flow between academia and industry; in particular to give researchers at an early stage in their careers greater exposure to business through training and placements.

### Brokerage

What is the best way to connect businesses and academics who might benefit from collaboration? This is of particular concern to SMEs who struggle to find the time to navigate both the academic research base and the support systems available.

Work is already under way – led by the National Centre for Universities and Business – to develop an online portal to facilitate this process. Improved online tools are undoubtedly important but to be effective they need to be accompanied by access to appropriately skilled personnel, as is already the case in Scotland.

Sharing physical space is one means of bringing people together. Yet the levying of VAT on shared facilities acts as a major disincentive. The Review urges the Government to look again at this.

### Growing critical mass

There is an exciting opportunity for a pump-priming scheme to enable small-scale collaborations to grow into group-level partnerships with critical mass and long-term horizons.

Using information from REF impact case studies as well as data submitted to the Review by university vice-chancellors, an assessment was made on the extent to which companies in different sectors engage in collaborative projects. Many are already engaged with academic researchers and really benefit. Yet other companies in the same sectors and of similar size are hardly engaged at all.

Some of the most challenging and exciting research occurs when a core group of researchers

identifies developments that could make a long-term difference to their particular company or sector, and subsequently embarks upon a sustained research programme to bring about that change.

Pump-priming could enable the creation of a critical mass of expertise, raise the visibility of use-inspired research within universities and help to unlock the full strategic potential of collaborative relationships. The public funding required would be extremely modest, but would encourage significant co-investment from businesses and others including, potentially, regional funding sources.

### Terms of engagement

The issues surrounding intellectual property (IP) and legal negotiations in general remain barriers to engagement, despite the substantial body of work undertaken by Richard Lambert and others.

There is a tendency in some universities and technology transfer offices to prioritise short-term income over getting that knowledge and technology into use. Universities should be able to gain income from the IP they generate; yet the focus needs to move towards knowledge exchange, partnerships and long-term benefits – ultimately, these are likely to yield a better return.

### Government strategy

The final report also makes recommendations about Government strategy. Research and innovation need to be fully integrated into industrial and sectoral strategies, with universities treated as core partners in their development and delivery. The Review team commented on the opportunity to use industrial strategy and the ‘Eight Great Technologies’ as levers to encourage greater business investment in innovation and R&D, or indeed associated manufacturing capability.

The current administration seems to have adopted the term ‘industrial approach’, in place of ‘industrial strategy’ which was the language used by the previous Government. The exact terminology does not matter. However, it is essential that we continue making progress towards an industrial framework that emphasises the UK’s priority sectors and technologies, and gives businesses and others the confidence to invest.

The Review examined the concept of ‘place’ in relation to collaboration. Local Enterprise Partnerships (LEPs) have an important role to play here and we recommend that Government develops a toolkit to support LEPs in delivering their innovation mandate. Innovate UK should play a pivotal role in coordinating innovation strategy at a national level.



I am conscious of being the latest in a long line of experts looking at this particular topic! So I am keen that this exercise renders any further reviews of business–university research collaboration unnecessary, at least in the near future. I have been struck throughout the review by the phenomenal engagement of the research community and believe that we have a brilliant opportunity to harness this momentum and bring about real change.

### Innovation

The Royal Academy of Engineering has recently published a report<sup>2</sup> on the importance of investing in innovation. It is not a part of the Dowling Review, but shares a similar focus.

Its key message is that, if the UK wants to reap the benefits of its world-leading research base, it must ensure that the country has a fantastic innovation system; for it is through innovation that we

unlock the potential in our research base and deliver products and services of value to our economy and society.

There is now good evidence that public investment in R&D ‘crowds-in’ private investment. In an ever more competitive global environment, Government needs to create a positive climate for innovation that encourages investment here, rather than in competitor countries.

The UK has many of the qualities needed to excel in collaborative research and innovation. Government’s focus now needs to be on making the whole system work more effectively so that our global standing is maintained – and even boosted – in years to come. □

<sup>1</sup> [www.raeng.org.uk/policy/dowling-review](http://www.raeng.org.uk/policy/dowling-review)

<sup>2</sup> [www.raeng.org.uk/publications/reports/investing-in-innovation](http://www.raeng.org.uk/publications/reports/investing-in-innovation)

In an ever more competitive global environment, Government needs to create a positive climate for innovation that encourages investment here rather than in competitor countries.

# A successful framework for innovation and collaboration

Peter Gregson



Sir Peter Gregson FEng MRIA is Chief Executive and Vice-Chancellor of Cranfield University. He was previously President and Vice-Chancellor of Queen’s University Belfast. He has been a Non-Executive Director of Rolls Royce Group plc and served on the Councils of the Royal Academy of Engineering and the Central Laboratory of the Research Councils.

Business/university collaboration builds on the world-leading research base that exists in the UK. This is often presented in terms of: 1% of the global population with 4% of the research spend producing 16% of the most highly-cited papers. That is an extremely effective and efficient platform upon which to build. I would urge the Government, in addressing the challenges that this Review has set out, not to inadvertently take actions that negatively impact on this particular strength.

While there are very good reasons for focusing on business/university research collaborations, it must be remembered that universities are primarily concerned with education and research. There are key elements of talent development, from apprenticeship schemes through to post-graduate education, as well as customised executive education and professional development, where universities like Cranfield collaborate very closely with business and government.

One of the Review’s fundamental conclusions is that the innovation system is too complex. That may be the case, but innovation *is* complex and does not follow a simple linear model. Furthermore, the term ‘innovation’ is not straightforward and there is a difference between what business means by innovation and what universities mean.

## SUMMARY

- The UK has an effective and efficient research base upon which to build.
- Innovation does not always mean the same for businesses and universities.
- The role of Government is to help the business/university innovation sphere flourish.
- Collaborations at all levels – regional, national and international – are important.
- Collaboration and innovation can only flourish in a consistent environment.

Discussions on this topic need to acknowledge the existence of a grey area here.

It is also very important to be clear on what ‘impact’ means. The idea of impactful research must not be muddled up with the concepts of entrepreneurial universities or with innovation. These are different activities – all part of an ambition, but all very distinctive in their own right.

I want to focus on a distinction between research and innovation in that triangular space that exists between Government, business and universities. This distinction was succinctly sum-

Different universities have different missions and different emphases, but regional, national and international collaborations are important to every university.

marised in a recent debate at the Royal Academy of Engineering: research is using pounds to generate knowledge, innovation is using that knowledge to generate pounds, and Government is there to create the right environment for this cycle to flourish.

Innovation, like research, is a long-term process, and so consistency of the environment is essential. In recent years, the policy was driven first through Regional Development Agencies (RDAs) which then changed into Local Enterprise Partnerships (LEPs), Catapults and other vehicles. This changing landscape has not been helpful. There must be a consistent framework within which to address this agenda.

The current terminology of an 'innovation framework' is sufficiently inclusive – it links Government and its industrial strategy, it links various sector-driven growth partnerships, as well as LEPs, Research Councils, Innovate UK, HEFCE and other bodies such as the Regional Technology Organisations (RTOs).

As innovation is chaotic by nature, the question for Government is how much streamlining can take place so funding is used effectively and efficiently. In that task of streamlining, not only should it address what is broken, but, crucially, it should not attempt to fix what is not broken.

### The people dimension

The Review recognises that people are central to success – it was ever thus.

There are already many examples of very close working between universities on the one hand and large organisations and corporates on the other. There are good reasons for that: there are compatibilities in terms of scale, structures, roles and responsibilities, so there is a good set of 'nodal points' to make the important interactions.

The trusting environments that have been built over the years mean that academics are on technology advisory panels and are familiar with technology road maps in companies, while companies are on industrial advisory boards at universities. Yet it is the same few companies that appear time and time again, be it Rolls-Royce, BP, Unilever, GSK, JLR, etc. The majority of commercial research funding comes from a very small number of companies – and that is an issue.

At the other end of the size spectrum, there are about a thousand spin-out companies on our science parks and about 10 times as many graduate start-ups associated with our universities. Many of these have very close engagement with people within our universities.

It is with the supply chain SMEs, so critical for genuine economic growth, that business–

university collaboration could and should be so much stronger.

The skills deficit in Science, Technology, Engineering and Mathematics (STEM) at all levels represents a huge challenge. The UK needs to double the number of undergraduate and postgraduate students in Engineering alone, yet the demographics are against us. The deficit must be addressed by increasing the diversity of home/EU students and by increasing the number of international students: both are vitally important. Yet the tightening of Tier 4 Visa requirements and negative messages in the international marketplace pose significant challenges as UK universities seek to redress this deficit.

Commentators often try to create a divide between those universities serving a region and those with global ambitions. The truth is that different universities have different missions and different emphases, but regional, national and international collaborations are important to every university. At Queens University, Belfast, with a very specific role in society, we recruited global talent and used it for local advantage. That local advantage was expressed in so many ways, from leadership in health and social care to Knowledge Transfer Partnerships (KTP) with family-owned businesses across Northern Ireland. There are big regional variations across the UK; collaboration has a complex landscape and universities and businesses must not be too neatly compartmentalised.

### Critical mass and sustainability

Returning to the SMEs, there are something like five million in the UK. There are perhaps 10,000 academics who might be able to link to some of them. But it is still not clear what such businesses need from universities and what universities can do for them. A focussed effort is needed to clarify needs and capabilities.

There are some very interesting industrial clusters developing; part physical, part virtual. Manufacturing is a good example: Research Councils have been supporting centres of innovative manufacturing; Catapults have been established; corporates and SMEs have been drawn into these developments.

Leverage into the research base is very strong in the UK. According to the Royal Academy of Engineering's Report *Engineering for a successful nation*<sup>1</sup>, the £2 billion of Government spend on R&D in universities leverages £9.5 billion of commercial R&D spend from business. That is an extraordinary statistic. I am conscious, though, of the importance of looking beyond just engineering and also considering benefits other than

the purely economic. It is striking that universities leverage £1.3 billion annually from medical charities: this involves 7.5 million donors a month linking with the science base in the UK. That must be one of the strongest outreaches to society from our science base.

The Review mentions Technology Transfer Offices, the interface between business and universities. But this is not just about Technology Transfer Offices, which are often at the leading edge of drawing research from universities through for public benefit. Within our universities there is often a disconnect between TTOs, research support offices and contract departments and this must be addressed, particularly if we wish to engage better with SMEs.

There is also a tendency for universities and their academics to underestimate the investment gap between the research ideas and product development. However, while some university TTOs have been promoting easy-access IP, we are not seeing businesses adopt that in large

numbers. So there is clearly more work needed to be carried out in this area.

### Consistency

Ultimately, collaboration and innovation are flourishing in the UK, and they require a consistent environment. There needs to be a Haldane Principle for innovation; it is very important that we do not over-manage the innovation cycle. An interesting statistic from a 2014 global review of university-based innovation ecosystems highlighted that the UK had three of the top five institutions in the world. This would have been inconceivable two decades ago, and reflects the strength of the partnership between universities, business and government over this period.

Let's build on this heritage. I would argue for sustained Government funding, simplified only where complexity is demonstrably a problem, and ensuring that it continues to be well-leveraged by universities and by business: that is a real strength here in the UK. □

Collaboration and innovation require a consistent environment. There needs to be a Haldane Principle for innovation; it is very important that we do not over-manage the innovation cycle.

# Helping smaller businesses engage with universities

Eric Hawthorn

## SUMMARY

- The support systems for innovation and collaboration are too complex.
- Local Enterprise Partnerships have a key role to play in this area.
- Too much change makes it difficult for businesses to navigate the funding structures.
- It is not enough to put the structures in place – there needs to be outreach in order to engage business and academia.

Radio Design started in 2007 with 11 staff. It has been successful because it has been innovative. We manufacture in the UK. The company now has over 300 people, with operations in the UK, India and China, as well as a small presence in Finland.

The reason behind the venture in India was that the market is massive. It is also chaotic, which means lots of opportunities. We won the 'Game Changer of the Year' Award from

the *Economic Times of India* for telecoms.

In 2012 we started a five-year collaboration with the University of Leeds. There is now a team of seven postgraduate researchers, led by Professor Ian Hunter and closely supported by Radio Design. The intellectual property (IP) that comes out of that collaboration vests in Radio Design. As a smaller business IP is critical, not just to the valuation of the business but also in providing protection against large, aggressive competitors who resent others pushing into their space.

The programme is closely managed; there are meetings with the university most weeks. Results have come quickly, with the research generating millions of pounds worth of product sales.

### Local Enterprise Partnerships

Since 2010, I have been a private sector member of the Local Enterprise Partnership. LEPs are relatively new. When I joined, there was no Board and it was still, in fact, being set up.

I now chair the Business Innovation and Growth Panel. Improving innovation perfor-



Eric Hawthorn is Managing Director of Radio Design Ltd, a mid-sized company that he established in 2007. Radio Design has two main business activities: the design and manufacture of radio frequency filter systems to enable the roll-out of high capacity mobile networks; and specialised hardware repair services for the telecommunications market. In 2012, Radio Design, the Royal Academy of Engineering and the University of Leeds established the Centre of Microwave Signal Processing led by Professor Ian Hunter.

### LEPs can make a real difference to innovation and collaboration, in terms of meeting local priorities.

mance is a priority. It had become increasingly apparent over the past few years that we just did not have the resources, the skills or the tools that were needed. That is changing.

LEPs can make a real difference to innovation and collaboration, particularly in terms of meeting local priorities. The Leeds City Region LEP recently signed a Memorandum of Understanding with our universities, demonstrating a real willingness to address local priorities. Of course, universities are international businesses, playing an international stage; yet if the local dimension could be addressed as well there could be huge benefits for everyone.

A number of the Review's findings resonate with me personally. The current innovation and collaboration system is too complex – there is no doubt about that. That is especially true for small businesses.

There is also the issue of matching businesses and academic institutions. In the Leeds region, there are around 105,000 VAT-registered business but only nine Higher Education Institutes. The number of small businesses interacting with those HEIs is very, very small though.

Many businesses do not even get started on this journey. That might well have been true in my case even though from day one I knew that it was innovation that was going to make us successful. The system is so complex that it is difficult to know where to start and the process gets more difficult once you do start looking. And then things keep changing and it is difficult to keep track.

One example is the Knowledge Transfer Networks (KTN). My business was closely involved with the ICT KTN. But now it has just gone, disappeared, which is really disappointing because we were starting to understand the network and get some value out of it.

#### Brokerage

Brokerage is essential, but just putting tools in place is not sufficient. A proactive approach is needed to encourage businesses and show them where to look for support. However, a more unified brokerage tool would be very good to have – assuming it simplifies the end result!

While motivation may be important for businesses, it is also necessary for universities and academics, particularly in terms of engagement with smaller businesses (large businesses can already point to some great success stories).

Impact is key for academics, but most see it in

terms of the Research Excellence Framework (REF). When I asked Professor Hunter, with whom I am directly engaged: "Why are you working with us? What is it that makes you want to be involved in this collaboration?" he told me that he actually likes it. He enjoys working on research that is directly related to impact. There needs to be a change within the universities so that both the institutions and more of the academics within them are focussed on this. It is unfortunate that collaboration and involvement with business appears to have less relevance currently than pure academic research.

Funding is important. While there is actually a lot of funding available, it can be difficult to find. Even when found, the administration that surrounds it is very complex.

Government can make a difference here. It is all very well having a strategy, but there has to be an implementation plan as well.

#### Key points

We really must simplify the system – that does not necessarily mean changing it, but I really like the phrase 'hiding the wiring'. Some of the administration that goes with the wiring needs to be taken away as well because for smaller businesses, that is very off-putting. Larger businesses have people that manage this process, but in smaller organisations it falls to the people who are trying to run the business at the same time.

Motivating people is vital. Case studies are a good way of showing people why they should be involved.

This Review is the first thing I have seen in a long time that really resonated with me. I was very impressed. The recommendations are well-constructed and they do take account of the existing infrastructure.

LEPs are still relatively new: they are still evolving. Leeds City Region has the single biggest award of local growth funding outside of the London area, but most of that has been allocated to capital projects, not innovation or R&D. It is only now that the focus is moving to innovation and what we can do about it. We are engaged with Innovate UK on how to promote innovation at a local level.

The term 'SME' is itself a problem. There is a massive difference between Radio Design with 300 people and Rolls-Royce with many more. With those 300 people, Radio Design is no longer classified as an SME. There is a large gap here and while there is more that we could be doing, we are caught in this gap between the very large businesses and smaller, growing businesses. Yet we, and many other businesses in our position, still have massive growth-potential. □

# The debate

Issues raised in the debate included funding support, STEM recruitment and public procurement.

There is evidence of growing interest among the research community for industry-related research, combine with a willingness to collaborate. It is crucial to acclimatise researchers at an early age to the importance of collaboration and the opportunities that flow from it. In Scotland, there is a closer engagement between business, universities and local authorities than elsewhere. In Northern Ireland, there are links to the USA, and a culture of collaboration.

The process of simplifying funding support mechanisms should not mean the removal of any arrangements which work. Perhaps more tools are needed to enable SMEs and start-ups to attract venture capital investment. Without investment, long-term growth and sustainability may be at risk. However, some sources of funding – venture capital for example – are not focussed on either and should be treated with caution.

There is an urgent need to increase the number of undergraduates and postgraduates in Science,

Technology, Engineering and Mathematics (STEM). Yet schools do not stress career and intellectual opportunities sufficiently. Universities and Government need to address this problem.

The Government needs to recognise the impact of immigration policy on universities and the economy. There is a continuing disparity between the number of men and women taking up STEM subjects.

Many SMEs encounter difficulties with public procurement. The NHS, for example, prefers to procure goods and services from large companies with an established track record, as do many Government departments. The result, in the life sciences, is that many researchers and smaller companies take their research and innovative products elsewhere.

Local contacts and institutions, such as local authorities, are important to the success of innovation and collaboration. Trust is built through personal contact and geographical proximity. □

## FURTHER INFORMATION

### The Dowling Review of Business-University Research Collaborations

[www.raeng.org.uk/publications/reports/the-dowling-review-of-business-university-research](http://www.raeng.org.uk/publications/reports/the-dowling-review-of-business-university-research)

### Department for Business Innovation and Skills

[www.gov.uk/government/organisations/department-for-business-innovation-skills](http://www.gov.uk/government/organisations/department-for-business-innovation-skills)

### Government Office for Science

[www.gov.uk/government/organisations/government-office-for-science](http://www.gov.uk/government/organisations/government-office-for-science)

### Innovate UK

[www.innovateuk.gov.uk](http://www.innovateuk.gov.uk)

### Research Councils UK

[www.rcuk.ac.uk](http://www.rcuk.ac.uk)

### The Royal Academy of Engineering: *The Universe of Engineering – a call for action*. A report chaired by Dame Sue Ion DBE FREng

[www.raeng.org.uk/publications/reports/the-universe-of-engineering](http://www.raeng.org.uk/publications/reports/the-universe-of-engineering)

### The Royal Academy of Engineering: *Investing in innovation*

[www.raeng.org.uk/publications/reports/investing-in-innovation](http://www.raeng.org.uk/publications/reports/investing-in-innovation)

### The Royal Academy of Engineering: *Engineering for a successful nation*

<http://www.raeng.org.uk/publications/reports/engineering-for-a-successful-nation>



# PRODUCTIVITY

The OECD estimates that labour productivity, in terms of GDP per hour worked, is significantly lower in the UK than the USA. A meeting of the Foundation for Science and Technology on 2 December 2015 considered how this could be addressed.

## The role of innovation in boosting productivity

Ruth McKernan



Dr Ruth McKernan CBE is Chief Executive of Innovate UK. She started her career in pharmaceuticals in research and commercial management in both the USA and the UK. She has been a Senior Vice-President for Pfizer and Head of Merck's neuroscience research centre. Dr McKernan moved to Innovate UK in May 2015.

Globally, innovation contributes up to 50% of all labour productivity growth. Productivity is maximised when around 2.5% of GDP is spent on R&D. The UK spends considerably less than other parts of the world, at 1.8%. However, since 2007, when Innovate UK, then known as the Technology Strategy Board, was set up, the UK Government has spent more than £1.5 billion on innovation, which has brought in another £1.5 billion in business and partner contributions. £3 billion is a significant investment for innovation.

Companies that consistently invest in R&D have higher productivity than companies that do not; in fact 13% higher than those who do not invest at all. This is not just in terms of direct returns but includes spill-over effects such as better value-added per employee, higher exports and so on. So R&D underpins productivity and I do not think anyone would argue with that.

Innovate UK has helped 5,000 companies since it began and over 2,000 businesses are currently in receipt of matched grant funding. Over that period, it has helped to add an estimated £7.5 billion to the economy. In terms of Gross Value Added (GVA), every pound spent by Innovate UK has returned more than £6 to the UK economy. This is good use of public funds!

We always carry out an econometric analysis of the money that we spend at the end of each programme and recently we have been looking at the low-carbon vehicle area and the automotive sector. There, for every pound spent, the return is between £10 and £28. So while overall our funding generates a return of just over £6 for every pound spent, in some sectors the return is much higher.

### Across the economy

Where has that money been invested? Figure 1 (opposite) shows how it is divided up across different sectors of the economy. Productivity is lowest in health and life sciences, so there is a great deal of work to be done to make sure that

### SUMMARY

- Since 2007, some £3 billion has been invested in UK innovation.
- Innovation contributes up to 50% of all labour productivity growth.
- Working with the research base allows UK businesses to translate great ideas into consumer products.
- Maximising the opportunities for productivity improvement relies on connecting the whole supply chain.
- Innovation involves all types of business from micro-firms to the largest operations.

money spent on research in this area is translated into economic growth.

Funding is also directed towards energy, transport and infrastructure, emerging and enabling technologies. Within the latter I include digital, satellite applications, graphene and quantum technologies – the technologies that will drive the future of the economy. The Government's document on productivity contains a great deal about infrastructure. If cities and our business landscape in general can be made to work better, that in itself will drive greater productivity.

This is not just about providing money to companies, it is also about connecting them to other businesses and people in their supply chain. We help them learn and grow, find their first customer and then find other customers who are going to buy their products, whether in the UK or abroad.

Innovate UK has a Five Point Plan. This provides a really good framework which explains how our work improves productivity (see Table 1, p40).

### The research community

We work closely with the research community, and have many programmes where they are partners. We aim to help turn their ideas into

business. We also work closely with Government Departments. A number of these (such as the Department of Energy and Climate Change as well as the Department for Culture, Media and Sport) have innovation as part of their agenda. We run competitions for them and we help them connect with the scientists who are driving innovation in their areas.

Take the Catalyst programme. We have partnered with the Medical Research Council (MRC) on the Biomedical Catalyst, and with the Biotechnology and Biological Sciences Research Council (BBSRC) on both the AgriTech and Industrial Biotechnology Catalysts. We have also partnered with the Engineering and Physical Sciences Research Council (EPSRC) on the Energy Catalyst. In essence, the partners each put funding in and provide support to help companies grow.

Some of these are small companies with a specific project, where they need R&D investment to deliver the product. That product life-cycle may be five or 10 years. They are carrying out the very early research that will lead to more work, at the end of which they will be able to sell a product. So these projects may be very early, very small studies, perhaps feasibility studies. But the Catalysts exist to provide support throughout the development process.

The funding that Innovate UK gives to a business is always matched by private capital, either put in by the company itself to match the grant, or put in by, for example, venture capital companies.

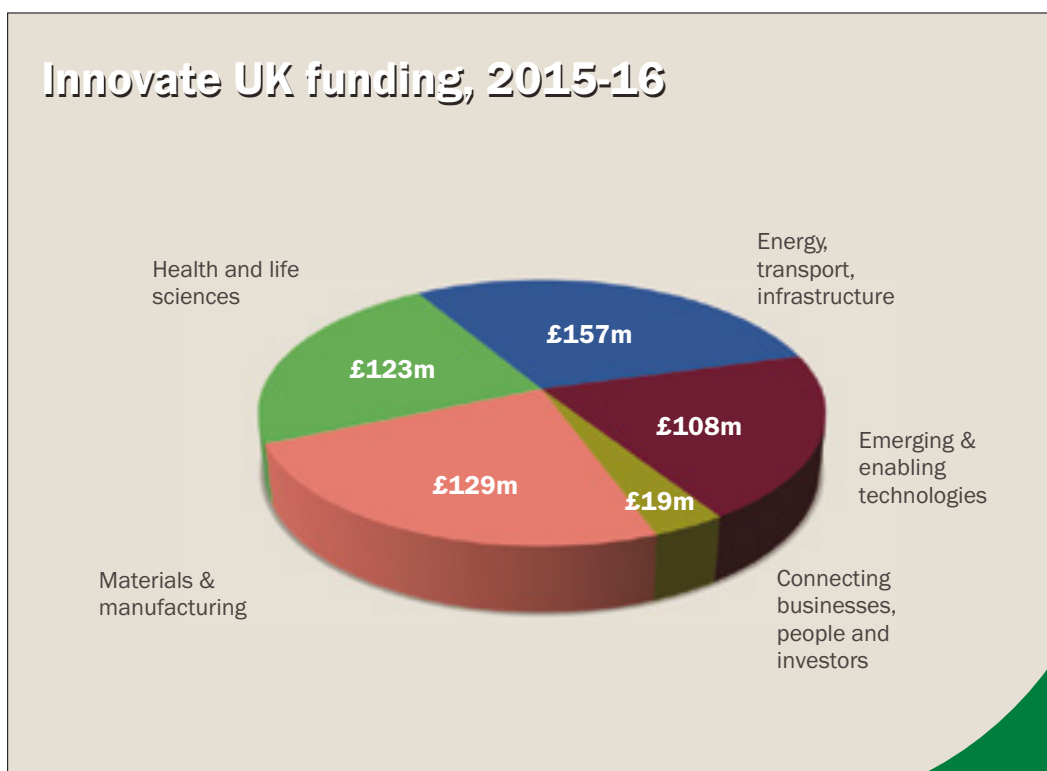
Looking at the list of biotech projects that have been supported, it goes from Autifony (a new drug for schizophrenia) to Ziarco – a treatment for Muscular Dystrophy. The sum total put into the biomedical sector so far is £200 million. This has resulted in £1 billion in follow-on funding – and that is just in the two to three years we have been running the programme.

Looking at specific examples, Endomag is a nanoscale magnetic tracer technology which has now been used to treat 10,000 patients worldwide. We funded them both through the Catalyst and also through our 'Future Health Mission' to California.

When treating somebody with cancer that has invaded into the nodes, you need to know where that cancer is. Endomag uses a magnetic detection system which does not involve drinking down a radioactive tracer. You can then take the tumour out, knowing that it has all been extracted because you are checking for it while the surgery is being done. When receiving an Innovate SME award recently, they said: "Without the funding from Innovate UK, we wouldn't be here today."

Another example is Discuva. This, too, benefited from funding via the Biomedical Catalyst, as well as significant venture capital investment after our funding had been confirmed. A deal was later done with Roche and they too won an SME award for attracting investment. Discuva is a device which helps to determine whether a given bacterial infection is resistant to standard antibiotics.

When receiving an Innovate SME award recently, the company said: "Without the funding from Innovate UK, we wouldn't be here today."



**Figure 1. Innovate UK funding 2015-16**

In order to grow the innovation ecosystem, you need to be able to connect with the large companies, who may know what they want but do not how to create those products.

## Company size

When it comes to accelerating UK economic growth, it is instructive to look at the size of the companies we support (see Figure 2, below). The landscape has changed over time. In the early days, funding was focussed on large companies rather than small, but the number of smaller companies receiving support has steadily increased. My view is that we should also be funding micro-companies (those with fewer than 10 staff) and small businesses with between 10 and 15 employees. We also need to measure the number of medium-sized businesses in this country, because these are the ones that already employ a lot of people, they pay tax and are really the engine of growth in the UK.

We are going to need a lot of micros and smalls to grow, as well as a substantial number of medium-sized enterprises, in order to boost the economy.

## Connecting the supply chain

However, a related point here is that, in order to grow the innovation ecosystem, you need to be able to connect with the large companies. They may know what they want, but do not how to create those products. They know the 'what', but not the 'how'. That requires connections with the SMEs who might already be on the journey to creating the piece that fits, as well as connections to the academic research that starts the process.

The automotive industry is a splendid example of how this can work. This is now the most pro-

## TABLE 1: INNOVATE UK'S FIVE POINT PLAN

1. Working with the research community and across Government to turn scientific excellence into economic impact.
2. Accelerating UK economic growth, nurturing small, high-growth companies, with strong productivity and export success.
3. Building on innovation excellence throughout the UK, investing locally in areas of strength.
4. Developing Catapults within a national innovation network.
5. Evolving our funding models; help public funding go further.

ductive sector in the UK and I think there is a lot there for other sectors to learn. Innovate UK has run a number of collaborative R&D Programmes where companies of different sizes have been brought together to tackle the same challenge. In the Evoque\_e project, the partners are developing future hybrid and battery vehicle technologies by putting different elements together, testing them and improving them.

The programmes we run also promote technology transfer between sectors. McLaren is synonymous with sports cars, yet the predictive analytics that are so important in Formula One



Figure 2. Accelerating innovation and growing businesses

for knowing how the car is performing as it goes around the race-track are also applicable to healthcare.

Isansys worked with McLaren to apply this technology. It invented a bandage-like detector which allows small babies to be taken out of incubators, held by their parents, walked around and not kept in an isolated system, while being continuously monitored. This is perfect for seriously ill babies.

Every matched grant is awarded through competition. These are entirely open and people anywhere in the UK can apply. We have analysed where that funding has been won and it is by no means restricted to the Golden Triangle between Oxford, Cambridge and London. Since we were set up in 2007, grants have been won all over the UK. In fact, the most successful area of the UK, per head of population, in winning Innovate UK funding is the North East. □

# Rebooting productivity policy

Jonathan Haskel

## SUMMARY

- Current analysis of investment needs an overhaul.
- Types of investment made by UK firms have changed.
- Not enough account taken of intangibles in the national investment data.
- This leads to a distorted view of the economy.
- Banking system may not provide the right environment for investment.

Figure 1 (see page 42) shows GDP per hour worked. The USA has the value of 1, so other countries are compared relative to American performance. In the 1970s, Germany, the UK and France were all about 35 percentage points behind, but all the economies caught up fairly steadily (with the UK somewhat lagging behind).

Resource extraction tracks economic growth, and growth is ultimately constrained by the economic availability of resource stocks (reserves). The seminal work on 'limits to growth' was undertaken by the Systems Dynamics Group at the Sloan School, MIT, in the early 1970s. Using a scenario approach – the World3 model – they compared the 'number of earths' required to support human activity (including the absorption of wastes) with humanity's ecological footprint, and projected this forward in time. In short, we are now in 'overshoot' – our needs have exceeded the resources available and so we must examine how we can continue to develop and support societies by decoupling growth from its impact.

How severe a decoupling show we pursue? Economists speak about decoupling that happens

'relatively' (degradation continues, but at a lesser rate to growth, pursued by the OECD since 1980) and 'absolutely' (degradation is truly stemmed, while development continues). We talk of 'resource productivity' (doing more for less) in order to secure absolute decoupling – indeed this is an enormous opportunity for clean technology innovation, if we want to take it.

The debate on decoupling is at the stage where the aim is now to stimulate a green economy with targeted interventions that avoid the uncertainties of wholesale disruptive change to the industrial economy. This approach is being adopted by many voices and strategies – from the deep ecology (radical, revolutionary, act now) movement to a more transitional approach.

One of these strategies is that of a circular economy – an economy that is, by intent, purposefully restorative.

## The green economy

It is worth reviewing the breadth of issues that the environmental sciences are expected to address within the business sector. Companies have to manage: increased expectations on environmental governance; a growing demand to perform beyond basic legal compliance; the expectations of self-regulation, sharing more risk and cost; global value chains vulnerable to occasional shocks; and the rise of codified ethical standards.

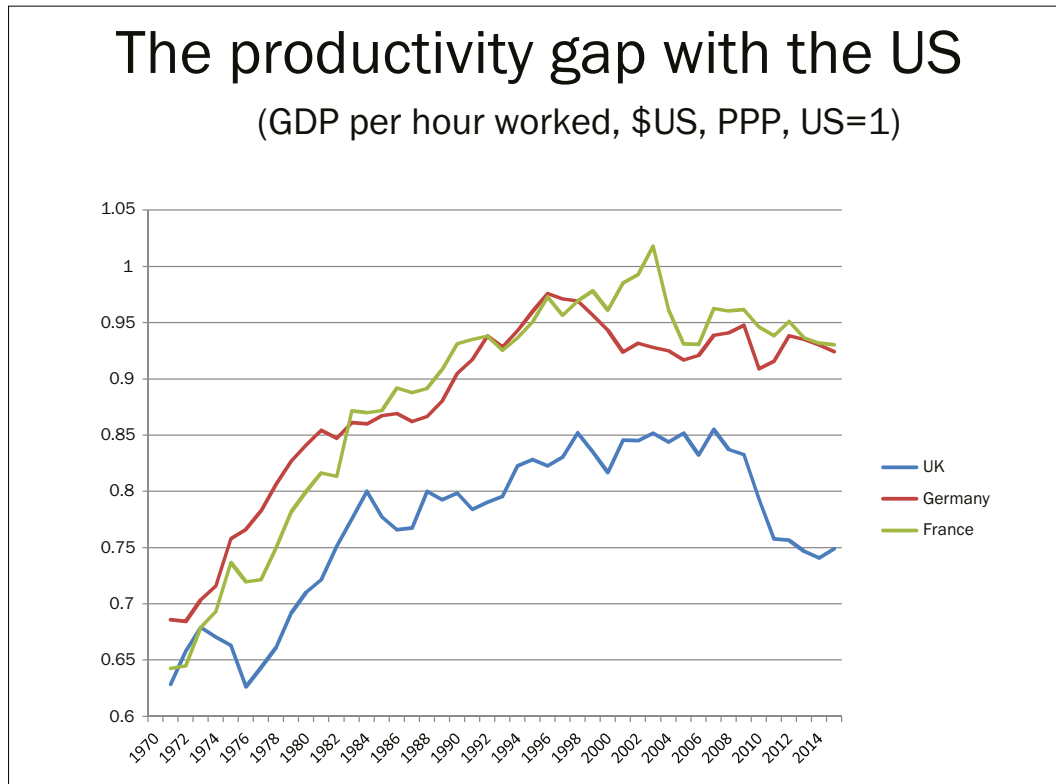
Business leaders in the 21st century are expected to articulate the sustainability agenda through a tough filter of business reality because the agenda has become a main board item, with growing



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Business leaders in the 21st century are expected to articulate the sustainability agenda through a tough filter of business reality.

It would be folly to assume one strategy will deliver all the outcomes we seek, so we need to work with a palette of responses.



**Figure 1. The productivity gap with the US**  
(Source: OECD, [http://stats.oecd.org/index.aspx?DatasetCode=PDB\\_LV](http://stats.oecd.org/index.aspx?DatasetCode=PDB_LV))

calls for the routine disclosure of environmental performance.

There is enormous business opportunity in all this. The international water sector, for example, is under considerable pressure. It is being required to reduce the energy costs of shifting water and so is seeking to revolutionise wastewater treatment and turn conventional unit processes into a manufacturing facility for phosphorus and nitrogen recovery. Biogas from digested sewage is being used to power on-site plant. These pressures can be viewed equally as business opportunities to drive innovation.

Governments talk increasing of a green economy. Advanced economies are becoming interested in the low-carbon environmental goods and services sector because of the prospects for growth, jobs, export, scale-up and the skills opportunity. The Department for Business, Innovation and Skills (BIS) estimates the global green economy to be a £3.4 trillion market, growing at about 4% a year. The UK is the world's sixth largest supplier, with 3.7% of the global market share supporting just under a million jobs in the UK alone.

Any new paradigm needs to focus on societal development, be uplifting (for societal buy-in) and value-centric to be recognisable to business.

## New business models

So what are the strategies for reducing the tension between resource extraction and environmental impact? These depend on whether one opts for 'evolution' or 'revolution'; for transitional or disruptive change. The needs are to secure value (business) and well-being (society) through less impact while at the same time restoring the environment. In policy terms, this is about articulating the future we want (UN) or living well within our limits (EU). It would be folly to assume one strategy will deliver all the outcomes we seek, so we need to work with a palette of responses. Hence the need for an in-depth understanding of what different business models can deliver.

## A new paradigm

The linear paradigm of 'make, use, dispose' from the 1950s must now be considered unhelpful. Even a thermodynamic view of resource extraction, manufacture, product use, and resource recovery (adopted in the late 1970s after the last energy crisis) does not deal easily with systems and their interconnectedness.

Any new paradigm needs to focus on societal development, be uplifting (for societal buy-in) and value-centric to be recognisable to business. It must also generate jobs, well-being and value while restoring the environment. The circular economy is one such paradigm. It has its roots in



the work of Fritz Schumacher, Walter Stahl and David Pearce. Reinvigorated by the Ellen MacArthur Foundation and others, with analytical insight from McKinsey and Company, it brings together the industrial and ecosystem in a new, practical way. Here, the business of the environment is writ large – integrating applied environmental science and technology and aligning these with the economic needs of the industrial system.

The circular economy is purposefully restorative by design, and one in which material flows are of two types: biological nutrients, designed to re-enter the biosphere safely, and technical ‘nutrients’ (product components and assemblies that feed the industrial system), designed to circulate at high quality without entering the environment. The focus is on maintaining the value of system components – a sequence of cascades for capturing their value is deployed. Reports by McKinsey and Company highlight a combined annual trillion dollar opportunity globally in net material cost savings through transition to a circular economy. This process is driven by factors such as increased design for re-use, new or enhanced recovery models, and the introduction of access- instead of ownership-models that promote greater circularity.

### Skills and big data

Recent audits of the skills required to address these needs show a rising need for modelling,

**We are certainly not short of data, information and evidence. The question for a systems approach is, can we generate meaningful insight from it?**

multidisciplinary thinking and translational science. We are certainly not short of data, information and evidence. The question for a systems approach is, can we generate meaningful insight from it that instils a sense of collective urgency to address these challenges?

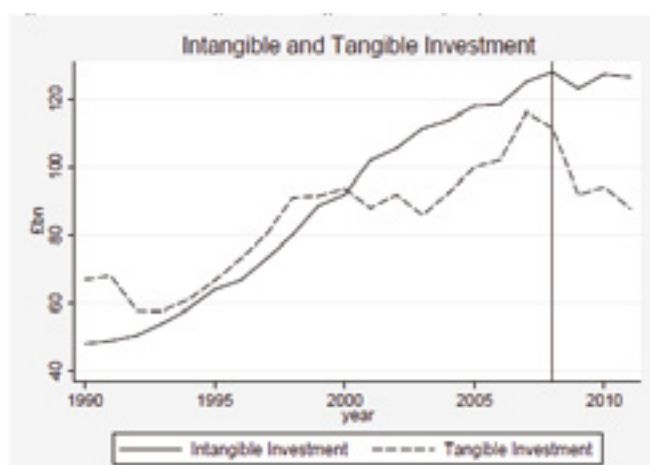
Cranfield’s recent success in this regard relates to risk and big data – recognising the enhanced systems understanding that the analysis of large volumes of data might yield.

To achieve that goal, a new generation of risk analysts needs to be trained in order to design mitigation strategies and seize opportunities that will emerge.

### Environmental reframing

We are forging a new forward-looking, value-centric, business-focussed literacy within the environmental sciences; one that can challenge and work with business. Along with other disciplines, environmental scientists are moving apace, reframing much of what we have done with a new resonance for industry and focussed on the enormous opportunities that the future will bring. □

## UK intangible investment exceeds tangible investment



Tangibles: computer hardware, machinery, buildings, vehicles

Intangibles: software, R&D, artistic originals, design, training, market research, business process re-engineering

**Figure 2. UK intangible investment exceeds tangible investment. (Tangibles: computer hardware, machinery, buildings, vehicles. Intangibles: software, R&D, artistic originals, design, training, market research, business process re-engineering)**

# The importance of collaboration

Tony Harper



Tony Harper is Head of Research and Advanced Systems Engineering at Jaguar Land Rover. He has been responsible for all of Jaguar's Computer Aided Design activities and was head of the Jaguar Vehicle Engineering team responsible for Concept Design, Packaging, Aerodynamics and Vehicle Computer Aided Engineering. Tony held this post during the development of the current XK and previous XJ product ranges.

## SUMMARY

- Working together as an industry has brought success and has attracted further investments.
- Nurturing the whole supply chain is more important than focussing on any single element.
- Greater integration of the universities with the supply chain is needed.
- There needs to be greater focus on technical skills in order to encourage greater productivity in businesses.

In the autumn of 2009, the automotive industry in the UK, and indeed globally, was staring into an abyss. At Jaguar Land Rover, there was speculation over bail-outs and Government help: most of this was misinformed but it gives you the sense of where the industry found itself only six years ago.

Contrast that with the situation today where Solihull, one of the plants under threat at that time, has just won another £120 million of investment. That is on top of more than £1 billion that have been committed since those dark days. Yet, normally, six years would be no more than a blink of an eye in our industry.

In 2009, all of our counterparts in the UK were staring down the barrel of the same gun. Yet as an industry, we did not talk to each other. This collective 'near-death' experience forced us to do so – to get together as a group.

Another notable event was the publication of the Stern Review on climate change and also the King Review on low-carbon vehicles. This flagged up that there was a very significant technical challenge to be addressed before 2020, whether we liked it or not. That was a technical and business challenge that was common to us all.

Two other things happened at that time. One was that Innovate UK announced £120 million of investment promoting R&D in low-carbon vehi-

cles. In addition, Shriti Vadera, who was a Minister at the time, said: "The Government wants to get together with you, in order to work out what we can do together to innovate and grow, assuming we all survive the next few weeks."

That was the starting point of a journey that continues today. The realisation that we had to get together as an industry coalesced around this £120 million opportunity. We all agreed that unless we did something, unless we came up with a common position, that money was probably going to be wasted. We agreed that we needed to create a technological roadmap to get us from our existing position to one where we had reduced the CO<sub>2</sub> of all of our vehicles.

That was achieved under the banner of the New Automotive Innovation and Growth Team (many of us did not realise there has been a previous Innovation and Growth Team, it had been that uncoordinated!). The team produced something that has become an icon in our industry now – the Automotive Council's Consensus Roadmap.

Since then, we have tried to take that seed and join up the rest of the ecosystem. Between ourselves, the Department for Business, Innovation and Science (BIS) and Innovate UK, we have been running the Integrated Delivery Programme since 2008-9. Because we managed to demonstrate success, we managed to attract further funds and investments.

The subsequent investments that we make as an industry are often ten times the initial, public investment. This involves more than just the spending on innovation. The automotive industry is very development-intensive and the money that we spend on development in order to bring these ideas to market is an order of magnitude higher than the investment in the innovation itself.

On the back of the success of that programme, we worked within what became the Automotive Council to identify opportunities, particularly in advanced propulsion systems. That gave birth to the Advanced Propulsion Centre (APC).

Now people talk about the Valley of Death or the need to bridge this gap or that, but the automotive industry is quite a complicated machine. In order to make it work, all of the bits need to be connected together.

We needed to create a technological roadmap to get us to a position where we had reduced the CO<sub>2</sub> of all of our vehicles.



**The Jaguar XF on the production line at Castle Bromwich**

Through the Automotive Council, it has been possible to bring together different elements, such as the initial investment, as well as private funding through things like the Advanced Propulsion Centre, and then there are the Innovate UK programmes. The other urgent challenge now is to really build the system back into the university base. The industry is not well-connected to that yet.

### **The supply chain**

Nurturing the entire supply chain has a greater effect on productivity than a focus on any one individual element. So in the UK, four of the top ten universities are producing academically excellent work related to the automotive sector, yet the results are not well-integrated with the rest of the ecosystem. In Germany their highest ranked university involved in this area is sixtieth in their rankings, yet the supply chain is connected together, helping them to get maximum benefit from the research. This suggests that there are opportunities we are not yet optimising in linking all that university activity with the rest of the ecosystem; and the Automotive Council is addressing this issue now.

The ecosystem we have today has developed from the challenge of CO<sub>2</sub> reduction and more specifically electrification. We are now moving on to think about other key areas that can help increase

productivity. A recent Automotive Council Technology Group meeting focussed on aesthetic design: our industry is very dependent on aesthetic design skills, but this area is both an opportunity and a current weakness within the UK. Other priorities are in software and electronics.

Now, while the programmes that Innovate UK, the Research Councils and APC support have not been the sole reasons that we have been able to make this journey over the past six years, they are definitely parts of the landscape of the journey. They have also contributed significantly to the confidence-building activity within Government and industry that has resulted in billions of pounds worth of investment.

### **The Spending Review**

The Comprehensive Spending Review could have thrown a couple of large spanners into the work of Innovate UK and of the APC. The good news is that the programmes have been preserved – indeed the APC has been such a success that it has been extended for another two years with an additional £200 million of funding. It is also

**UK universities are producing academically excellent work related to the automotive sector, yet the results are not well-integrated.**

starting to attract further inward investment – German companies are asking to be part of it. Global investors in R&D, looking for the next place to invest, are saying that, actually, it is in the UK that things are happening.

In Germany, whether in companies or universities or any collaborative activities, the general skill levels and technical literacy of the management are very high. That means that investment decisions are made wisely, the right equipment is

bought, the right investments are made in R&D, the right push is made on productivity and I would argue that these skill sets are not always present in the UK.

However, if you grow healthy ecosystems, you cannot help but create the skills that you need. It is an inevitable side effect of this process. I am not talking about taught programmes or courses, I am talking about the way this activity generates key skills which encourage productivity. □

# The debate

Issues raised in the debate included the adequacy of data, the living wage, policy and management culture.

There are significant doubts about the adequacy of aggregated statistical data about investment and productivity in conveying an accurate measure of the true productivity gap between the UK and the USA.

Not only are there significant variations between different economic sectors but also the scale of the post-2008 decline in UK productivity has been exacerbated by the relatively larger

weight of the financial sector in the UK economy.

International data are meaningful only if based on internationally agreed definitions. Moreover, the USA shares the UK's position in having large volumes of intangibles excluded from the data.

### Productivity versus employment

The impact of the introduction of a minimum living wage may be positive for productivity but adverse for employment. Indeed, the UK's current, relatively high employment rate is the logical corollary of the UK's comparatively poor productivity performance. However, higher productivity and greater innovation could lead to increased output and an expanding economy and thence the prospect of improved employment opportunities.

Are University Technical Transfer Offices a help or a hindrance? In the USA, MIT does not have anything of the kind but instead has an industrial liaison office which develops partnerships – it may be a model worth considering in the UK.

The importance of a stable and consistent policy environment for investment in innovation was highlighted. However, stability of policy should not be at the expense of flexibility in response to international competition.

When comparing the UK and Germany it has to be acknowledged that there are very different management cultures.

The UK needs to do better in obtaining financial benefits from its high quality research and so generate more resources to be ploughed back into research.

Does higher GDP really lead to a better sustainable life for the community? After all, GDP, as currently measured, does not provide a full measure of wellbeing. □

## FURTHER INFORMATION

### The productivity gap with the US (GDP per hour worked, \$US, PPP, US=1), OECD

<https://data.oecd.org/lprdy/unit-labour-costs.htm#indicator-chart>

### The House of Commons Science and Technology Select Committee Report: The Science Budget

[www.publications.parliament.uk/pa/cm201516/cmselect/cmsctech/340/340.pdf](http://www.publications.parliament.uk/pa/cm201516/cmselect/cmsctech/340/340.pdf)

### The Dowling Review of Business-University Research Collaborations

[www.raeng.org.uk/policy/dowling-review](http://www.raeng.org.uk/policy/dowling-review)

### Spending Review and Autumn Statement 2015

[www.gov.uk/government/topical-events/autumn-statement-and-spending-review-2015](http://www.gov.uk/government/topical-events/autumn-statement-and-spending-review-2015)

### Catapult Centres

[www.catapult.org.uk](http://www.catapult.org.uk)

### Innovate UK

[www.innovateuk.gov.uk](http://www.innovateuk.gov.uk)

### Research Councils UK

[www.rcuk.ac.uk](http://www.rcuk.ac.uk)



# ENERGY FUTURES

What is the future of the energy sector in Scotland, given both the risks and opportunities currently facing the industry? A joint meeting of The Foundation for Science and Technology and The Royal Society of Edinburgh on 22 October 2015 discussed the issue.

## The benefits of renewable energy

Phil Boswell

### SUMMARY

- The UK Government's cuts to renewable energy subsidies will harm both existing businesses and start-ups, resulting in job losses and discouraging investment.
- In Scotland, 40% of families live in fuel poverty while the big energy companies make record profits.
- Renewable energy provides an opportunity for a more competitive energy market with lower costs for the consumer.
- Unconventional oil and gas extraction, or 'fracking', might damage clean water supplies and will produce only finite supplies of energy.
- Scotland's natural resources are well-suited to renewable energy.

Energy is a critical component of the Scottish economy and has a pivotal role in the country's future. Yet the UK Government has missed a valuable opportunity to encourage growth in this sector. It has cut the budget for the Department of Energy and Climate Change (DECC) by £70 million.

Some £40 million of this lies in cuts to subsidies promoting energy efficiency. That means axing programmes such as the Green Deal and the Green Deal Home Improvement Fund as well as stopping subsidies for solar power and feed-in tariffs. Such programmes were designed to help individuals and families make their homes more energy-efficient.

### Creating jobs

Subsidies for renewable energy would have created business opportunities for SMEs as well as corporations. Cutting these removes incentives for businesses to enter the energy sector and is particularly discouraging for small start-up companies. This harms local and national businesses while leading to job losses around the country.

For example, changes to the feed-in tariffs for solar energy are predicted to result in the loss of 20,000 jobs with 1 million fewer solar panels being installed in the next five years. This is despite the fact that industry experts have predicted that the UK solar industry would be strong enough to go subsidy-free by 2020 if the feed-in tariff were maintained.

### Ending fuel poverty

Subsidies to energy efficiency do not only affect businesses. The most recent statistics from the Scottish Government in the Scottish House Condition Survey show that nearly 40% of households in Scotland are living in fuel poverty<sup>1</sup>. Fuel poverty has more far-reaching effects than simply not being able to maintain heating. According to a report commissioned by Friends of the Earth in 2011, entitled *The Health Impacts of Cold Homes and Fuel Poverty*, children living in cold homes are more than twice as likely to have respiratory problems as those living in warm homes<sup>2</sup>. The same report showed that adolescents living in cold homes are five times more likely to have multiple mental health problems than adolescents living in warm homes.

Fuel poverty means that the proportion of household income that could otherwise be used to buy healthy, nutritious food goes on paying energy bills. It has deleterious effects on people's emotional well-being and on their educational attainment. This combination of mental and physical health problems, poor diet, emotional turmoil and diminished educational attainment, caused in part by fuel poverty, is a recipe for condemning people to a cycle of poverty.

The primary contributors to fuel poverty are household income, fuel costs and the energy efficiency of homes. Reducing subsidies that could



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**Tackling fuel poverty must be a key factor when considering future growth potential in the energy sector in Scotland.**



**Changes to the feed-in tariffs for solar energy may result in a million fewer solar panels being installed in the next five years**

enable people to make their homes more energy efficient by installing insulation and energy-efficient boilers, and by generating their own solar energy, is a regressive step.

Energy inefficient homes are often due to poor quality housing. Condensation and damp force people to open windows during the winter while the heating is on. Fuel poverty also is tied in with other issues such as the current housing crisis.

Tackling fuel poverty must be a key factor when considering future growth potential in the energy sector in Scotland. Ending fuel poverty goes hand-in-hand with more efficient use of fossil fuels and a move toward exclusive use of renewable energy.

### Challenging the energy suppliers

At the same time as many households are struggling to keep the heating on, the big six energy companies are making massive profits. Scottish Power quadrupled its profit last year, from £27 million to £114 million. British Gas profits rose 99% from 2014 to 2015 – at the same time as its parent company Centrica plans to cut 4,000 jobs.

Not only have they been making massive profits, the Competition and Markets Authority has recently found that energy companies have been overcharging their customers to the tune of £1.2 billion per year<sup>3</sup>. The lack of action on this finding, by both the UK Government and the companies involved is disturbing.

The dominance of the big six energy companies is a clear case of market failure. It is now time for a change. The emergence of the renewable sector

offers a crucial opportunity to create a competitive, functioning market that works for consumers rather than just for monopolistic corporations.

### The risks of fracking

Many believe that the future of Scotland's energy industry lies in unconventional oil and gas extraction such as hydraulic fracturing of shale, or 'fracking'. However, fracking is not without risk. It has been acknowledged by the US Environmental Protection Agency that fracking might cause the contamination of drinking water wells<sup>4</sup>.

Clean water is one of Scotland's most plentiful and precious resources, and is sometimes referred to as 'blue gold'. As such resources become increasingly scarce throughout the world, an opportunity arises for an export industry for Scotland.

Some have suggested that a future global flare-up could revolve around access to clean water. It is essential that we protect this invaluable resource.

I have been a strong supporter of the Scottish Government's moratorium on unconventional oil and gas extraction, and am pleased that the moratorium has been expanded to include underground coal gasification. Despite the moratorium, energy companies involved in unconventional gas extraction continue to pursue plans to expand their operations. It is up to these companies to prove that these operations are safe and will be policed and enforced by regulation. Finally, like any other fossil fuel, the oil and gas that would be extracted through fracking is finite.

### Harnessing Scotland's natural resources

Scotland's renewable energy sector has a huge capacity for growth. We have one-tenth of Europe's wave energy potential and a quarter of its offshore wind and tidal potential. For such a small nation these statistics are staggering.

Not only does Scotland have the potential to power itself entirely from renewable energy, we also have the opportunity to develop an export market for this high-demand resource. This means that Scotland can remain a dominant player in the global energy industry as it reduces its dependence on oil. For Scotland, the future clearly lies in renewable energy. □

**Not only does Scotland have the potential to power itself entirely from renewable energy, we also have the opportunity to develop an export market.**

<sup>1</sup> [www.gov.scot/Resource/0046/00465627.pdf](http://www.gov.scot/Resource/0046/00465627.pdf)

<sup>2</sup> [www.foe.co.uk/sites/default/files/downloads/cold\\_homes\\_health.pdf](http://www.foe.co.uk/sites/default/files/downloads/cold_homes_health.pdf)

<sup>3</sup> [www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/442500/EMI\\_PFs\\_Summary.pdf](http://www.gov.uk/government/uploads/system/uploads/attachment_data/file/442500/EMI_PFs_Summary.pdf)

<sup>4</sup> [cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=244651](http://cfpub.epa.gov/ncea/hfstudy/recordisplay.cfm?deid=244651)

# Scotland's position in the energy market

Iain Conn

## SUMMARY

- Everyone is trying to balance the priorities of security, climate change and affordability.
- Europe's energy costs are twice that of the USA, labour costs double that of Asia.
- Scotland starts from an enviable position.
- To remain viable, North Sea production costs must be reduced.
- Demand management and energy efficiency offer great opportunities.

The world spends \$7 trillion a year on energy, some 10% of the world's GDP. Given our world's dependence on current energy systems, change will be difficult. It took 150 years to move from wood to coal and another 150 to move from coal to oil and gas. Try to effect change too quickly and the process will become very expensive.

Everyone is trying to balance three priorities – security, climate change and affordability. In terms of affordability and competitiveness, Europe has a particularly challenging position. Energy costs are twice those of the USA, while industry's labour costs are twice that of Asia. Affordability is, therefore, key in how fast we move and which changes to make.

However, Scotland starts with an advantage, in terms of both security and climate change, although affordability must still be borne in mind.

## Security of supply

Scotland is a major energy exporter, producing 67.6 million tonnes of oil equivalent, but only consuming 14.9 million tonnes. Once losses of 7.4 million tonnes are taken into account, 45.3 million tonnes remain available for export. In order to optimise its energy, Scotland also imports and exports another 25 million tonnes, largely in the form of natural gas.

The picture is dominated by the production and export of oil and gas from the North Sea. Scotland produced 94% of the UK's oil and 51% of its gas in 2014. So Scotland has clearly achieved security of supply.

## Climate change

On the question of climate change, Scotland's energy consumption mix is about 35% oil (mainly for transport and petro-chemicals), 41% natural gas which is mainly for domestic heating and industry, 21% electricity and 3% other sources including biogas.

About one-third of its electricity is nuclear and a further third renewables. With the substantial use of natural gas for heating, Scotland has significantly lower carbon emissions than the rest of the UK. Indeed, Scotland has a good chance of meeting its 2020 goals in delivering 30% of overall energy demand from renewables, with 100% of electricity being renewably sourced.

## Affordability

The major (but not sole) reason that Europe's energy costs are twice those of the USA is that country's development of shale gas. Electricity in America costs 10.1p/kWh while in the UK it is 15.5p on average and 16.0p in Scotland. Natural gas is 2.9p in the USA, 5.0p in the UK (and slightly better in Scotland at 4.8p).

In a UK energy bill, half the cost is due to transport, distribution and transmission costs together with Government levies. The Government has recently reduced the amount spent on renewable obligations and the levy framework: it cannot afford to subsidise change at too fast a pace. However, this does mean lower growth in onshore wind and there will be implications for the solar industry in the UK too.

I support interventions which focus on affordability because ultimately it is my customers who have to pay the bills. It is not possible to have all these Government support levies, which people have to pay for, as well as cheap energy. So, while Scotland has an enviable starting point, the way forward has to be carefully managed.

## The North Sea

Scotland's strong position as an oil and gas producer and exporter is threatened today and we must improve the North Sea at lower prices. Low oil and gas prices, high relative costs and a generally mature basin are threatening its viability.

It is being impacted by the policy of Saudi



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Micro-generation with combined heat and power units in consumers' homes will allow them to sell electricity back to the grid and this gives them more control over their energy usage.

Arabia, which is chasing market share. Its goal is that the world should use more low-cost, high-margin barrels, rather than more high cost, low margin barrels. So they are taking the war to the Americans, Canadians and Venezuelans (and their financiers), effectively telling them: "If anyone is going to win in terms of market share, it is us." To achieve that, Saudi Arabia has been driving prices down: I think they will stay down for some time.

What does that mean for the North Sea? Well, investment is being slashed – in 2017 it will be one third of the 2014 figure. About 50% of UK production today would be uneconomic at \$55 a barrel and we are below that figure.

This region has some of the highest production costs in the world: they have trebled over just the last 10 years. What must be done? Drive production efficiency. Reduce capital costs, although it is an open question whether these can be reduced fast enough in the current climate. Share infrastructure, reduce taxation (a big issue for Government) and find more competitive sources of oil and gas.

### Shale gas

Shale gas should be cheaper to produce because it is onshore. Fracking is not a new technology – it has been around since 1940. It can be done safely: it needs to be done safely and responsibly and the UK needs it. Scotland does not have a great deal of it, though. The Midland Valley has 80 trillion cubic feet. The Bolan shale in Lancashire has about 1,330 trillion cubic feet, about 16 times as much. Nevertheless, an appraisal on its viability needs to be carried out.

### Demand management

Oil companies and energy people tend to count barrels rather than demand. Yet there are some really exciting developments in energy demand management. The traditional grid system is being replaced – quite quickly – by distributed energy systems. These give businesses, for example, more control through smaller, on-site generation facilities. They can use back-up generators to reduce bills. Newer, more efficient, on-site heating and power systems can even contribute to meeting demand at times of peak load.

For consumers, for example, micro-generation with combined heat and power units in their homes will allow them to sell electricity back to the grid and this gives them more control over their energy usage. I can see a future where the national grid is to some degree an insurance policy – you just need it in case your own systems stop working.

Centrica has installed 252,000 Hive smart thermostat control units in people's homes, helping them use less energy because they can better manage their energy systems and so making it as efficient as possible. We are rolling-out 15 million smart meters at a cost of £3 billion. More information gives people more understanding and so greater ability to change their behaviour, using less energy more efficiently.

Centrica produces 4% of all of the oil and gas within the UK, so we are a large part of the UK energy system – and that of Scotland. The future is not bleak, but we need to identify and adopt pragmatic pathways to that future. We have learned enough about energy in the last 20 years to know what has to be done. We just have to go there. □

# A role for shale gas

Gary Haywood



Gary Haywood is Chief Executive Officer, INEOS Shale. He has been CEO of INEOS Olefins & Polymers UK as well as Petroineos Refining Ltd, the PetroChina/INEOS refining operations joint venture in Europe.

I am often asked why shale gas is needed when we have renewables. The answer is that renewables alone will not be sufficient to supply our energy needs in the immediate future. Currently, 80% of homes in the UK rely on gas for heating. And even with increased renewables capacity, we will need gas to provide energy when the wind does not blow and the sun does not shine. We also need gas for feedstock and to make the plastics and chemicals used in everyday products such as clothes, appliances and pharmaceuticals.

Gas will be essential if the country is to reduce the use of coal and so achieve lower carbon emissions. In 2011, coal accounted for almost half the

energy used in the UK. It is predicted that by 2035 the figure will be less than a quarter. To achieve this, consumption of gas will need to double from its current 20% to 40%. No matter how quickly the renewable energy sector grows, it will take some time before it can replace our current energy sources.

While the need for gas will increase, there has been a steady decline in North Sea gas and oil production and a corresponding rise in the dependence on imported gas. The UK has moved from being self-sufficient in gas in 2000 to importing over half of its requirements. This has important implications for energy security and for living



standards, as well as for the economy in Scotland and northeast England.

### Shale gas

It is not known how much shale gas there might be in Scotland, but there is certainly much potential. It could provide 20–50% of our gas demand for decades. To exploit this valuable resource we need to determine the extent and location of Scotland's shale gas reserves.

The US experience has shown the potential. A single shale basin in the eastern USA, the Marcellus Shale, began producing gas at 1 billion cubic feet per day in 2009, and by February 2014 this had risen to 14 billion cubic feet per day. To put this into perspective, total UK consumption is about 8 billion cubic feet per day. While Scotland (or even the entire UK) may not be able to equal this, it does provide an indication of what can be done with shale reserves if we apply appropriate extraction technology. INEOS currently has licences to explore just over 700 km<sup>2</sup> of potential shale gas formations in Scotland.

Development of shale gas depends upon four factors. First, of course, the geology has to be suitable for development. Second, specific skills are needed to extract the shale gas and the UK is short of skills such as hydraulic shale fracturing. Third, a cost-effective supply chain is necessary. At the moment the costs of drilling and hydraulic fracturing in the UK are enormous, between two and five times the costs in the USA. To be viable we

## SUMMARY

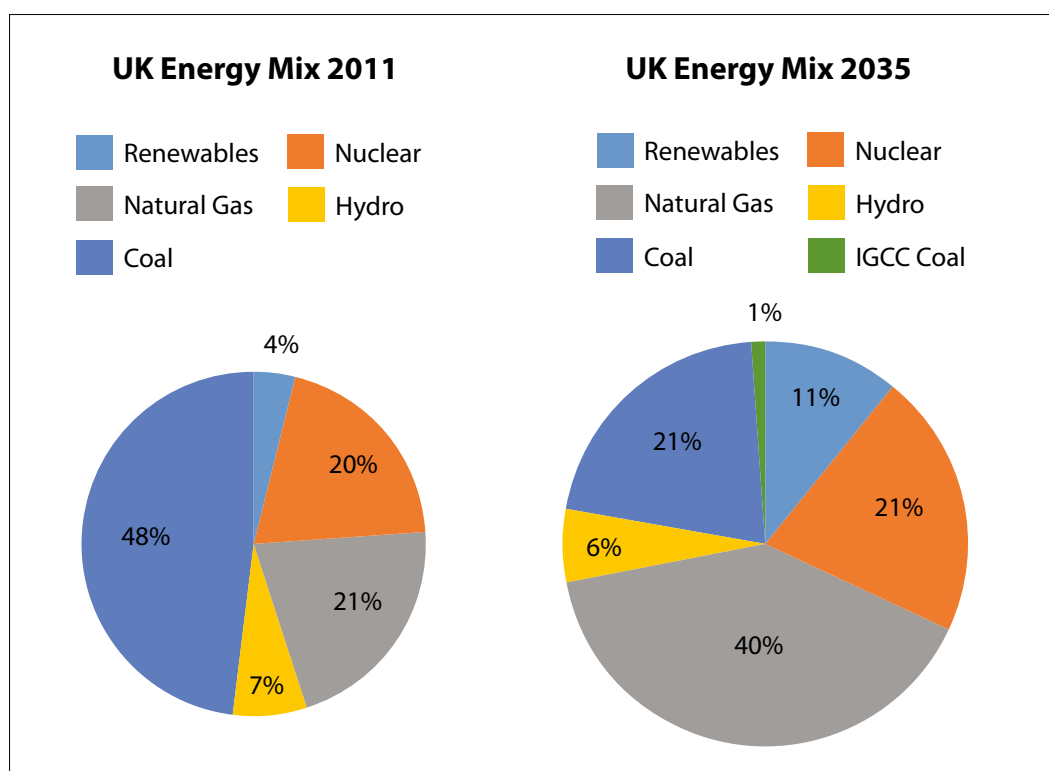
- Renewable energy will not be sufficient to supply our energy needs in the immediate future.
- To meet carbon reduction targets we need to replace coal with gas.
- Shale gas, together with renewables, could supply up to half of our energy needs for decades.
- Development of shale gas relies on suitable geology, specialised skills, a cost-effective supply chain and public acceptance.
- Public education and dialogue is needed to persuade people that, properly regulated, shale gas can be a safe and secure energy source that does not harm the environment.

need to bring these down. Fourth (and possibly the most important factor), is public acceptability of shale gas.

### Gaining public acceptance

The acceptability of shale gas to the public is the most challenging aspect of shale exploration. There is a high level of public concern about water contamination, seismicity and the impact on communities. The public mistrust the industry, but tend to trust environmental campaigners.

So people need to be encouraged to look objectively at the scientific evidence. The Royal Society



**Gas plays a growing role en route to a low-carbon future**

### The supply potential of shale needs to be proven and to do that we must fracture some wells.

and the Royal Academy of Engineering have reviewed the scientific and engineering evidence on hydraulic fracturing. They concluded that the health, safety and environmental risks can be managed effectively in the UK by the use of operational best practices enforced by strong regulation. They reported that fracture propagation is an unlikely cause of contamination and that the seismic risks are low. They also noted that robust monitoring of well integrity is vital.

In terms of environmental impact and effects on the local community, shale developments are spread over a wide area with minimal impact on the surface. They are generally the size of a football field and are silent in operation. The drilling and fracturing stage creates a building site, but takes only about six months. Once that is completed, we have a site that will produce gas for 20 years.

Scotland does have shale gas resources.

Whether they are commercially viable is still open to question, but the potential is there. If they can be developed, there could be a significant boost to jobs, GDP and energy security. The potential of shale needs to be proven and in order to do that we need to drill and fracture some wells. Although supply chains are currently expensive, if the shale industry develops the supply chains will become more viable.

I support the Scottish Government's moratorium on hydraulic fracturing as an opportunity to engage the public in a dialogue about shale gas extraction, although I am not certain that the extension of the moratorium to 2017 is necessary.

It is vitally important that the period of the moratorium is used to engage in a steady programme of dialogue. The emotional reaction that people have about hydraulic fracturing has to be addressed with a rational analysis of the risks. Public acceptance will only be gained through a wider understanding of the need for shale gas and its potential value to communities, backed up with objective, scientific evidence about the level of risk it presents. □

# Balancing our energy portfolio

Rebecca Lunn



Professor Rebecca Lunn FRSE FREng is Head of Department, Civil and Environmental Engineering, and Professor of Engineering Geosciences, at the University of Strathclyde. She is an expert in ground engineering and energy geosciences. She is also a member of the Scottish Government's Geothermal Energy Expert Group and was a member of the UK Government's Advisory Committee on Radioactive Waste Management from 2008-2015.

Over the coming years Scotland will lose over half of its current capacity to generate electricity. Currently Scotland's electricity is supplied by gas (10%), nuclear energy (35%), coal (20%) and renewables (35%). By 2016 coal will have been shut down, and by 2023 both of Scotland's nuclear power stations will be decommissioned. That will mean that Scotland will be a significant net importer of power from the rest of the UK. This power will be generated by gas-fired and new-build nuclear power stations.

Electricity is only 21% of Scotland's energy consumption. 55% goes on heating, and that is met almost entirely by gas. Lowering coal consumption to meet carbon targets (by closing coal-fired stations in Scotland and the rest of the UK) will increase gas consumption still further. A 'greener' low-carbon future looks more gas-dependent.

In the Royal Society of Edinburgh's report Options for Scotland's Gas Future<sup>1</sup>, we looked at four options: reducing demand, increasing offshore gas production, increasing onshore gas production and increasing imports. We considered factors such as safety, energy security, health and well-being, the environment, climate change, as

## SUMMARY

- Scotland is set to lose over half its current electricity generating capacity due to closure of the coal-fired and nuclear power stations.
- Scotland will then become a net importer of electricity generated from England and Wales.
- Under current UK policy, Scotland's imported power will come from the proposed new fleet of nuclear power stations and from existing gas-fired power stations.
- Reducing Scottish and UK coal consumption to meet carbon targets may increase gas consumption for power production.
- The options for meeting future demand are: reducing demand, increasing onshore energy production, increasing offshore production; and increasing imports.
- Decisions have to be made on how to meet future energy requirements and what level of energy security risk is acceptable.
- Public education and debate is essential to avoid crisis decision-making.



### Encouraging a resurgence in North Sea exploration activity is likely to require Scottish Government investment

well as economic factors affecting not only the industry but also the consumer.

#### Reducing demand

In Scotland over an eight-year period, demand for heat has been reduced from 60,000 gigawatt hours (GWh) to 48,000GWh. This has been achieved through improvements in insulation and by using heat pumps. The major barrier is the cost to Government as it is principally achieved through grants. Reducing demand for heat is a capital investment priority for the Scottish Government.

#### Increasing offshore gas production

Existing oil and gas fields in the North Sea are mature and, as the remaining volumes of gas diminish, are increasingly uncompetitive. Increasing offshore gas production requires exploration to discover new gas fields and may involve production from less conventional sources, such as deep water reservoirs, tight gas and high pressure/high temperature reservoirs. Exploration activity in the North Sea has diminished to almost nothing over the last two decades and encouraging a resurgence is likely to require Scottish Government investment.

#### Importing energy

Importing energy is relatively cheap and is the most cost-effective option for the consumer. Yet gas production and transportation still has environmental and social impacts. Importing our energy results in those impacts being outside Scotland's regulatory control. It also raises issues

of social justice, since environmental and health impacts often fall on the local population and the local workforce, who may not be receiving the benefits of energy production and consumption.

A significant issue with increasing energy imports is Scotland's energy security. In 2014, 53% of our gas was imported, some from regions that are politically unstable, such as Qatar, Russia and North Africa. Disruption to energy production in these regions could lead to UK energy shortages and, hence, to social unrest.

#### Increasing onshore gas production

There are three forms of unconventional onshore gas that Scotland could develop: shale gas, coalbed methane and underground coal gasification. There are significant resources of coalbed methane.

There is media hysteria about unconventional gas and the public is confused about hydraulic fracturing. For example, there is talk of hydraulic fracturing for coalbed methane, which is incorrect; hydraulic fracturing is not required for coal-bed methane production. There have been significant problems with pollution in the USA, but these are due to poor regulation. For example, groundwater contamination is not caused by hydraulic fracturing or by extracting methane, but because the water that is produced with the gas could pollute ground water.

In the USA, product has been stored in open surface ponds, which can leak and pollute drinking water aquifers. This is a simple problem to solve, but the process has been very poorly managed. In

The question is not simply 'Should we produce shale gas?' because the answer from the public and politicians is likely to be 'No'.

the UK, all of the independent expert panels have concluded that if the industry is well regulated, unconventional gas production can be safe.

### Energy storage and transmission

If Scotland is to decrease its carbon footprint, we either need to increase our power and heat generation from renewable sources or invest in nuclear power. The Scottish Government has opted for increased renewable production. Most renewable sources are climate dependent and cannot be relied upon to produce a steady supply.

Once Scotland's existing nuclear power stations are closed, we will rely on the rest of the UK to maintain a stable baseload power supply. Hence, to have a sustainable long-term policy based on renewables, new technologies are required to enable significant power storage. This will require investment in technology development for power storage.

Renewable energy sources are primarily in remote locations. The current national power grid is not designed for transmitting power from its extremities; increased renewable production will also require significant capital investment in the national grid.

There is an urgent need to increase Scotland gas storage capacity in Scotland and the rest of the UK. The UK currently has one of the lowest gas storage capacities in the world (as a percentage of consumption), which leaves us highly vulnerable to disruptions in supply.

In combination with our high percentage of gas imports, this results in poor UK energy security. Technology exists to store gas in the sub-surface, but there is a need for increased capital investment, and issues of planning permission and public acceptability are inhibiting progress onshore.

### A publicly-informed decision

It is clear that there are no easy options. There are some difficult decisions to be taken. Sticking our heads in the sand and relying on imports will put our energy security at risk. We already import over 50% of our gas and that proportion is set to rise.

The question is not simply 'Should we produce shale gas?' because the answer from the public and politicians is likely to be 'No'. We need to ask ourselves how we want to source the UK's future energy requirements, what balance of energy portfolio we want, how much storage capacity we should invest in and how much security risk we are prepared to accept.

In our report we recommended participatory decision-making. Citizens' panels could be used to educate people and help shape policy. We need to change the public attitude of 'not in my back-yard' and help people understand that if they say no to domestic production they are, by default, saying yes to something else if their energy needs are to be met. At the moment I do not think there is an adequate understanding of that.

Social justice also comes into this debate. The UK imports over half of its gas energy – in other words, we do not shoulder the environmental impact of the energy we consume. Instead, that impact is borne by people a great distance away. If we produce our own, we can ensure the industry is well regulated and reduce any impacts to an absolute minimum. It is critical that we raise the level of debate and discussion on energy. If we do not, we are likely to end up in crisis. In 2013, the UK was one day away from not meeting its gas demand. Crisis-led policy making leads to poor decisions and poor regulation. □

<sup>1</sup> [www.royalsoced.org.uk/cms/files/BriefingPaper15-01.pdf](http://www.royalsoced.org.uk/cms/files/BriefingPaper15-01.pdf)

## POLITICS, SCIENCE AND MARKET FORCES

*Ben Ritchie is a Senior Investment Manager for Pan-European Equities at Aberdeen Asset Management. He gave a short response to the speeches at the beginning of the discussion period.*

The energy debate seems to me to be circumscribed by the trinity of politics, science and market forces. Leadership from politicians will be crucial to align these three. Investors obviously want the prospect of returns, but in a context of stability and consistent policy-making. This applies whether we are supporting governments, corporations or individuals. At present, policy is being driven by politics. Scientific evidence and market global market trends are being ignored.

Fracturing shale to release gas is an example of this. The word 'fracking' is quite emotive, and good policy leadership is critical. Having a general moratorium on fracking is fine in terms of politics but may not result in the right kinds of policies. Blanket bans on fracking also cover the use of unconventional recovery techniques offshore, but these are needed to support growth and production in an industry already facing significant pressures. Policies need to take into account scientific logic and market forces, as well as political influences.



# The debate

Issues raised in the debate included funding the switch to renewables, shale gas and North Sea investment.

Reducing household demand for energy is desirable, but there are different ways of achieving this. Some thought the priority should be to use excessive profits from suppliers to lower the cost of heating for people living in fuel poverty. This would entail growing the renewables sector to increase competition.

Others saw the priority as changing household behaviour by ensuring that householders have full information about their fuel costs and are able to manage their supplies through distributed generation means such as solar panels. Yet will distributed generation systems spread quickly enough, now that subsidies are being reduced? They will always need backup from the grid.

## Focus on technologies

Still others favoured a drive for the use of particular technologies, such as heat pumps. However, none of these measures will be effective in reducing the price of energy unless the cost of developing and improving the energy network is raised through taxation, rather than at the point of purchase. Without this change, energy costs for the consumer will continue to rise and fuel poverty increase.

All shared the speakers' concerns about the 20-year gap before renewables can replace coal and nuclear energy, with the resulting danger of a supply crisis. Although much can be done to promote distributed generation systems, reduce demand and encourage start-ups and innovation,

efforts will fail unless there is long-term consistency in Government policies on taxation, subsidy and regulation.

The Scottish and UK Governments should recognise the importance of maintaining investment in the North Sea, which employs 100,000 people and is struggling to reduce costs. Action should be taken now to protect offshore fields. There is a strong case for abating the petroleum revenue tax.

## Renewables shortfall

Scotland currently overproduces electricity but if it becomes more dependent on renewables, whose productivity is intermittent, it could see a shortfall in supply. We should not try to replace gas with electricity. Instead, more research should be directed at finding ways to counteract the instability of renewables, such as novel technologies for the storage of electricity.

It is a dangerous assumption that further indigenous gas resources will not be required in the next 20 years.

Determined leadership is needed to engage the public in the wider energy debate and on the safety and environmental acceptability of hydraulic fracturing of shale to release gas.

At present political leadership is focussed on specific issues – nuclear and fuel poverty – and is failing to communicate the full facts about wider energy issues to the public. □

## FURTHER INFORMATION

### Scottish Government

[www.gov.scot](http://www.gov.scot)

### Scotland Office

[www.gov.uk/government/organisations/scotland-office](http://www.gov.uk/government/organisations/scotland-office)

### *Shale Gas Extraction in the UK: A review of hydraulic fracturing*, Royal Society/Royal Academy of Engineering report

[www.royalsociety.org/topics-policy/projects/shale-gas-extraction/report](http://www.royalsociety.org/topics-policy/projects/shale-gas-extraction/report)

### The Royal Society of Edinburgh

[www.royalsoced.org.uk](http://www.royalsoced.org.uk)

### *Options for Scotland's Gas Future*, Royal Society of Edinburgh report

[www.royalsoced.org.uk/cms/files/BriefingPaper15-01.pdf](http://www.royalsoced.org.uk/cms/files/BriefingPaper15-01.pdf)

# THE ARCTIC

Changes in the Arctic could have major implications for the UK in a number of areas.  
A meeting of the Foundation for Science and Technology on 4 November 2015 considered  
how this country should respond to these changes.

## Responding to a changing Arctic

Robin Teverson



Lord Teverson chaired the House of Lords Select Committee Inquiry on the Arctic. He has also chaired the Lords EU External Affairs sub-committee, and has spoken for the Liberal Democrats on energy and climate change issues in the Lords. He was previously an MEP, representing Cornwall and Plymouth during the 1990s, and spent his early career in the freight industry. He is also a director of the Marine Management Organisation.

In every Parliamentary session, the House of Lords establishes four 'ad-hoc' select committees to look at items of special interest. Each reports back within a parliamentary year, and then the committee dissolves. The Arctic is a part of the globe where a great deal of change is occurring, due especially to climate change and its repercussions – and was therefore a highly topical subject for an Inquiry<sup>1</sup>.

The Committee did not, however, look at the causes of climate change – just the implications for the UK. We felt it was particularly important for the British Parliament – and the House of Lords in particular – to take up this issue because the UK is the nearest non-Arctic state and we have real, longstanding interests there. While there are eight states in the Arctic Council, the Shetlands are a mere 320 miles away from the Arctic Circle.

### A changing environment

The minimum area of sea ice cover in the region in summer has almost halved over the past couple of decades. Even more importantly perhaps, the volume of ice has gone down by some 75%, because when the sea refreezes there is only the thickness from one year. That does not affect sea level as such. However, looking forward, the disappearance of the Greenland Ice Sheet would be dramatic. This would raise global sea levels by some 7 metres or 23 feet, which puts the impacts of climate change in the Arctic into perspective!

The Committee went to Spitsbergen in Norway's Svalbard archipelago, a mere 800 miles from the North Pole and largely ice-free these days. While it has a population of just 2,000, it has an excellent university facility. We discussed a number of issues with students and staff while there.

The good news is that the Arctic is one of the best-governed regions of the world. The Arctic Council comprising eight states was founded in

### SUMMARY

- The UK is just 320 miles from the Arctic Circle and has a longstanding interest in the affairs of this region.
- Too little is still known about the region and the UK could play a major part in increasing knowledge.
- There has been a lack of focus on the Arctic recently which needs to be rectified.
- A new balance needs to be struck between the UK's involvement in north and south polar regions.
- The UK should consider appointing an ambassador to the Arctic.

1996 and has grown in stature. It has started to create enforceable agreements: of those, one concerns oil spills, another focusses on search and rescue (which is particularly important in the context of increasing tourism).

The Council has a number of observers. The UK was one of the first and in 2013 the number was increased substantially to include India, China, South Korea, Singapore and Italy, Poland and Japan. Why the interest from the fast-growing, large Asian economies? Well, for Singapore, for example, it is clearly around freight and transport routes, but generally it is the draw of resources.

The Arctic is very remote and very different from other parts of the world. Unlike the Antarctic it has no landmass: its high seas are beyond the jurisdiction of individual nations. So there are many challenges.

The Inquiry did not examine issues of security in detail, but this area is not immune from geopolitical events taking place elsewhere. While we were taking evidence, the Russian annexation of Crimea took place. At the same time there was a huge fall in commodity prices for mineral extractors and oil companies. Both had major effects.

Although the Arctic Council does not deal with military matters, it is based on strong

There has been talk of a 'scramble for the Arctic'. Yet the number of vessels transiting the Northern Passage through Russia remains very small.

cooperation in science and in areas like shipping and research. One of the important recommendations that we put forward is that it needs to be isolated from wider international problems. The previous Canadian Government took a robust stance towards Russia and a number of meetings did not take place. Generally, though, cooperation in the Arctic has continued and we welcome that.

### The peoples of the Arctic

It should be noted that the Council has special representatives of indigenous people. The Arctic has some four million inhabitants. Most of these live in Russia, but half a million are indigenous people – whether First Nation in Canada, Sami in Scandinavia, Inuit and various Native American tribes. With the growth in the number of observers, there is a concern that their voices could be squeezed out. Yet it is clearly important that those communities are able not only to survive, but to thrive and to be a determinant of development.

There has been talk of a ‘scramble for the Arctic’. Yet the number of vessels crossing the Northern Passage around Russia remains very small: ice-breakers remain essential at present. Most traffic is to existing settlements – not transits from one ocean to another. So although these routes can substantially reduce journeys from the Pacific to other areas, this is not going to be a major area of development in the short term.

For mineral extraction, too, the pace of development will remain slow: indeed, in 2015 Shell stepped back from exploration offshore in the Chukchi sea. It is extremely expensive to set up mining there. One example we heard about was from the Yukon in Canada. Just flying one team of staff to a mine every two weeks and bringing those on leave back to base costs something like US\$100,000. That indicates the remoteness and expense involved.

Because the pace of development is likely to be slow, the Committee believes there is time to set down appropriate rules and to find the right ways to handle development in advance, rather than having to respond later.

The area which astonished us most was the dramatic lack of knowledge about this region – whether in terms of mapping and hydrographic information, or about ecosystems and scientific information. Although the Arctic Council and its various elements carry out a great deal of cooperative science work, there is a huge amount still to do. The UK has a part to play here, working more closely with other observer states and Council members to make sure that we really do increase our knowledge of the region.

There are two areas in the middle of the Arctic which are not designated as Exclusive Economic Zones (EEZ), and there we argued that, in regard to the fisheries industry, there should be a moratorium. Discussions are under way and we very much welcome the progress made in that area.

### UK interests

In the Antarctic, the UK has a strategic interest but we have land claims as well. There is also excellent scientific work going on. However, the Inquiry concluded that a better balance is needed between our involvement in north and south polar regions.

The changes in the permafrost urgently require further research. It is vital to understand very much better the impacts of the methane and carbon in the permafrost and also the methane in the Arctic sea floor. With so much development in remote areas depending upon ice roads, permafrost and climate change actually works against on-land development rather than for it. So there are challenges there as well.

The Inquiry recognised the important work undertaken by the International Maritime Organisation, based in London, especially the new Polar Code. However, further improvements are still needed in regard to issues like the use of heavy fuel oil and black carbon emissions.

### The UK policy context

Although Britain is the ‘nearest neighbour’ with a long history of interest in the Arctic, the Inquiry felt there had been a certain loss of focus recently – and this at a time when the rest of the world is devoting more attention to the region. One of our major recommendations was that the UK should appoint an Arctic ambassador, as a number of other countries have done. This should be someone with a scientific background, with some diplomatic experience too, who is able to bring together all the various strands of policy we have in the UK, whether industrial, environmental or geopolitical.

The UK already has a framework strategy for Arctic policy<sup>2</sup>. Although supportive of this policy, the Committee felt it was too defensive and that Britain should show greater leadership while of course showing respect for the Arctic nations on the Council. We can be one of the leading observer nations. In conclusion, the House of Lords will continue its interest in this region and strive to ensure that the UK plays its full part in the future of the Arctic. □

<sup>1</sup> The House of Lords Arctic Select Committee Report [www.parliament.uk/arcticcom](http://www.parliament.uk/arcticcom)

<sup>2</sup> [www.gov.uk/government/publications/adapting-to-change-uk-policy-towards-the-arctic](http://www.gov.uk/government/publications/adapting-to-change-uk-policy-towards-the-arctic)

Because the pace of development is likely to be slow, the Committee believes there is time to set down appropriate rules and to find the right ways to handle development in advance, rather than having to respond later.

# Increasing our engagement

Jane Rumble



Jane Rumble is Head of the Polar Regions Department at the Foreign and Commonwealth Office. She has been Head the Department since January 2007, previously having spent over three years as Deputy Head. Jane started her civil service career in the Department of the Environment, where she undertook a range of environmental and corporate policy roles, on topics including health and safety as well as genetically modified crops.

While the beautiful, pristine wilderness depicted in series such as *Frozen Planet* does exist, the Arctic is not all like that.

It is important to recognise that the Arctic is not a homogenous region; it is made up of different countries, peoples and interests. Of the four million inhabitants, the overwhelming majority live in Russia. The northern Norwegian Arctic is quite well developed, whereas northern Canada is quite sparse in terms of population.

Yet it is not an un-governed space: it falls under the jurisdictions of eight Arctic States, five of which border the Arctic Ocean and so have associated maritime rights. There has been mining development and hydrocarbon extraction for several decades. So, while the beautiful, pristine wilderness depicted in series like *Frozen Planet* does exist, the Arctic is not all like that.

The UK is the nearest neighbour to the Arctic and we have maintained a very longstanding interest in the region. But current and future changes in the Arctic will inevitably have significant implications for this country (see Table 1, page 43).

## A policy framework

The Government tried to bring all of these considerations together in October 2013, when the UK published its first Arctic Policy Framework<sup>1</sup>. It was a matter of walking a very delicate tightrope at the time.

It was important not to overplay our hand because of the sensitivities of some of the Arctic states. The EU had already put forward an Arctic Strategy which was not well received. So we referred to it as a policy framework rather than a strategy. It would be something we could deliver through diplomacy, coordination and engagement.

The key principles are set out under three broad pillars. There is the Human Dimension looking at governance and engagement of the indigenous people in the region. We recognise that the Arctic Council is the pre-eminent body for governance of Arctic matters and the one that we will engage with. However, it does not cover items like fishing, defence, security: so there are other forums through which we interact as well.

Within the Environment Dimension, the objective is to gain greater understanding of the Arctic through scientific collaboration and to promote policy development on the basis of sound science.

The third, the Commercial Dimension, includes energy security, shipping, bio-prospecting and fisheries among other issues.

## SUMMARY

- The Arctic is not homogeneous: it consists of a number of different countries, peoples and interests.
- As the nearest neighbour to the Arctic, developments there will inevitably have implications for the UK.
- Particular emphasis is being placed on scientific cooperation.
- The UK's primary policy objective is that the Arctic should remain peaceful, stable and well-governed.
- The UK is strengthening bi-lateral agreements with Arctic states.

So, the framework encapsulates the ways in which the UK has been trying to increase its engagement using communication and outreach. We have a focus on education and our website<sup>2</sup> is a feeder into the UK's geography curriculum. It is promoted through the Royal Geographical Society and is being upgraded to ensure that it is mobile- and tablet-compatible and can be viewed on YouTube.

## The House of Lords Inquiry

The Lords Inquiry has performed a very valuable service in bringing focus to a topic that is often regarded as both vast and nebulous. It was a very useful exercise to go through all of the different aspects of the Arctic and its interaction with the UK, while not being side-tracked onto climate change, which is a vast and separate issue.

The Government's response was published in July 2015<sup>3</sup>. The date is important because it was after the General Election, so this is a statement of current Government policy. It endorsed the previous framework, but it also set out a number of further steps which add to the trajectory of UK Arctic engagement and interest.

Some of the key actions have been concerned with making sure, as far as possible, that the UK is well represented on the scientific and technical bodies of the Arctic Council. Particular emphasis has been given to scientific cooperation and in fact the UK was one of very few observer states to submit full information on its methane and black carbon emissions targets.

Our team has been representing the UK at



Arctic events around the world. Perhaps surprisingly, there are more events about the Arctic than about the Antarctic! The recent Glacier Conference, hosted by President Obama and US Secretary of State John Kerry, aimed to coordinate input to the Paris climate change conference by the Arctic states and observers, pointing out the effects of change on the Arctic.

The UK has also been active in the science and innovation network; there are over 75 universities and institutes that have some Arctic focus. A Danish report ranked the UK as fourth in number of citations and third in the number of articles on this topic. So when some of the Arctic States say that the UK is not truly 'bi-polar', we can demonstrate that, actually, we are. The UK's research station in the Ny-Ålesund in the Svalbard archipelago, which was the subject of a 'virtual visit' by the Lords Committee, is also producing great science.

In regard to our commitment to science in the region, the £15 million investment allocated for 2010-15 is now bearing fruit. The results of several research projects have already been published. A further £16 million has now been announced for Arctic research and we are promoting this across the Arctic states to ensure we get international engagement. The UK is also to have a new polar research vessel: although its primary task is to support the UK's presence in Antarctica through science, it will operate in both north and south polar regions and I am sure it will do lots of work in the Arctic.

### Strengthening engagement

The UK's future priorities can be broadly divided into two: 'international' and 'domestic'. The main priority remains that the Arctic should remain peaceful, stable and well-governed. Given the events taking place today, we are not complacent about the effort required from the Arctic States, and indeed observer states like the UK, to ensure that this remains the case. Without this, everything else is, frankly, completely academic.

We need to maintain the UK's commitment to



**The Arctic falls under the jurisdictions of eight Arctic States, five of which border the Arctic Ocean and so have associated maritime rights**

the Arctic Council and ensure that this country is well-represented. We are also looking at strengthening our bi-lateral engagement with the Arctic States. There is already a good Memorandum of Understanding (MOU) with Canada, as well as one with Norway which we are about to renegotiate.

We are working with the EU to encourage a positive outcome to the fisheries moratorium, as well as engaging in future European Polar Net scientific opportunities. We hope that UK companies will involve themselves in the Arctic Business Forum.

Within the UK we are looking forward to engaging with the newly reinvigorated All-Party Parliamentary Group on the Polar Regions, chaired by James Gray with his deputy Neil Carmichael. They have an ambitious agenda which we are supporting.

We hope to hold a Wilton Park conference in 2016, once again to reinforce the UK's position in the affairs of the region. The intention is to examine where the UK and the other observer states can support the work of the Arctic Council through wider international forums where the Arctic States themselves would be in the minority. □

<sup>1</sup> [www.gov.uk/government/publications/adapting-to-change-uk-policy-towards-the-arctic](http://www.gov.uk/government/publications/adapting-to-change-uk-policy-towards-the-arctic)

<sup>2</sup> [www.discoveringthearctic.org.uk](http://www.discoveringthearctic.org.uk)

<sup>3</sup> [www.gov.uk/government/publications/responding-to-a-changing-arctic](http://www.gov.uk/government/publications/responding-to-a-changing-arctic)

Climatic	Environmental	Economic
Arctic changes have the potential to affect UK, European and global weather patterns.	UK shares a common marine and avian biodiversity with much of the Arctic.	Thought to hold 25% of the world's undiscovered hydrocarbons.
Melting ice sheets contribute to global sea level rise.	Potential shifts in the distribution of marine species, including fish stocks.	Potential new trade routes.

**Table 1. Three key areas of interest in the Arctic**



# Understanding changes in sea ice

Julia Slingo



Dame Julia Slingo DBE FRS DSc is Chief Scientist at the Met Office. She leads a team of over 500 scientists working on a broad portfolio of research that underpins weather forecasting, climate prediction and climate change projections. Since joining the Met Office, she has sought to integrate the UK community in weather and climate research to ensure that the UK receives maximum benefit from its science investments.

Looking at the seasonal evolution of Arctic sea ice cover over recent decades, the evidence is clear. As the years progress, the cover gradually drops, particularly in summer to the minimum in September. Over the decades, from the 1980s to the present day, sea ice extent moves further and further below the long-term average for 1981-2010, with some years lying outside the 30-year spread, especially in summer. In recent years there have been some large losses of summer sea ice cover.

While it is possible to debate whether or not the Arctic is changing by cherry-picking individual years, reviewing the figures decade-by-decade shows that something very dramatic is happening.

Another way to characterise this phenomenon is to plot the difference from the long-term average for each month since records began in 1979. What becomes apparent is an overall decline in sea ice cover for all the months of the year. In the early part of the record there is a fairly random variation in the monthly anomalies suggesting no seasonal preference. Then in 2007, a dramatic minimum in summer ice occurs, associated with anomalous wind patterns over the Arctic: the winds were unusually strong and quite a lot of the ice was advected across the basin, revealing a lot of open water.

Since then, the Arctic has moved into a different pattern of behaviour with the monthly anomalies showing a strong annual cycle indicative of large ice loss in summer followed by recovery in winter. Today, the whole system is much more fragile in the summer months. The ice re-forms in the winter but is lost again quite quickly in the summer. Is this a tipping-point in a system close to the edge of sustainability?

By the end of this century, under a high emissions scenario as envisaged by the International Panel on Climate Change (IPCC), the Arctic may be completely ice-free in summer. While there is a great deal of uncertainty in when that will actually happen, the IPCC has been very clear about the general direction of travel.

## Ice volumes

However, it is not just the cover but the volume of ice that is important, since it is the volume that determines the mass and energy balance. There have been studies for some time based on data from submarines and so forth, but more recently

## SUMMARY

- The Arctic is a very complex system which has seen significant changes.
- Advances in observations and modelling have improved our understanding of the region.
- Further changes are expected in years to come as the planet continues to warm.
- Changes in the Arctic are likely to have impacts further afield.
- Understanding the links between the Arctic and UK weather and climate is becoming increasingly important.

the CryoSat programme has made it possible to map the sea ice thickness.

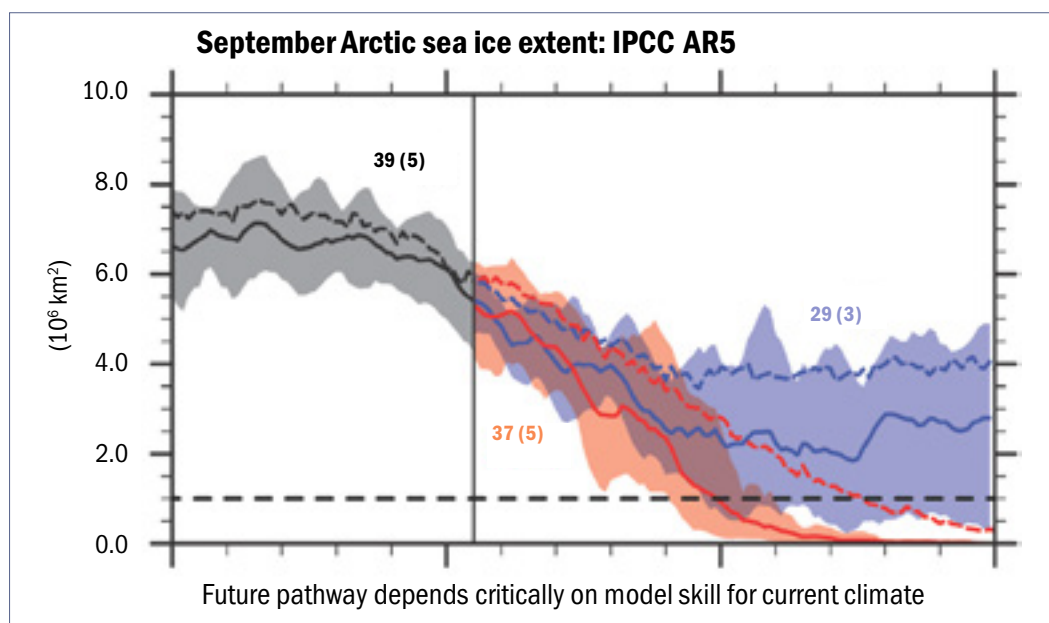
So a really good understanding of ice thickness and hence ice volume is now emerging. What we see is that much of the multi-year ice has been lost; indeed, a large part of the Arctic now is covered by single-year ice (or close to). The consequence is that a storm like the one that occurred in August 2012 can break up the ice cover: this was the principal reason for dramatic loss that year. These storms are unusual, but they occur from time to time and could be the final blow for the summer Arctic ice.

## Dynamics of Arctic sea ice

Arctic sea ice is not static. It does not just form and melt in the same place, it moves around, driven by the great currents – the ocean circulation which is strongly influenced by the bathymetry of the Arctic. In addition, there is a great deal of fresh water flowing in from the Eurasian continent. About 40% of the rivers drain into the Arctic. How that fresh water gets mixed into the central Arctic sea is of great interest, but not something we understand well yet.

It should also be recognised that the pattern of circulation and ice-movement, as well as the ocean currents, can be disrupted by changes in atmospheric circulation. With an anti-cyclonic atmospheric circulation, fresh water accumulates in the Beaufort Gyre and, in the opposite situation, fresh water is exported.

Why does that matter? Because that changes the density of the water flowing out of the Arctic and into the Atlantic and that in turn can affect the



**Figure 1. Reducing uncertainty in Arctic sea ice predictions**

strength of the Atlantic Thermohaline Circulation. Over recent years, there has been a fall in the salinity of the water in the Beaufort Gyre. At some point, that water may propagate out of the Arctic and come into the North Atlantic, changing the strength of the thermohaline circulation.

### The Arctic is a complex system

Some people see the Arctic as a deceptively simple system: an increase in temperature causes ice to melt; this results in a darker surface which absorbs more of the sun's energy; and so on. That is a one-dimensional view of the Arctic which bears little relation to what is actually happening. The region is much more complex. The transport of energy, of salinity, of heat, of fresh water from river outflows and indeed pollutants like black carbon into the Arctic and out again – all are absolutely critical for describing the very subtle energy balance of the whole system.

That complexity explains why the IPCC projections of September Arctic sea ice have such a wide spread. However, it is possible to give a relatively clear message of where the region is heading. When we take all the IPCC models, in some instances there might still summer sea ice by the end of the century.

If we take only the more realistic models based on their ability to represent observed Arctic sea ice behaviour – and there are only a few of them (five out of 37) – then we get a different perspective of when the Arctic might be ice-free in September; it happens sooner rather than later. So there is still much uncertainty which we need to reduce if we are to get a clear idea of where the climate is heading.

As the Arctic opens up, there will be an increasing need for weather forecasting and the forecast-

ing of ice movement in the region. That is what the World Meteorological Organisation's Polar Predictions Project is concerned with. There are significant challenges here in understanding the meteorology of Arctic weather systems, yet this is vital for successful operations in the Arctic and for ships to cross the Arctic safely in summer.

This is very exciting. The Year of Polar Prediction – which actually lasts for two years, mid-2017 to mid-2019 – will be a major international initiative employing a number of additional observing systems around the rim of the Arctic Ocean. It will complement the more fundamental research that is also going on.

Prediction tests our current understanding of a system and our ability to simulate it, so this project promises to open up many scientific insights.

There has also been a great deal of progress in the last few years in the use of fully-coupled climate models for seasonal forecasting of the summer sea ice minimum in the Arctic. The latest models have a much higher resolution in the ocean and atmosphere, and the simulation of the Arctic is much-improved. Last year's forecast of  $4.4 \times 10^{12} \text{ m}^2$  for the September monthly minimum in Arctic summer sea ice extent was very close to what was observed.

### Impacts on the UK

So what does a warming Arctic mean for the UK? There has been speculation about Arctic amplification – that a large warming of the Arctic is disrupting our weather patterns and leading to more prolonged spells of settled weather but also some very stormy weather. Is it changing the nature of the Jetstream, perhaps? Well, the jury is still out on this and the

### FURTHER INFORMATION

**The House of Lords Arctic Select Committee Report**

[www.parliament.uk/arcticcom](http://www.parliament.uk/arcticcom)

**Adapting To Change: UK policy towards the Arctic**

[www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/251216/Adapting\\_To\\_Change\\_UK\\_policy\\_towards\\_the\\_Arctic.pdf](http://www.gov.uk/government/uploads/system/uploads/attachment_data/file/251216/Adapting_To_Change_UK_policy_towards_the_Arctic.pdf)

**House of Lords debate on the Select Committee Report on the Arctic**

[www.publications.parliament.uk/pa/ld201516/ldhansrd/text/151103-0001.htm#15110341000427](http://www.publications.parliament.uk/pa/ld201516/ldhansrd/text/151103-0001.htm#15110341000427)

**Government response to House of Lords report**

[www.gov.uk/government/publications/responding-to-a-changing-arctic](http://www.gov.uk/government/publications/responding-to-a-changing-arctic)

**Arctic Council** [www.arctic-council.org](http://www.arctic-council.org)**British Antarctic Survey** [www.bas.ac.uk](http://www.bas.ac.uk)**Discovering the Arctic** [www.discoveringthearctic.org.uk](http://www.discoveringthearctic.org.uk)**Foreign and Commonwealth Office**

[www.gov.uk/government/organisations/foreign-commonwealth-office](http://www.gov.uk/government/organisations/foreign-commonwealth-office)

**Met Office** [www.metoffice.gov.uk](http://www.metoffice.gov.uk)**Scott Polar Research Institute** [www.spri.cam.ac.uk](http://www.spri.cam.ac.uk)

latest research does not give this much credence.

On the other hand, observations do suggest that low Arctic sea ice in summer predisposes us to a negative North Atlantic Oscillation in winter – in other words it might be a colder winter. Yet this is not the only factor affecting UK weather, take the big El Nino event this year for example. There are so many factors that analysing and predicting what the Arctic itself is doing to our weather is incredibly difficult.

There is a very long way to go before we have the ability to give a definitive answer on what the changing Arctic might mean for the UK. Yet it is hard to believe the changes that are going on there will not affect the water masses that enter the North Atlantic and hence the Thermohaline Circulation. The Gulf Stream is part of that circulation and so understanding how the changing Arctic will affect the ocean is vital and requires a great deal more work.

The Arctic is a really complex system which has seen significant changes commensurate with global warming. Further changes can be expected as the years go by and the planet continues to warm. The Arctic will not change linearly, though, because of the interaction between natural variability and long-term climate change. However, understanding the links between the Arctic and UK weather and climate is becoming increasingly important and we must make it, and continue to make it, an active area of research. □

## The debate

Issues raised in the debate included the impact of geopolitics, global warming and the coordination of UK efforts.

The nature of the changes in the region and the resulting opportunities (as well as dangers) are global in their impact. More distant states, such as India and Singapore, understandably share the UK's interests and concerns about climate, scientific research, energy supply, shipping routes, etc.

It has been a major success to date to insulate international cooperation in the Arctic from wider geopolitical tensions. Can this continue, though? The sanctions against Russia in the wake of its annexation of Crimea could have adverse consequences for research and other cooperation in the Arctic. The more that major countries outside the region see their interests being directly affected by events in the Arctic, the more likely that friction and conflict may arise, not only between those states but also between them and the eight Arctic States. Not all states interested in the region can be relied upon to consider the concerns of the indigenous population too. Perhaps greater application

of 'soft sciences' in Arctic issues could help deal with potential international problems.

The stability of the Greenland ice shield is not yet a problem but the impact of melting on global sea levels would be immense. Moreover the effect of a global temperature rise on such ice sheets could be felt for centuries after temperature had stabilised.

### Effects of melting

Melting permafrost in the summer will destabilise buildings, cut off transport links and potentially release large quantities of methane, a potent greenhouse gas. Changes of water temperature influence fish habitats. For example, cod are seeking cooler waters by moving north from the Labrador coast.

The UK's potential contribution to developments in the Arctic extends well beyond science into areas such as oil, gas and minerals developments, as well as law, finance and insurance. These interests could be better coordinated. □

**Using science to authenticate, verify or assure the identity of people and things**  
**2 March 2016**

**Sir Mark Walport** FRS FMedSci, the Government Chief Scientific Adviser  
**Professor Sue Black** OBE FRSE, Professor of Anatomy and Forensic Anthropology at the University of Dundee  
**Dr Derek Craston**, the Government Chemist and Managing Director of Science and Innovation at LGC

**Bringing science to the heart of government: the Nurse Review of the Research Councils**  
**12 January 2016**

**Sir Paul Nurse** FRS FMedSci, Chair, the Nurse Review of the Research Councils, and Director, The Francis Crick Institute  
**Professor Phil Nelson** FREng, Chair, RCUK Executive Group and Chief Executive, Engineering and Physical Sciences Research Council  
**Gareth Davies**, Director General, Business and Science, Department for Business, Innovation and Skills  
**Professor Dame Jocelyn Bell Burnell** DBE FRS FRAS PRSE, President, The Royal Society of Edinburgh [Panellist]

**Closing the US/UK productivity gap: connecting innovation and research to economic output**  
**2 December 2015**

**Dr Ruth McKernan** CBE, Chief Executive, Innovate UK  
**Professor Jonathan Haskel**, Professor of Economics, Imperial College Business School  
**Tony Harper**, Head of Research and Advanced Systems Engineering, Jaguar Land Rover

**Responding to a changing Arctic: The House of Lords Arctic Select Committee Report**  
**4 November 2015**

**The Lord Teverson**, Chair, House of Lords Select Committee on the Arctic, House of Lords  
**Jane Rumble**, Head, Polar Regions Department, Foreign and Commonwealth Office  
**Professor Dame Julia Slingo** DBE FRS, Chief Scientist, Met Office

**The Accelerated Access Review for the Department of Health (the Taylor Review)**  
**26 October 2015**

**Sir Hugh Taylor** KCB, Chair, Accelerated Access Review, Department of Health  
**Sir Leszek Borysiewicz** FRS FRCP FMedSci FLSW, Vice-Chancellor, University of Cambridge

**The Future of the Energy Sector in Scotland**  
**22 October 2015**

**Phil Boswell** MP, MP for Coatbridge, Chryston & Bellshill, House of Commons  
**Iain Conn** FREng FRSE, Chief Executive, Centrica plc  
**Gary Haywood**, Chief Executive Officer, INEOS Shale  
**Professor Rebecca Lunn** FRSE FREng, Head of Department, Civil and Environmental Engineering, Professor of Engineering Geosciences, University of Strathclyde  
**Ben Ritchie**, Senior Investment Manager, Pan-European Equities, Aberdeen Asset Management [Panellist]

**The Dowling Review of Business-University Research Collaborations**  
**7 October 2015**

**Professor Dame Ann Dowling** DBE FRS FREng, President, Royal Academy of Engineering  
**Sir Peter Gregson** FREng, Vice-Chancellor and Chief Executive, Cranfield University  
**Eric Hawthorn**, Managing Director, Radio Design Ltd  
**Professor Jeremy Watson** CBE FREng FIET, Professor of Engineering Systems, University College London [Panellist]

**How can international research be mobilised to drive down the cost of renewables, storage and smart grids to achieve parity with coal fired electricity generation?**  
**8 July 2015**

**Sir David King** ScD, FRS, HonFREng, The Foreign Secretary's Special Representative for Climate Change, Foreign and Commonwealth Office  
**Dr Bernie Bulkin**, Director, Ludgate Investments Ltd  
**Ed Heartney**, Environment, Science, Technology and Health Counsellor, Embassy of the United States of America in London  
**Sir Colin Humphreys** FRS FREng, Department of Materials Science, University of Cambridge [Panellist]

**The business of the environment: can the tension be resolved between resource extraction and environmental protection?**  
**24 June 2015**

**Professor Duncan Wingham**, Chief Executive, Natural Environment Research Council  
**Professor Simon Pollard**, Pro-Vice-Chancellor, School of Energy, Environment and Agrifood, Cranfield University  
**The Lord Oxburgh**, House of Lords

**Professor Jane E Francis**, Director, British Antarctic Survey [Panellist]

**Is the Haldane Principle fit for purpose in the 21st Century?**  
**3 June 2015**

**The Lord Hennessy of Nympsfield** FBA, Member, House of Lords Select Committee on Science and Technology, House of Lords  
**The Lord Rees of Ludlow** OM Kt FRS, Former President, The Royal Society  
**The Rt Hon David Willetts**, Former Minister of Universities and Science  
**Professor Jane Elliott**, Chief Executive, Economic and Social Research Council [Panellist]

**A framework for making policy choices: bridging the gap between scientific and value judgements**  
**20 May 2015**

**Sir Mark Walport** FRS FMedSci, Government Chief Scientific Adviser, Government Office for Science  
**Professor Angela R McLean** FRS, Co-Director, Institute for Emerging Infections, University of Oxford  
**John Pullinger**, National Statistician, Head, Government Statistical Service and Chief Executive, UK Statistics Authority

**What are the lessons learned from the response to the Ebola outbreak?**  
**25 March 2015**

**Professor Chris Whitty** CB FMedSci, Chief Scientific Adviser, Department for International Development  
**Dr W Ripley Ballou**, Vice-President and Head, Clinical Research and Translational Science, Vaccine Discovery and Development, GSK Vaccines  
**Dr Oliver Johnson**, Programme Director, the King's Sierra Leone Partnership  
**Dr Gina Radford**, Deputy Chief Medical Officer for England, Department of Health

**Our plan for growth: science and innovation (Cm 8980)**  
**4 February 2015**

**The Rt Hon Greg Clark** MP, Minister of State for Universities, Science and Cities, Department for Business, Innovation & Skills and Cabinet Office  
**Professor Dame Ann Dowling** DBE FRS FREng, President, Royal Academy of Engineering  
**Dr Mike Lynch** OBE FRS FREng, Founder, Invoke Capital  
**Professor Alex Halliday**, Physical Secretary and Vice-President, The Royal Society [Panellist]

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## Reception

**3 December 2014**

**The Rt Hon David Willetts MP**, MP for Havant

**Sir Mark Walport FRS FMedSci**, Government Chief Scientific Adviser, Government Office for Science

## The Hauser Review of the Catapult Network

**12 November 2014**

**Dr Hermann Hauser CBE FRS FREng**, Chair, Hauser Review of the Catapult Network

**Simon Edmonds**, Director, Catapult Programme, Innovate UK

**Adrian Allen**, Commercial Director, University of Sheffield Advanced Manufacturing Research Centre (AMRC) with Boeing

## Maximising the strengths of the research and innovation base in Scotland (debate in Edinburgh co-organised with The Royal Society of Edinburgh)

**29 October 2014**

**Professor Muffy Calder OBE FRSE FREng FBCS**, Chief Scientific Adviser for Scotland

**Professor Alice Brown CBE FRSE FRSA**, Chair, Scottish Funding Council

**Anne Richards CVO CBE**, Global Chief Investment Officer, Aberdeen Asset Management

## How can the UK transport network be made more resilient to extreme weather events?

**22 October 2014**

**Richard Brown CBE**, Chairman, Transport Resilience Review for the Department for Transport

**Doug Johnson**, Deputy Director Applied Science and Scientific Consultancy, Met Office

**Jerry England**, Group Asset Management Director, Network Rail

## Science and Society programmes: what are the best ways of measuring success? (Round-table discussion)

**16 October 2014**

**Sir Roland Jackson Bt**, Executive Chair, Sciencewise

**Professor Nick Pidgeon MBE**, Professor of Applied Psychology, School of Applied Psychology, Cardiff University

## Regulating charities: a Whitehall perspective (House of Lords Luncheon for Learned and Professional Societies)

**3 October 2014**

**Ben Harrison MBE**, Policy Manager, Office for Civil Service at the Cabinet Office

## What is the right level of response to anthropogenic induced climate change?

**16 June 2014**

**Sir Mark Walport FRS FMedSci**,

Government Chief Scientific Adviser, Government Office for Science

**David Davies MP**, MP for Monmouth

**Professor Jim Skea CBE**, Imperial College London and the Committee on Climate Change

**The Rt Hon Peter Lilley MP**, MP for Hitchin and Harpenden

## Making the most of UK/China research and innovation partnerships

**11 June 2014**

**Professor Tony Cheetham FRS**, Treasurer and Vice-President, The Royal Society

**Michael Kwok**, Managing Director and Head, Shanghai Office, Arup

**Professor Robin Grimes FREng**, Chief Scientific Adviser, Foreign and Commonwealth Office

**The Rt Hon David Willetts MP**, Minister of State for Universities and Science, Department for Business, Innovation and Skills

## Making the most of UK/China research and innovation partnerships (Round-table discussion ahead of the evening debate)

**11 June 2014**

**Sir John Boyd KCMG**, Chairman, Asia House

**Michael Kwok**, Managing Director and Head, Shanghai Office, Arup

## Responding to the rapid increase of Antimicrobial Resistance (AMR) in organisms

**4 June 2014**

**Dame Sally Davies DBE FMedSci**, Chief Medical Officer for England and Chief Scientific Adviser, Department of Health

**Dr Jeremy Farrar OBE FMedSci**, Director, The Wellcome Trust

**Dr Patrick Vallance FRCP FMedSci**, President, Pharmaceuticals R&D, GSK

## Delivering the Agri-tech Strategy: Improving the quality and productivity of the UK food production and processing sectors

**21 May, 2014**

**George Freeman MP**, MP for Mid-Norfolk, House of Commons

**Dr Peter Bonfield OBE FREng**, Independent Chair, British Food Plan, Defra and Chief Executive, BRE Group

**The Lord Haskins**, Former Chairman Northern Foods and House of Lords

## Policy choices for the reduction of bovine tuberculosis (TB)

**2 April 2014**

**Adam Quinney**, Farmer and former Vice-President, NFU

**Professor Rosie Woodroffe**, Senior Research Fellow, Institute of Zoology, Zoological Society of London

**Dr Miles Parker OBE FSB**, Senior Research Associate, Centre for Science and Policy, University of Cambridge

**Professor Chris Gaskell CBE**, Principal, Royal Agricultural University

## Turning knowledge into value: adding value to the marine sector from research and innovation

**10 March 2014**

**Professor Ralph Rayner**, Sector Director Energy and Environment, BMT Group

**Professor Ed Hill OBE**, Executive Director, National Oceanography Centre

**Professor Rick Spinrad**, Vice-President for Research, Oregon State University,

President-Elect, Marine Technology Society

**Professor Richard Clegg**, Managing Director, The Lloyd's Register Foundation [Panellist]

## The challenge of communicating uncertainty in risk estimates to decision-makers

**5 February 2014**

**Sir Mark Walport FRS FMedSci**, Government Chief Scientific Adviser, Government Office for Science

**Tom Bolt**, Director, Performance Measurement, Lloyd's of London

**Judith Hackitt CBE**, Chair, Health and Safety Executive

**Dr Michelle Harrison**, CEO, Government and Public Sector Practice, WPP [Panellist]

## The economics of decarbonisation of the UK electricity supply: how much are we prepared to pay to meet carbon reduction targets?

**27 November 2013**

**James Smith CBE**, Chairman, The Carbon Trust

**Dr David Clarke FREng**, Chief Executive, Energy Technologies Institute

**Baroness Verma**, Parliamentary Under-Secretary, Department for Energy and Climate Change

## An international initiative to drive down the cost of solar and associated storage

**27 November 2013**

**Sir David King FRS**, Foreign Secretary's Special Representative for Climate Change, Foreign and Commonwealth Office

**Ian Simm**, Chief Executive, Impax Asset Management

## Maximising the value of UK strengths in research, innovation and higher education

**13 November 2013**

**Professor Sir John O'Reilly**, Director General, Knowledge and Innovation, Department for Business, Innovation and Skills

**Ben Ritchie**, Senior Investment Manager, Pan-European Equity, Aberdeen Asset Management

**Professor Geoff Rodgers**, Pro-Vice Chancellor for Research, Brunel University

**Peter Marsh**, Author 'The New Industrial Revolution' and former Manufacturing Editor, Financial Times [Panellist]

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Royal Society of Chemistry  
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