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Energy security of supply

Science communication

Strategic subjects in higher education

Science and the City

Nuclear power

THE FOUNDATION FOR SCIENCE AND TECHNOLOGY

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Climate Change Programme review

The Royal Society, in its response to the Government's Climate Change Programme review, has warned that the Government "is still over-estimating how much the UK can cut its carbon dioxide emissions without changes in current policy". Sir David Wallace, Vice-President of the Royal Society, said on 16 May that "at the current rate, even the Government's revised assessment of how much carbon dioxide the UK will cut is frankly unrealistic".

The Royal Society has recommended that the Government should, in its revised climate change programme, introduce a carbon tax which would put a cost on all emissions of carbon dioxide from all sectors including industrial, domestic and transport. This would encourage the development of cleaner technologies and a move away from carbon based fuels in the overall energy supply as well as promoting energy efficiency measures. A report by the Royal Society has shown that the impact of a carbon tax on long-term global GDP would be negligible.

It also argues that the Government's revised Climate Change Programme must "spell out its resolve to look at how we deal with the loss of capacity from nuclear power stations and look at the role that all energy sources including nuclear, along with energy efficiency measures, might play in meeting the Government's ambitions for cutting carbon dioxide emissions".

Meanwhile the Sustainable Development Commission (SDC), the Government's independent advisory body on sustainable development has produced a report, *Wind power: tackling climate change and energy security*, which argues that "the UK has the best and most geographically diverse wind resources in Europe, more than enough to meet current renewable energy targets". Looking further ahead, Sir Tom Blundell, former Chairman of the Royal Commission on Environmental Pollution, says in the report's foreword: "At current levels of gas prices, and certainly if credit is given for its carbon-free status in line with current Government estimates of the social cost of carbon, [wind] is already cost-competitive with gas-fired electricity on the best onshore wind sites, and seems likely to be the cheapest of all forms of power generation by 2020 on such sites, even without a carbon credit."

This contradicts the 2004 report from the Royal Academy of Engineering, *The Costs of Generating Electricity*, which argued that gas turbine and nuclear generated electricity was about two thirds of the cost of onshore wind energy. The RAE report allows for significant conventional back-up power to compensate for the intermittent nature of wind power. The SDC study says, though, that increasing the proportion of wind power in the electricity system does not require greater back-up capacity.

www.royalsoc.ac.uk
www.sd-commission.org.uk
www.raeng.org.uk

EU proposes a doubling of research spending

EU funding for R&D is set to double under proposals issued by the European Commission in April. The Seventh Framework Programme will run from 2007 to 2011 and envisages a total Community expenditure of EUR7.32 billion.

This is split between five areas or types of activity: cooperation – trans-national cooperation on policy-defined themes; ideas – investigator-driven research springing from research community initiatives; people – supporting individual researchers; capacities – which the Commission rather circuitously describes as 'support of research capacities'; and a much smaller component for 'non-nuclear actions of the Joint Research Centre'.

Activities within the 'cooperation' category take the lion's share of the funding – some €44.7 billion. Nine broad priority areas have been identified: health; food, agriculture and biotechnology; information and communication technologies; nanosciences, nanotechnologies, materials and new production technologies; energy; environment (including climate change); transport (including aeronautics); socio-economic sciences and the humanities; and security and space.

The Commission says that "investing in knowledge is certainly the best, and maybe the only, way for the EU to foster economic growth and create more and better jobs, while at the same time ensuring social progress and environmental sustainability". The proposals will have to be negotiated with the Council of Ministers and the European Parliament before they can be finalised.

http://europa.eu.int/eur-lex/lex/LexUriServ/site/en/com/2005/com2005_0119en01.pdf
www.foundation.org.uk/801/130704.pdf

Road pricing a step nearer

The Department for Transport (DfT) is to conduct a pilot study in a major urban centre to evaluate the potential of road pricing for cutting congestion. The transport secretary, Alistair Darling, said at the beginning of June that five or six areas were under consideration and that the decision would be taken during the next two years.

A DfT feasibility study, published last July, concluded that road pricing could reduce congestion by up to 40% and could lead to savings of £12 billion a year through time savings and increased reliability.

www.foundation.org.uk/801/090305.pdf

Review of strategic subjects in higher education

In a letter to the chairman of the Higher Education Funding Council for England (HEFCE) on 1 December 2004, Education and Skills Secretary Charles Clarke asked the Council for advice on the issue of strategic subjects in higher education (see also pages 13-17 of this issue). The letter asks "whether there are any higher education subjects or courses that are of national strategic importance, where intervention might be appropriate to enable them to be available". It also invites the Council's views on how to encourage further research collaboration between higher education institutions, and how these bodies might make a greater contribution to regional skills strategies. HEFCE is due to respond in June 2005.

www.hefce.ac.uk/news/hefce/2004/stratsubj/ssletter.pdf

Emissions trading begins in earnest

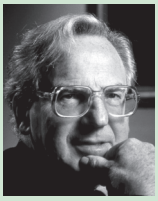
The UK Emissions Registry opened in the last week of May, allowing spot trading of carbon emissions allowances to take place for the first time under the EU Emissions Trading Scheme. Up till this point, only forward trading – mainly for December 2005 – could take place. The Emissions Trading Registry is web-based, and records CO_2 allowances and units that are held in firms accounts, and their compliance. It allows allowances to be transferred to other accounts both within the UK and in other participating countries. The Registry software, developed by The Department for the Environment, Food and Rural Affairs (Defra), has now been licensed to 12 other EU states.

The UK, though, has been forced to accept a lower total volume of allowances than it had proposed in its revised National Allocation Plan (NAP) submitted last November to the European Commission. The revisions were due to changes in energy consumption projections, with consequent increases in emissions allowances. The Commission rejected the revised version, arguing that it had definitively accepted the original, July 2004, plan. The British Government has referred the matter to the European Court of First Instance, but no decision is expected till 2006.

Energy is a vital component of virtually every aspect of modern life. The challenge of ensuring secure supplies of this essential commodity was the focus of the Foundation's meeting in Edinburgh on 28 October 2004.

Renewables – more than motherhood and apple pie

Stewart Sutherland



The Lord Sutherland of Houndwood Kt FBA PRSE is president of the Royal Society of Edinburgh. He is a member of the Select Committee on Science and Technology of the House of Lords and he took part in the committee's inquiry into renewable energy. Lord Sutherland is a distinguished philosopher and fellow of the British Academy. He has been principal and vice chancellor of the University of Edinburgh and principal of King's College, London, as well as vice chancellor of the University of London. He is currently provost of Gresham College and a member of the Council of the Foundation for Science and Technology.

We are all in favour of renewable energy. It is not just motherhood and apple pie, it is more than that; we all want to see more renewable energy because long-term sustainability is an issue of which, I think, the population is now more aware than ever. However, what are the practical steps needed to increase the proportion of renewables used in the creation of energy and power? How does this relate to security of supply? I want to raise one or two of the issues that were addressed in the *Renewable Energy Practicalities* report from the House of Lords Science and Technology Inquiry. I want to look at one or two of the conclusions and some of our suggestions to the Government.

There are a number of aspects to security of supply. Clearly, it means that there is enough energy to generate electricity or to run cars, be that gas, oil, renewables, nuclear or hydro. Yet, who is responsible for that? If we are drawing our gas supplies from central Russia, is that a secure base on which to build the economy (the Middle East and North Africa bring the same sort of issues to mind)? There is a separate range of questions about the security and effectiveness of supply routes — how do you get the resources from there to here? There is another element too: how do we get electricity down the wires to the users? Look at the problem in New York in 2003 — there was plenty of energy over the border in Canada but there was a problem in actually getting it through the switching system which resulted in a blackout in the city.

So, security of supply covers a range of issues, starting, most obviously, with how we prevent the lights going out. Where does real responsibility for this lie? The Government has a policy in which the market plays a very large part. Now, like motherhood and apple pie, I am in favour of markets as well; they are good things but they have their limits and constraints. It is the business of a large company to carry out its tasks in such a way that it makes a profit: it is not therefore going to take on unnecessary risks. The members of the inquiry believed there has to be a degree of partnership and interaction between government and business, clear shared responsibility with clear accountability.

Take the issue of wind power: the Government is committed to a very specific target and rightly so. We are in favour of wind power, we want this to be maximised. Yet wind can be intermittent and may die away when a high pressure area settles over the country. There is a risk involved. So, you have to have a back-up supply of some kind. Currently, if you have 10 per cent of your capacity in electricity generation coming from wind, you will need something like 20 per cent extra capacity to deal with the fluctuations that this implies. That means the Government's target of 10 per cent by 2010 actually implies 20 per cent additional generating capacity. And the more you go above 10 per cent of wind power, the greater the additional cost in generating the back-up and therefore the greater the commercial risk somebody has to take. Companies may take that on, but, again, they may not.

Current grid design carries a risk, too. If the pattern of electricity supply is to accommodate a move towards a larger number of generating centres (as would be the case with renewable generation) then the grid has to be altered in a number of ways. Infrastructure costs are attached to this, be it switching capacity or the fact that electricity may have to flow at different times up or down the wires. The money needed for this future provision will have to be found. We could, of course, depend more heavily on our connections to mainland Europe for our energy; again there has to be investment and there are costs. One of the conclusions that we came to through all of this was that energy — particularly electricity — is currently under-priced in this country.

This is where our proposals for government come into play. There is a need for policy, planning and targets that are more coordinated than the mantras of 'joined up government' that we hear. There are some good initiatives but if you try to find where responsibility lies for this long-term policy planning and implementation, it is not as easy as you would expect. We

decided to be straightforward and to call for a dedicated Minister of Energy whose sole responsibilities would be energy supply and the creation of the long-term stability that we want in building up capacity. That individual would have to bring about the right conditions for the Cabinet and, eventually, Parliament to make fairly big political decisions.

One of these decisions concerns the percentage of energy supplied by renewables. This is a very important question; we have referred to wind, but we also recommended very strongly that further exploration should be given to tidal power and wave power. Our committee (of the inquiry) was shown how the risks attached to a single form of renewable energy could be mitigated substantially if there was a whole series of renewable sources in the supply mix; not all of them are at risk at the same time and in the same conditions. The Government would need to decide on these questions because we do not think that the market will.

Regulation is in need of overhaul. A biomass producer told us that they could use chicken effluent but not the feathers, because one was classed as waste material and one was not! This may be a trivial example, but it highlights the fact that some clarification of regulation is essential.

There has to be a decision on the nuclear option: as power stations run down a significant part of our capacity disappears but, as yet, there is no clear government policy about how that will be replaced.

discussion

Policy and investment. Policy and regulation need to be stable and predictable if business is to invest in long-term projects. The record of government in changing the rules can be seen in the experience of the North Sea energy industry over the last 20 years. While stability is essential, so too are coherence and consistency. Too often different government departments seem to set targets independently of each other and these policies can work against each other. The comment was made that security of supply, prices and the drive towards a low carbon economy are potentially in conflict and there is a need for a more integrated approach.

Nuclear has an advantage in relation to CO_2 emissions, but there are difficulties and drawbacks — disposal of waste material, for example. Whichever way we go, the huge costs, significant investment and technological problems must be addressed between now and any re-commissioning or new building that might take place. The decision is again a Government matter.

The members of the inquiry believe that the responsibility for security of supply — to ensure that the lights do not go out — ultimately rests with the Government. We do not believe that the risks involved will be accepted by the private sector alone. Nuclear, renewables, costs of infrastructure: all of these require Government decisions and without a Minister of Energy to drive them forward, they might not be taken.

I remember a slogan of Macmillan's: '300,000 houses a year'. Owing to insufficient government attention in the years after the war, huge housing problems had arisen. A minister was appointed, one with talent because he did make huge inroads into the housing market. He had sufficient powers and, more importantly, the ability to argue in Cabinet. We need something of that order today: a minister with sole responsibility for energy who would try to bring about the conditions for long-term stability in prices of power, and particularly renewables. Firms will not invest unless they see a reasonable horizon when prices will match the level of investment required.

I believe this is not simply a matter of either the market or the state providing the answer, but rather public/private partnerships of one form or another. We will also need extended and informed public debate on the issues relating to security of supply, driven not just by groups like us, but by Government.

Looking at the options

Peter Mather

Peter Mather is head of country, UK, and vice president, Europe Region, for BP Group. Prior to this appointment he was vice president of external affairs, with responsibility for Europe, including UK and EU activities, and sub-saharan Africa. He has run the supply, trading and marketing business for BP's North Europe gas business and was managing director of BP's UK gas and power activities.

We have not worried about security of supply for years, but suddenly the phrase seems to be on everybody's lips. A number of things have put this at the top of the agenda: the terrorist attack of 9/11 clearly had an enormous impact, particularly in the US, and has created a concept of homeland security which includes energy (a lot of the terrorist activities were deemed to be coming from energy-producing parts of the world). Geo-political instability in Iraq, the potential fragility of Saudi Arabia and its regime, the shift to greater import dependency in the US and Europe (including the United Kingdom) and, more recently, higher energy prices have all put this issue into stark relief.

There have been market and infrastructure failures. Lord Sutherland referred to the blackout in New York, but things have also gone wrong in California, London and parts of Europe, fortunately on a relatively minor scale. There have been corporate failures such as Enron, the biggest energy trader in the US and one of the biggest in Europe, which clearly do not inspire enormous confidence in the market. Finally, the global climate change debate is inextricably linked with security of energy supply.

Why is security of supply such a big issue in the United Kingdom? We have been energy self-sufficient for 20–25 years now and we have been very comfortable; to be perfectly frank, we have not needed an energy policy (and we have not had a particularly active one) because this has been a period of oversupply, from our wonderful assets in the North Sea. We have been spoilt with very low prices: the average price of crude oil in the 1990s was US $18.50 a barrel and

when I took over my previous job, heading up natural gas for BP in the United Kingdom, I think gas was selling at 9 pence per therm.

Today, gas prices are much higher and the UK regulator, Ofgem, has recently investigated why this has happened. Two factors highlighted in an Ofgem report were the link with Europe and European oil prices (the United Kingdom is no longer an energy island) and the decline in UK supplies. In fact, I believe the United Kingdom is still just self-sufficient in natural gas but not during peak periods. If we do get that 1 in 20 really cold winter that everyone says should come next year (but has not for the last three) then we could have an issue.

Security of supply has also climbed up the political agenda in this country because of our commitment to the Kyoto agreement and the major focus on this subject that the UK presidency of the G8 will have in 2005. In addition, we have an ageing energy infrastructure — not just our nuclear power stations but a lot of our conventional power generation plants are quite old.

Production in the United Kingdom is in line with current demand, but by 2015 that will no longer be the case. So what is going to fill the gap? There are several possibilities: pipeline gas from Norway; liquefied natural gas (LNG) which is going to play a role in the United Kingdom that it has not played for years (the UK was actually one of the first players in this industry, many years ago); the interconnector capacity between Bacton and Zeebrugge, which was originally designed to take gas from the United Kingdom to Europe but is now being upgraded so that it can become more of an entry point for supplies to this country; and finally, storage. Traditionally, the United Kingdom has had very low storage capacity, mainly because of the gas fields sitting off Norfolk and Scotland. However, as these are depleted, we will have to get up to the same level of storage capacity as the Continent, which is significantly greater.

Security of supply is not just about gas, it is also about transport fuels. These account for between a third and a half of our future contribution to CO_2 levels in the atmosphere, so they are a massive part of the problem of climate change. The world has not yet found an adequate substitute for the internal combustion engine, although many have tried. We have looked very hard at the problem at BP, but oil is an incredibly efficient fuel for transportation. There have been recent advances like zero sulphur fuels and increasing dieselisation, which emit about 14–15 per cent less CO_2 than conventional petrol. Indeed, we have just put a new product on the market called BP Ultimate which again reduces CO_2 by 10–12 per cent because of the efficiency improvement in the engine; there is a lot that can be done with the existing hydrocarbon mix in the internal combustion engine. But we have to look beyond that. Hydrogen is possibly the only contender that we see at the moment: however, it has a number of problems.

Hydrogen does not exist in a natural state so it has to be extracted either from hydrocarbons or from water – and that is an energy intensive process. In addition, there is no infrastructure for hydrogen distribution. We have just completed a fuelling station in Romford in Essex which will fuel a hydrogen fleet in London. The planning permission process has been an absolute nightmare, if I am honest; there is a lot of bad feeling about hydrogen in the same way there is about nuclear – people think about the Hindenburg airship that blew up in 1937 (somebody told me that actually what exploded on the Hindenburg was not the hydrogen, it was the kerosene that was required as back-up). For our generation transport fuels are crucially important.

Demand management — reducing vulnerability by consuming less — is an area where, just in our own manufacturing business, we have found enormous savings. Five years ago, site managers did not have a clue what their emissions were or what they spent on energy: energy was the business we were in so it was not seen to cost anything. In fact, it does cost something because you either have to buy it in or you forgo an opportunity to sell it out. We are actually spending about $300-400 million a year on energy-saving activities within our business but the Net Present Value (NPV) of these investments is much greater. In other words, it is good business; saving energy in manufacturing plants and offshore facilities is very, very good business.

There are a number of areas where I am sure technology and innovation will bring new solutions. Carbon sequestration is one. We discovered gas in Algeria that had a 10 per cent CO_2 content which is far too high for the European grid (which takes something like 3 per cent). We are now engaged in a project that re-injects the CO_2 1,800 metres under the Sahara desert where we hope it will stay. In terms of CO_2 savings this is equivalent to taking 200,000 cars off the road. If the world could think about carbon sequestration on a more coordinated and larger scale, that would make a big contribution to tackling climate change. There are others of course.

Security of supply and climate change are interconnected. Import dependency is not that bad; many countries in the OECD have been dependent on imports for many, many years and Algeria, Russia, even OPEC, have been reliable suppliers. Even during the worst of its internal problems, Algeria was a reliable supplier of natural gas. I am not aware of problems with supply from Russia during their turbulent years, so it is not all bad being import-dependent; the United Kingdom is no longer an island and it will be less so with all these pipelines coming in.

Investment is taking place, the industry is not just sitting on its hands, but can everything be left to the market or does there need to be intervention? I have spent my life working in markets, so I am obviously biased: I do believe that markets can provide solutions if they are allowed to function properly. This is not what happened in California; intervention in that market made it dysfunctional and the whole thing did not work. However, I do believe that a framework is required from the Government so that we know that there will be consistency of approach for 10 or 20 years. I know that is asking a lot of any government but I think that will help to stimulate investment.

We also need diversity of supply. We must not become over-reliant on any one particular source — Russia for example — we need a broad mix. And finally, we need to keep our options

discussion

Non-fossil fuel. What could replace nuclear power? There will be a gap as the current plants are decommissioned. Wind power only accounts for 0.4 per cent of current generating capacity. The comment was made that all the wind farms in the world, if located on the South Downs, would not generate 20 per cent of UK demand. Many of the renewable technologies still need considerable research and funding to move them forward. Major investments in transmission infrastructure will also be needed to provide grid access for wind power. The Government needs to set ground rules for the planning system, which is there to protect people as well as to allow economic development.

Creating the conditions for stability

Kieron McFadyen

Kieron McFadyen is technical director of Shell in Europe and is the Royal Dutch/Shell Group's senior exploration and production representative on the board of Shell UK. He is also a member of Pilot, the Industry Leadership Team and a board member of the UK Offshore Operators Association. Previously, as vice president Europe, he had the key task of supporting the development of Shell Exploration & Production's new European organisation.

The importance of gas security of supply to the United Kingdom is pretty well laid out in the Energy White Paper. By 2020, just 15 years from now, gas will be responsible for something like 80 per cent of electricity generation. Now, gas and oil have helped, with coal, to make the United Kingdom self-sufficient in energy. But that is changing; my understanding is that we are already importing gas. This means that the United Kingdom needs to start looking at gas supplies from other areas, both within Europe and beyond.

It is absolutely vital for us to maintain a long-term view of energy supply against short-term alternatives; energy supply is, almost by definition, a long-term issue. With respect to the UK's Continental Shelf (UKCS) in the North Sea, we must strike the right balance between maximising its capability on the one hand and balancing that with imports on the other. In addition, we need to harness the technology that we have developed. The North Sea has been a tremendous testing ground for technology in many respects; we need to build on that and see how that can help us find other sources of supplies.

There is no doubt that massive investment is needed. New gas supply projects are by nature risky and investment levels extremely high. Recent figures from the UK Offshore Operators Association indicate that UK operators will be investing some £18 billion over the next five years to maintain existing supplies and to develop new supplies within the area of the UKCS. It is absolutely vital that regulators and government and industry provide a stable fiscal framework and a stable regulatory framework to ensure that we maintain that level of investment.

The United Kingdom is already importing gas. France, Germany and Italy have been in a similar situation for many years and they have managed to fulfil local and national energy needs through the importation of energy. The North Sea has served the United Kingdom extremely well; over the last 30 years its oil and gas have met our energy needs.

In regard to the maturity of UKCS, we are about halfway through — a healthy middle age — so the North Sea still has a very productive life ahead, another 30 years at least. Yet some things are changing. The North Sea is becoming more difficult because the sources of hydrocarbon are becoming smaller and deeper and, from a geological point of view, they are more difficult of access. Norway, in comparison, has produced something like a third of its national oil and gas resource. Given these changes, it is absolutely imperative to get the indus-

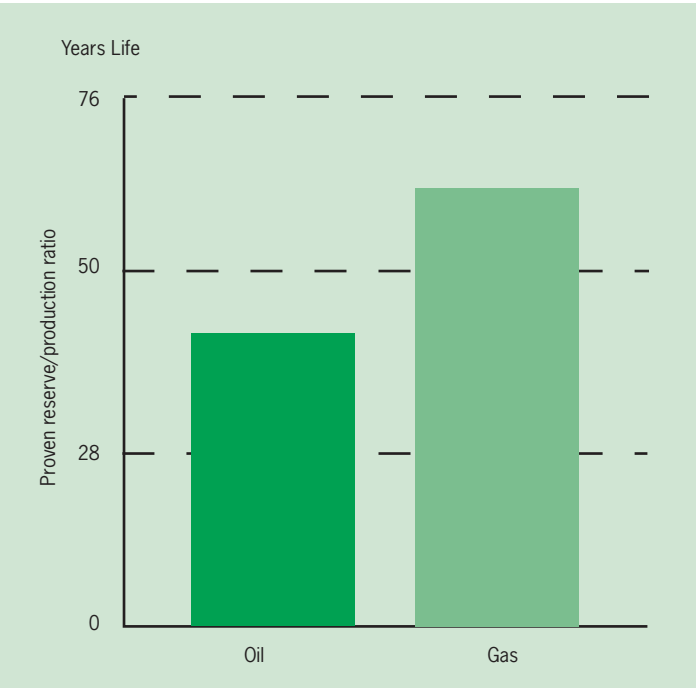


Figure 1 Comparison of remaining oil and gas reserves. Global gas reserve is 50% higher than oil at some 60 years of current demand

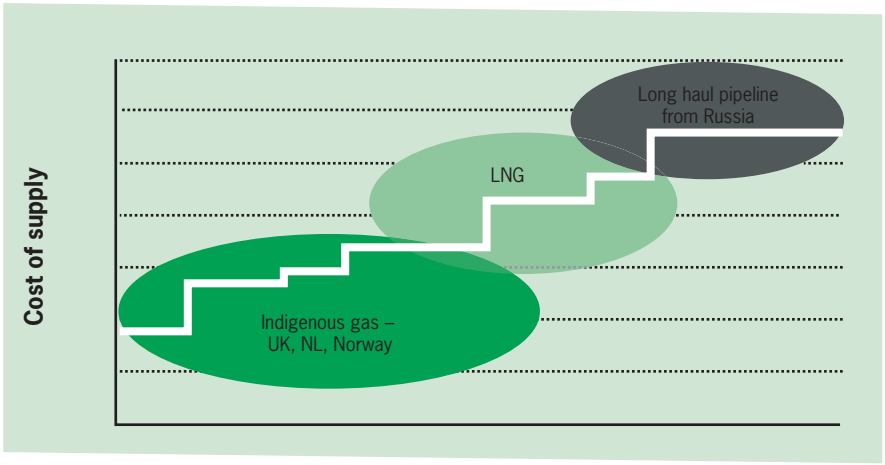


Figure 2 Natural gas supply — UK options. One Shell EP focus is European Pipeline Gas

try together with regulators and government, so that we get clear, consistent and stable frameworks. Look at Shell's investment in the area. Today, we are a major player: we operate 21 major platforms, 50 fields and three offshore gas plants. We produce about 25 per cent of the United Kingdom's oil supply and approximately 25 per cent of the UK gas supply.

While companies like Total, BP and Shell will continue to make the most of the oil in place and exploit the existing infrastructure, we will also push the boundaries. If we look at the recent 22nd round of exploration licence awards here in UKCS, you will see Shell and BP, as venture partners, successfully applying for licences in this area we call the Atlantic Margin, where the seabed shelves, in pursuit of new reserves.

Security of supply relies, crucially, on the provision of infrastructure, not only to the owner but to other users. There is a very clear pattern in the industry today where investors in, and owners of, infrastructure are making that more available to third parties. That makes good business sense for everyone involved. Shell is investing in new infrastructure both to make the most of the fuel sources we already have, but also in the search for new supplies. In the last 10 years, Shell has invested $8 billion in North Sea infrastructure, so you can imagine that we want to make the most of it. We have no intention of pulling out of the North Sea; we have been there for 30 years and we will be there for another 30 years.

We are also productively managing a portfolio: the exploration and trading market is quite liquid, there is a lot of trading going on and that is good. This market allows new entrants to come in and spend money where, perhaps, the major players do not and that has to be good for the business.

In Shell, we believe there is currently sufficient pipeline capacity in or around Europe to supply UK needs; this is driving our strategy and it is based on economics and an evaluation of the source of supplies. We are also a major player in liquefied natural gas (LNG) but we still see, at this moment in time — and I stress 'at this moment in time' — pipeline gas into the United Kingdom as the best option. Others have a different opinion, seeing LNG import into the United Kingdom as a viable proposition at this juncture.

One primary area of strategic importance for us is the liberalisation of European energy markets. We support the adoption of the EU's Second Gas Directive, because this takes a regional view. Another is the stability and predictability of decision-making; this is absolutely essential to support this level of investment (Shell aims to invest some $6–7 billion between 2005 and 2007). Just consider the pipeline from Belgium to the United Kingdom: it is 235 kilometres long, it cost hundreds of millions of dollars and it will meet about 10 per cent of UK gas demand. Investors need to have confidence that there are stable frameworks to allow these investments to take place. I am encouraged that the UK regulator Ofgem, when it looked at this project, showed a willingness to exempt this pipeline from third party access requirements; there is a recognition that regulators have to take seriously the conditions required to make these investments.

While there is a need to ensure that new and existing gas supplies make the most of existing infrastructure, it is also necessary to put in place the political and other frameworks to allow new infrastructure to be laid. The Langeled pipeline will bring supplies from the Ormen Lange gas field off Norway. This will provide something like 20 per cent of UK gas supply by early 2007. It is a fantastic development that took cross-border cooperation to make it happen. I must pay tribute to the UK and Norwegian governments for providing the framework to allow the decisions to be taken and investments to be made.

As a technical man, I want to add a bit about the technology which is going to play a key role in developing new energy supplies in the upstream, both oil and gas. We recently announced that we would start production of our Goldeneye Field off the north-east of Scotland. This is possible because we made a major technical breakthrough. An offshore gas platform consists mainly of gas processing facilities. We have challenged that paradigm and separated the production system so that the gas platform is now onshore where fuels are being produced from the reservoir and can go straight to the market. This is a major breakthrough.

There are many other technical developments, such as low cost drilling operations. We are testing a drilling operation that is manned by five people; after testing it onshore we will take it offshore where it will have a big impact on drilling operations. We are using expandable tubing technology that has taken 10 years to develop. With our partners in Norway, we are looking into the development of sub-sea compression. This will allow the industry to move into deeper water; another piece of technology that is going to be key to ensuring UK gas supply.

To supply gas, we need the systems in place to allow us to take the investment decisions. The big challenge in the short and medium term is to make sure that we identify the necessary conditions to allow the transport of gas across borders and that is why our recent experience with the Norwegian government is important. These frameworks need to be put in place and we need to build on them. A year ago Shell decided to change its country-based structure in Europe and re-structure into a European organisation. In this way we can look for opportunities on a regional basis and we can deploy capabilities on a regional basis so that UK engineers have work possibilities throughout Europe.

Finally, I want to make a point about UK industry. When I came to this job a year ago, I joined Pilot, a forum consisting of operators, supply chain, regulators and government. It is a very effective forum, chaired by the minister for energy: issues are presented there, issues are dealt with and decisions are taken. For me this was unprecedented. Initially, I asked myself "What is this? I am sitting with a competitor, with a regulator, with a supplier, with government, trying to take decisions." I can tell you this works, this works for the United Kingdom. As I said, the challenge is in taking this framework and applying it cross-border.

How can the public's understanding of science be improved and its suspicions diminished? The Foundation's meeting on 10 November 2004 looked at the issues involved.

Cultivating a thousand flowers

Colin Blakemore

In October 2003, Professor Colin Blakemore became chief executive of the Medical Research Council. His research is concerned with vision and the early development of the brain. He has been president of the British Neuroscience Association, the Physiological Society and the new Biosciences Federation. He has also been president and chairman of the British Association for the Advancement of Science.

I should like to reflect on whether the development of science communication is essentially a linear evolution or one in which many flowers are blooming - you pick the bouquet you want. I shall argue that there is every reason to maintain a rich and fertile garden of activities. Let there not be any doubt about my own commitment to the goals that we all share: relating science to the needs of the public, involving the public in our thinking about science and making science an intrinsic part of the culture of this country.

It is 20 years since the birth of the modern era of science communication. That was the publication of the Bodmer report, *Public Understanding of Science*, which emphasised two things: the scientist's duty to communicate, and the deficit model – the notion that the public's trust in science could be increased by reducing the public's ignorance about science. After the Bodmer report came the establishment of COPUS and then the Wolfendale Report of 1995, which argued that those engaged in publicly-funded research have a duty to explain their work.

The establishment of the public understanding movement was followed by a proliferation of activities: the science book prizes, grants and training courses in public communication, National Science Week, the Michael Faraday award, and so on. But the growth of science communication was accompanied by the well-known series of controversies and problems faced by science, from radioactive waste disposal and mad cow disease right through to foot and mouth and nanotechnology.

Lord Jenkin, the Foundation chairman, was principally responsible for the House of Lords' very influential report (2000) *Science and Society.* Its emphasis was on the critical problem of public confidence in science. This report marked a transition in the evolutionary process, from public understanding (the didactic downward approach; the deficit model) to one of dialogue and involvement, in response to the crisis in confidence. This has stimulated a further wide range of activities: the establishment of the Dana Centre by the Science Museum, the Café Scientifique movement blossoming around the country, citizens' juries, focus groups, consultation papers, lay membership of the Research Councils' committees and boards – all processes to encourage consultation, dialogue and involvement.

So, where do scientists now fit in the trust table? MORI says that confidence in scientists, judged by that simple question, "Do you trust X?" has been rock solid at two-thirds of the public for 10 years, despite the torrent of controversies, and is actually increasing. Peter Briggs, (former CEO of the British Association) has pointed out an intriguing feature of these trust tables. Doctors, teachers and clergy gain the highest confidence ratings. What have they got in common? Why is it that journalists are abysmally low at 13 per cent approval, but television newsreaders, who are, of course, journalists, are at 71 per cent? Peter's argument, and I think it carries a lot of weight, is that people have more trust in other people whom they see behaving and performing – those whose facial expressions and body language are seen. Faceless, impersonal individuals are not so trusted.

This reminds me of the transition in the understanding of risk assessment that happened in the 1970s and 1980s: the growing realisation that you cannot quantify risk perception without understanding that it is people, with the irrationality of human nature, who react to risk. The psychological dimension in risk assessment is terribly important. It is equally significant in determining confidence in other people. Seeing other people as human beings is important in deciding whether you trust them. That, by the way, is a very strong argument for authentic scientists playing a part in public communication, not simply leaving it to professional science communicators to deal with the media and the public.

Clearly the level of public trust is also influenced by knowledge about how scientists obtain their funding and their orders. Scientists from a university background generally have higher trust ratings compared with those from industry. Equally, environmental groups score pretty well compared with government scientists. Perceived scientific independence (which cannot be manipulated by paymasters), determines trust.

Is the evolutionary process of the science communication movement entering

a third phase? In the past few months, there has been a flurry of interest in a new approach. A recent pamphlet called *See-through Science* (www.demos.co.uk/catalogue/paddlingupstream), published by Demos, a left-leaning think tank, argued that we must move beyond dialogue now to something they call "upstream engagement". It argues, to quote from the pamphlet, that "broader societal acceptance of new technologies, especially where these are novel and raise concerns, requires open dialogue throughout the developmental process; if opportunities are to be realised, then engagement and dialogue must take place at the right time and involve the right people." The right time for them, it seems, is at the beginning, in the process of deciding priorities, selecting which research to do and recognising in advance the potential risks. Demos says that the Research Councils have a potentially decisive role in determining whether upstream public engagement becomes a meaningful reality.

Let us just examine that. The Research Councils generally act in what is called 'response mode'. They respond to the needs and arguments of their research communities. They are now being encouraged to think more strategically about their science in the context of the needs of the country. That is not a bad thing. But are we really suggesting that the public should take the place of the research panels that judge applications and try to set broad strategic goals, in the context of their knowledge of the needs and capacities of the scientific community?

Last year, and in contrast to the Demos paper, Bill Durodié published a critique of the dialogue agenda (Critical Review of International Social and Political Philosophy, **6**: 82-92, 2004). He argued that dialogue, far from advancing the cause of public engagement, was actually diminishing it. It had four failings: it demoralised scientists by implying that they could not make their own decisions properly; it patronised the public by giving a kind of sham involvement and power, inevitably trivialising the process; it elevated new experts, giving a platform to disenchanted individual scientists, lobbying groups, NGOs, and so on; and it could be used by politicians as an excuse for not having made sensible decisions.

discussion

Prejudicing independence. The question was raised whether it was really right for scientists to declare their personal values and to question who stood to benefit from new technologies and who controlled them. There was a danger of prejudicing the independence of science: the bodies involved in a debate were liable to represent interest groups. Research was properly judged on the basis of reproducibility and peer review, not the motives of those who conducted it. On the other hand, scientists were not necessarily objective. They made choices which reflected their personal views. Scientists were members of the public themselves and needed to learn to recognise the factors that influenced their behaviour. Lay people could help scientists do this.

The British Association produced a robust response to Durodié, in which they too embraced the upstream model (Jackson R *et al*, *Strengths of public dialogue on science-related issues*. Critical Review of International Social and Political Philosophy. In press).

It is salutary to consider a few recent controversies that we would all have liked to avoid, and to ask whether upstream engagement might have prevented or ameliorated them. Remember that what is proposed is that the public should be involved in setting the agenda for scientific research.

First, MMR and autism. That controversy was triggered by Andrew Wakefield's claim that there might be a causal link. The cost in time and effort created by that almost certainly wrong hypothesis has been immense. But how would having the public on the panels of the Medical Research Council (MRC) have avoided this? It was an unpredicted controversy driven by an individual scientist and, because it was a great story, amplified by the media.

As far as nanotechnology goes, I would argue that the debate is being driven by the scientific community, who are better placed to recognise the potential problems. It is not stimulated by public concern; further, it has not captured the interest of the media because it is not so easily hyped or sensationalised.

With GM, there were other individual scientists involved, there was the stigma of commercial involvement and there was genuine concern about a risk to health. Monsanto's communication strategy failed to make the case for the benefits of GM technology. Again, how could having the public on the boards of the Biotechnology and Biological Sciences Research Council have avoided this problem?

Finally, mobile phones, another area of great controversy. Discussion was initially driven, to a large extent, by the Stewart Report, in which the scientific community proposed a precautionary approach. In fact, the public has been much more concerned about mobile phone masts than about phones themselves, despite the fact that radio frequency (RF) fields from masts, at ground level, are generally hundreds of thousands of times weaker than those from phones. In my opinion, the concern about masts is largely due to the failure of people to see any personal benefit from masts. They spoil the landscape and might affect property values. If the public were to set the agenda for research in this area, they would want to concentrate effort on epidemiological studies of health and exposure to masts, whereas research aimed at pinning down any possible 'non-thermal' effects of RF fields is likely to be more productive.

Since the Bodmer report, the burgeoning science communication community has learned much about the different ways in which the public can be informed about, and entertained by, the excitement of science – and involved in useful ways in what scientists do. There is a very strong case for more openness and visibility of scientists, and more direct contact between scientists and other people which, in the words of the Demos paper, can help to bring out the public in the scientist. After all, scientists are members of the public too and they share many of the perceptions, the prejudices, the concerns of other ordinary people.

However, let us not abandon the good thinking in the Bodmer report. Unless dialogue and engagement are underpinned by solid knowledge, then they are bound to fail. The public understanding of science is still, in my opinion, absolutely crucial to the dialogue process. So, let a thousand flowers bloom.

discussion

Involving the public. One way to engage members of the public with science, it was suggested, was to appoint them to panels making research funding decisions. It was suggested that if members of the public had been involved at an early stage in decisions on the MMR vaccine it might have been recognised that mothers faced a real dilemma. There was, however, a question of who were the right lay people to be involved in funding decisions.

Engaging in dialogue – and being human

Kathy Sykes

Professor Kathy Sykes is Collier Chair in Public Engagement in Science and Engineering at the University of Bristol. She directs the Cheltenham Festival of Science and sits on advisory groups on science engagement for the Government (the Council for Science and Technology), the Royal Society, the Wellcome Trust and Research Councils. She was Head of Science for Explore@Bristol. Kathy is a physicist, with a PhD from Bristol University. After her first degree she taught maths and physics in Zimbabwe with VSO.

Dialogue: what is it, why do it, when do we do it, how can we do it better and are we making progress? Engagement is partly about scientists and policy makers understanding the public, as well as vice versa. It is about listening to people before we start talking and realising that it can actually help in research. So many people, Nancy Rothwell among them, have said, "I have been asked questions that made me start a new line of research because they came from such a different perspective."

Dialogue means talking to the public on ethical issues and with a really open mind. It is not about letting the public make decisions. I think that we can make better decisions if we understand the public better; they will raise concerns that we have not thought of and then we can address them. This is not rocket science.

Why do dialogue? I believe that if we do this really well we will improve trust in science and the governance of science. I think that we will have better discussions around science and we will make better decisions for society. David King, the UK Government's chief scientific adviser, says if we do not get this right there will be no science – it is crucial as that.

One of my favourite sentences in the Jenkin report, *Science and Society*, says, "People who do science do have morality and values, of course." Many scientists I know are driven in their work because they believe so passionately in the beneficial impact that it could have. However we tend, as scientists, to say that we are not going to talk about the ethics, we are just going to do the science – ethics are not our arena. So we are asking the public to trust a group of people who seem to be beyond morals, who seem to be beyond values. If scientists start to talk about their own ethical beliefs they will start, I believe, to seem to be more like human beings. The Jenkin report is asking scientists to talk about their own values and, in that way, they will command more public support.

In 1994, before the issue of GM really became a hot issue, the Biotechnology and Biological Sciences Research Council ran a consensus conference at the Science Museum. A group of ordinary people met over a period of weeks and got fully informed about the topic. They heard many different perspectives and came out with some really valuable recommendations. They said that we needed to label clearly the GM content of foods and that had to be agreed internationally; that the patenting laws were a complete mess and, if we did not sort them out, we would run into problems. They acknowledged that this technology had incredible possible benefits and might help to feed the world. But they also warned that if we do not let developing countries help to shape the agenda that will not happen; instead, it will all be commercially driven and the public will not accept it. Finally, they said that a government minister should oversee the arena to take us forward thoughtfully. If we had listened to any of those recommendations in 1994, might we not be in a better position today?

There are potential benefits of GM, but nobody is now in a position to talk about them because the debate has become so extreme. We could have had a much more informed, better-developed dialogue that took account of public concerns and hopes, and developed everything more wisely.

When do we do dialogue? If all we do is engage with the public around the time that we start to regulate, about the time that technology is being created, we have missed the opportunities to help us think about how to use science and technology better. An example of doing it way downstream is the GM Nation debate, when the public were asked whether we should commercialise GM or not. We were doing that round about market testing time - way downstream - whereas the GM consensus conference was way upstream. I would argue that the further upstream we can get, the better it will help our thinking. In other areas where we have tried to do this upstream (for example, the Warnock Report), we have had a much better impact. On nanotechnology, the Report from the Royal Society and the Royal Academy of Engineering is really doing things upstream and puts us in a better, more prepared position.

How to dialogue better? I talked about the example of the consensus conference. We need deliberative dialogue so that people have time to go away and talk to their families, think, sleep on things and then come back to the issue and consider it more. There have to be clear objectives and scope and there have to be clear ways of feeding into policy: it has to happen at a time when policy makers want to hear about the issue and at a time when they can actually do something about it. It needs to be inclusive,

With British universities closing chemistry and physics departments, the Foundation's meeting on 23 November 2004 considered how best to safeguard these strategic subjects and looked at how the business community could contribute to this goal.

Strategic subjects are becoming endangered

Howard Newby

Sir Howard Newby CBE is chief executive of the Higher Education Funding Council for England (HEFCE), before which he was vice-chancellor of the University of Southampton (1994 to 2001). Previously he had been chairman (1988-94) and chief executive (1994) of the Economic and Social Research Council, Professor of Sociology at the University of Essex (1983-88) and Professor of Sociology and Rural Sociology at the University of Wisconsin, Madison (1980-83). From 1999 to 2001, he was president of Universities UK, the body that represents the university sector. He was president of the British Association for the Advancement of Science for 2001-02.

This meeting is exquisitely timed. Yesterday the University of Exeter announced that it would close its chemistry department. Tomorrow we are due to receive a letter from the Secretary of State asking us to consider the sustainability of strategically important subjects. Our theme is evidently topical. It is also important.

I shall concentrate on the so-called 'STEM' subjects – science, technology, engineering and mathematics – but there are also others that give cause for concern.

The Higher Education Funding Council for England, together with its counterparts in Scotland and Wales, are together the successors of the University Grants Committee (UGC), for which there is still a powerful nostalgia among academics – much of it well placed. Then, of course, there were many fewer universities and many fewer students.

The UGC had powers that I can only dream of. Its visiting committees could pronounce, at the end of their visits, that a university could have a law school, or a psychology department, but that it could not teach Japanese.

These arrangements were first modified two decades ago in an attempt to introduce a market approach into higher education. Now, with the ink barely dry on the Higher Education Act 2004, we have a more potent recipe. The Funding Council will have to think carefully about its future role. We shall remain the principal source of funds for non-research activities, but we shall also be the custodian of the public interest in higher education – a kind of regulator.

The passage of the Education Act in 2004 engendered high political controversy: the Government will not be eager to return to these matters for a while yet. But in the past year, we have also had the Lambert Review on the industrial demand for links with higher education. The Ten-Year Science and Innovation Investment Framework, certain to influence the pattern of university research, has a lot to say about strategically important subjects. The fees issue has also become an important factor in the thinking of all universities, while regional stakeholders have acquired an important influence on future higher education.

The upshot of these developments is that universities have been given greater autonomy, even though they are constrained in the setting of fees. They are expected to manage their own affairs within the constraints of our block grant. Our role is to provide funding and a framework of accountability. But the Funding Council does not have planning powers to ensure the sufficiency and adequacy of provision.

We are at present engaged on a review of the funding of university teaching. The funding formula is now based on what institutions spend on the various subjects, but we recognise that an assessment of the costs of teaching, perhaps by an extension of what is known as the TRAC methodology, could be a better basis for the funding formula.

Nevertheless, we have always recognised that in a very small number of 'minority subjects', we need to intervene on the supply side. We support some subjects even when they attract very few or even no students, so as to sustain some national capacity in teaching and research. That has not been a controversial issue. The list, which we review periodically, consists mostly of exotic languages or area studies, with a sprinkling of science and technology subjects – paper technology at Manchester and leather technology at University College, Northampton, for example.

The new problem is different. Many subjects generally regarded as core subjects have suffered persistent and precipitous declines at undergraduate level. These include all the STEM subjects although, among the sciences, biology and medicine are not seriously affected. Most but not all branches of engineering are affected and there has been a marked decline of mathematics student numbers. I should add that modern languages such as French, German and Spanish are in decline and we are also concerned about the teaching of the quantitative aspects

of social science – statistics, demography, operations research and so on.

Chemistry typifies the problem. Although the number of entering students did not decline this year, there had been a fall of a third in the previous five years. Other subjects have suffered similarly. But no university can sustain serious losses in subjects for which there is declining demand. So our problem is that some former core subjects are taking on some of the characteristics of minority subjects – notably the mismatch between supply and demand for places. However, there is a national interest in sustaining provision in these subjects, and this cannot be equated with the sum total of individual universities' interests.

How do we build and sustain capacity? The first need is for a measured and constructive national debate that recognises both the autonomy of universities and that the aggregate of their interests may not add up to the overall national interest. We need to chart a sustainable course between these two positions.

The task is to balance supply and demand. With subjects such as Chinese studies, Arabic studies and Japanese, it is not clear whether the action is needed on the supply side or the demand side. But for the STEM subjects, there is no doubt that the problem is on the demand side. There are still plenty of physics and chemistry departments; the problem is to sustain undergraduate demand. That applies even to the most research-intensive departments, whose lifeblood is a steady supply of undergraduate students.

I have already explained that HEFCE does not have planning powers. How then can we sustain subjects while not intervening heavy-handedly in the micro-management of institutions? We cannot support shrinking departments indefinitely in the hope that, one day, students might turn up. But we need to think carefully about the unintended consequences of seemingly rational decisions. While the recent closures of chemistry and physics departments have mostly been sensible rationalisations, they have been geographically random. The result is that some parts of Britain are now largely bereft of provision. So where are future science students to go? Especially if fees and other factors give them an incentive to study locally?

The Regional Development Agencies (RDAs) have developed their own strategies, as have the sector skills councils. These strategies depend upon the availability of well-trained graduates in subjects important to the regional economy; yet provision is sometimes withdrawn precisely in those fields in which RDAs are looking for support. We need a dialogue between all the stakeholders: HEFCE cannot issue directions. To borrow a phrase from a predecessor of mine at Universities UK, Martin Harris, higher education may at present be over-regulated but under-planned.

The origins of many of these problems lie in the school system, not in higher education. By the time students get to us, they have decided whether to study arts or sciences and, sometimes, perhaps even which disciplines they wish to follow. There is a lot of evidence that students are turned off science in school. The university sector, employers and schoolteachers need jointly to find ways of encouraging more students to take science.

'Strategically important subjects' and 'securing the public interest' are neat phrases, but they provoke as many questions as they answer. Who determines what is strategically important, and to whom? We do not wish to go back to the detailed subject reviews the UGC used to undertake. It is a much bigger system now. But we need to ensure that students have access to courses we believe to be nationally important.

We should also ponder the consequences of recent changes in student financing – the introduction of tuition fees and the changing regime of maintenance awards. Increasingly, students seek to live near their homes. As things now are, 60 per cent of 'full-time' students work 18 hours a week or more; living in familiar territory may give them access to local labour markets they understand. It is therefore crucial that we deliver higher education to them where it is needed, perhaps with the help of distance learning and sometimes at the workplace.

Again there is a need for dialogue. We need to find a way of enhancing the ubiquity of supply that satisfies the interests of the higher education sector, the other stakeholders and the students themselves – but it must be a way that avoids draconian regulation. So far, the higher education sector itself has accepted that there is a problem we need to address.

What I have done is to list some of the issues that have arisen or will arise. Can we be sure the new market will deliver the quality and diversity of students that we need in the subjects that are important to Britain's economic and social future? As I have said, a letter from the Secretary of State asking us to look at these issues is imminent. After consultation, HEFCE will respond constructively.

I cannot yet tell you what we shall say, but I shall leave you with a proposition. We know that neither formal manpower-planning nor *laissez-faire* will meet Britain's needs in higher education. What we need is a strategic perspective that will command the respect of all. HEFCE is funding a project by the Royal Society of Chemistry to explore ways of making the classroom teaching of chemistry exciting both for teachers and students. We are now talking to other professional societies representing other STEM subjects. From these activities may spring revisions of the school curriculum, which may in turn point higher education towards better methods of satisfying the national demand for higher education.

discussion

Is science boring? Many school students feel that scientific subjects are not only difficult but boring. They are also asked to choose between subjects at too early an age. Few have any understanding about possible careers or how exciting science can be. Teachers who inspire enthusiasm are, inevitably, rare but they could be encouraged and their numbers increased if universities liaised closely with teachers, helping them to develop their skills. By bringing pupils into universities, businesses and other institutions (such as hospitals) they would see what scientists really did and what problems they were tackling.

discussion

The causes of decline. The suggestion was made that the current way of teaching scientific, technical, engineering and mathematical (STEM) subjects might be part of the problem of a decline in student numbers. The classification of scientific subjects into strict disciplines like physics, chemistry, etc, might be too rigid and result in the existence of too many small departments. This could hinder interdisciplinary learning and the development of a more general interest in science as a whole. Solving exciting and difficult problems demands work in various fields and no discipline stands on its own.

The regional voice in education

Pam Alexander

Pam Alexander has been chief executive of the South-East England Development Agency since January 2004. She has been involved with regeneration enterprises for nearly 30 years. She was chief executive of English Heritage (1997-2001), and deputy chief executive of the Housing Corporation (1995-97). At the Department of the Environment (1975-94) she worked on local government finance, transport, inner-city regeneration and housing policy. Ms Alexander is chair of the Peabody Trust and a non-executive director of The Housing Finance Corporation Ltd.

The Regional Development Authorities (RDAs) exist to foster sustainable economic development in the nine regions of England designated in 1999 (Scotland and Wales are catered for similarly but separately, under the aegis of their national assemblies). We are now being asked by Government to interest ourselves in knowledge transfer and innovation. We cannot achieve anything on our own, so partnership is central to my theme.

Each RDA has developed a Regional Economic Strategy in concert with its key stakeholders. All focus on achieving greater employment and greater productivity. One of our functions is to help deliver the current science and innovation agenda. For example, the RDAs have been charged with bringing business and universities together within the Department of Trade and Industry's (DTI) £180 million a year programme on collaborative R&D and knowledge transfer networks.

In 2003, RDAs invested some £240 million in Science, Engineering and Technology (SET) related activities. We are closely engaged with the business skills agenda and will in April [2005] take over the management of *Business Links*. Through our investment development managers, we have strong one-to-one relationships with the larger businesses in our regions – particularly with foreign direct investors. Our manufacturing advisory service has helped over 800 companies; some 250 of them with in-depth approaches to lean manufacturing which have yielded £8.5 million worth of savings and an increase in turnover of £6 million in the first year. We have also developed enterprise hubs and I am particularly excited by our success, in partnership with HEFCE, the Office of the Deputy Prime Minister and a number of educational institutions, in bringing new opportunities to young people in our priority regeneration areas of Hastings and the Medway towns through new 'university centres'.

The RDAs believe that skills are key to future economic performance. UK plc needs an internationally competitive workforce, graduates with the appropriate skills for long-term employability and better skilled people in our under-performing areas. What shocked me most, on coming to this job a year ago, was that one in eight of the workforce in the south-east of England lacked basic literacy or numeracy skills.

It is now clear that more skilled workers, such as medical and scientific researchers, financial analysts and even university lecturers, could find themselves competing with highly skilled but lower paid workers thousands of miles away. Only last week, Novartis (the pharmaceutical company) was said to be moving significant research programmes to China, a country whose $77 billion research and development expenditure is now more than double that of the UK in cash terms and some 1.5 per cent of its own GDP.

In this environment, how do we support and create an internationally competitive workforce? Making subjects available for study and research is necessary but not sufficient. There is evidence that the rate of innovation in Britain is only 60 per cent of that in Germany and not much higher than that of Greece. But the figures also show that British companies are good at devising new corporate (and marketing) strategies. While everyone else is getting on and doing it, we are enjoying planning what we might do if only the strategy would stand still. We are good at ideas and we seem to be good at telling people what should be done but less good at making sure that it happens.

Businesses tell us that this is a critical issue in relation to the skills of their new graduate employees. Leadership and management skills are essential to the management of innovation. One of our goals is to provide middle-managers in medium-sized companies with mentoring and facilitating networks involving higher education institutions: this might overcome some of these obstacles.

	S&T workers as a percentage of total employment pool	Researchers per 1000 employed
UK	25	6
France	29	8
Germany	34	7
USA	33	9

Table 1. Science and technology skills in an internationally competitive world. Source: SEEDA

Business leaders also bemoan the difficulties of attracting and retaining graduates with the appropriate skills and knowledge, especially in the physical sciences and languages. Our offering to employers is not as strong as it needs to be, perhaps because employers have not often been involved in creating or developing curricula. Another issue affecting the competitiveness of our workforce is the availability of high-level technical skills. I have an example from nanotechnology. Professor John Wood, of the Council for the Central Laboratory of the Research Councils (CCLRC), has pointed to a shortage of people able to 'move atoms about', despite a strong demand from high-tech companies to get into this area. Such high-level skills exist in many research-oriented higher education institutions, but there is no financial incentive for their dissemination. Short, flexible and focused sessions of training would meet the need.

Skills for employability depend not just on the subjects studied, but on the suitability of what is learned for employment. I support the recommendation of the Lambert Review for more employer involvement in curriculum design and course delivery. That could ensure that graduates are well suited to the markets they enter. The IT skills council, e-Skills UK, said that even graduates with good degrees from top universities need a further two years within a company to get up to speed on such crucial skills as project management, writing a decent business case, people skills and other business skills. But the universities, not unreasonably, were adamant that they were producing good graduates, who all got good jobs, so what was the problem?

Another priority is to widen access to learning and to skills development, particularly in the under-performing areas of UK plc. Higher-education participation rates are often way below average, even in the South-East. Only 21 per cent of young people under 21 go into higher education in Kent and Medway, for example, well below the South-East average of 33 per cent. This is one reason why our coastal towns lose young people and then do not have the skills to attract well-paid and sustainable jobs.

Our challenge is to articulate the needs of business more effectively as well as their difficulties, such as releasing staff for full-time training. We are in the very early days of articulating the demand. All the English regions have developed new partnership groups to help define the needs of businesses in their regions. In the South-East we are, to begin with, concentrating on further education where there is a huge amount to do. There are obstacles to be surmounted – for example, the unwillingness of many employers to invest in training for their employees and the unwillingness of many HE institutions to provide other than full-time courses because they feel that this compromises their independence.

In each region, RDAs are forming a high level forum between vice-chancellors and senior business executives to advise on regional priorities and to take an interest in the supply of science, engineering and technology skills. Every RDA should have a Science and Industry Council by the end of 2004. If we are to compete in international markets, our universities need strength in depth. So, across the development agencies, our focus for the future is working with universities on collaborations for excellence and to create critical mass in important subjects and technologies.

case study

University Centre, Hastings. In her talk, Pam Alexander gave six examples of initiatives recently taken by RDAs. One is University Centre, Hastings, sponsored by her own agency SEEDA.

This project, which has so far cost £7 million, is designed to break the deprivation and 'lack of aspiration' in the severely deprived seaside town of Hastings and the surrounding locality. Students come from the locality and teaching is provided by a number of higher education institutions in the South-East.

The curriculum is driven strongly by the area's immediate needs with courses in tourism management and in regeneration studies in an area undergoing a 10 year regeneration programme. The centre has been designed for 1,000 students and is expected to reach capacity in four years.

Similar initiatives have begun in the Medway area and the Thames Gateway, with towns such as Ashford and Milton Keynes now discussing linking into the growth plan.

Meeting industry's needs

Tom Swan

Tom Swan OBE is chairman of Thomas Swan & Co Ltd, a privately owned manufacturer of speciality and fine chemicals. His company has invested widely in British universities to develop technologies. He has also served on the Cabinet Office Deregulation Task Force. He was awarded the OBE in 1999 for services to the chemical industry.

As an industrialist, as long as the subjects that are relevant to my business are available for study, I am a happy man. I need the purely academic subjects such as chemistry, physics and engineering to be taught. In another universe, I need electricians, fitters, plumbers and welders just as much. My contention is that we need two different types of universities to meet my requirements. In this country today there is a greater shortage of people with vocational qualifications than with academic qualifications - which does not imply that the academic situation is satisfactory.

Without direct experience of vocational education, and at the risk of entering uncharted territory, it is my perception that the Germans, with their technical high schools, have got this part of higher education right. I am envious of the output of these universities - lab technicians, plumbers and fitters. Combined with modern apprenticeship schemes, Germany has at its beck and call a deep fund of skills that we lack.

Where does that take me? It is simple really. First, have two types of universities, academic and vocational. Second, at the academic universities concentrate on traditional science and maybe arts subjects, modernised where appropriate and – this is important – do not dilute these core subjects with bolt-on options such

as chemistry with business studies – Ugh! At the vocational universities, cover a broad range of skills and also methods of acquiring those skills, for example, sandwich courses and apprenticeships.

A second aspect of tonight's theme is whether we have the right strategy for higher education. As an employer, I can judge only by the results of the current strategy – and by the quality of the graduates and the quality of the research. I am not sure you will like what I am going to say: compared to 30 or 40 years ago, the quality of first degree graduates has plummeted.

What are the reasons? Has the output of the schools deteriorated? Are there too many universities with too many undergraduates who are not capable of benefiting from a university education? Or does the wide selection of easy subjects in secondary schools mean that universities must lower their entry requirements to attract students, thus creating a vicious downward spiral in quality?

To answer my own question, I do not believe that we have the right strategy for higher education. Those capable of intellectual achievement should be able to achieve high and respected grades in testing examinations that demonstrate an in-depth understanding of the subject. But first, we have to attract them to the subjects.

Here, the first port of call must be inspirational teachers. That is easy to say but very difficult to achieve. Yet teachers are fundamental to any strategy and there are numerous schemes and programmes to help them learn and be more efficient. But the only way of getting excellence in science teaching is to pay the good teachers very generously indeed.

The second port of call is to make science and the application of science interesting at a young age. The Jesuit, Ignatius Loyola, said, "Give me the boy until he is seven and I will show you the man" (women did not exist in those days). It is my firm belief that you start the required process of improving secondary schools – and hence universities – in primary schools. I believe in this sufficiently to have put a considerable amount of money, my money, into founding a primary school programme at the Chemical Industries Education Centre at the University of York called *Children challenging industry*. It is a serious attempt to bridge Key Stage 3 by creating a deep-seated interest in manufacturing industry and science.

We must achieve excellence throughout primary and secondary schools, but from the employers' point of view breadth of education can come later - after the first degree. If as an employer I need a chemist, the fact that a graduate has a degree in chemistry and business management is a *disadvantage*. If a chemist shows signs of wanting to go into management, as an employer I will train him and give him that chance but, to begin with, I want a chemist, as good as possible.

Without going into the detailed whys and wherefores, I plead again for a clearly visible split between academic universities and vocational universities. So far, you may have noticed, I have not once mentioned the Tomlinson Report. This is because I wanted to put my thoughts forward in my own simple language; Tomlinson, of course, says the same things far more cogently than I. He is, of course, covering all subjects and not just the sciences. I disagree with his proposals for coursework; as an employer, I would want a science graduate to have got to university through a system of testing, external examinations rather than subjectively-examined coursework. The potted version of this is: "Start young, aim for excellence and have two types of universities".

Finally, within the academic universities, not every university should offer the whole spectrum of sciences. It should be decided, and there needs to be an element of planning here, which will specialise in what and how many places will be available, thereby ensuring that only the best applicants will be offered places. Today comes news that Exeter is closing its chemistry department. Many may lament this, but it is a tough world out there and I believe that only the best departments nationally should survive.

The last point leads into the second of my main headings: the quality of research. The relationship between industry and universities in this field is the subject of the Lambert Review. I have collaborated a great deal with many universities, not just in Britain. I have not dared to add up how much we have committed to these collaborations, but in my mind they have all been successful. What makes for successful collaboration? Well, that is easy, a good result manifested either as a spin-off company or as new products and processes. But how can good results be assured?

An industrial partner will usually seek a centre of excellence with which to collaborate. Universities must make such centres easy to identify. I believe the notion of centres of excellence supports the argument for specialisation in science subjects. In chemistry, for example, it would be much easier to attract stars to a relatively few but excellent chemistry departments than many moderate ones. To put it another way, an industrialist like me is more interested in a chemistry department that employs a Nobel Prize winner in the type of chemistry in which I am involved, rather than a five-star rated department with no stars – if you follow my meaning!

Collaborative research needs to be managed. The industrial partners must invest the appropriate time and quality of management in the project's progress. I have been astounded to hear that a large, well-known company, having established a collaborative grant with a very well-known university, thought that it was adequate to visit and discuss the project once a year. Apparently this is more the rule than the exception. Such behaviour does no favours to anyone, least of all the university. By comparison, we visit at least once a month and, although some academics grumble at the discipline this entails, they all acknowledge that the project and therefore the university department is better for it.

So where does all this lead us? We have a lot to do at the input end in the schools. Science and industry must be made attractive, otherwise I cannot see how to supply employers with the quality of graduates or post-docs that they will need. Doing nothing is not an option – as demonstrated by the fact that my company is now having to employ graduates from Europe, specifically from France.

The current quality of graduates, taken across the board, is tolerable but declining. That will not be put right unless the input is put right. Nevertheless, we need to reorganise the university system to ensure the specialisation that leads to centres of excellence. It is also true that centres of excellence cannot be created without suitable financial incentives to attract the stars.

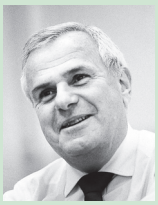
discussion

Higher education provision. The Government target is for 50% of young people to go through higher education, but one contributor queried whether this was a sensible figure. Others though emphasised the need for a knowledge- and service-based economy to have a high proportion of well-qualified people in the workforce. If the definition of 'higher education' were to cover vocational training as well – perhaps through foundation degrees – a 50% target, or even a higher 60% figure, would be realistic and desirable.

The need for increased investment in Research & Development (R&D) was explored in a dinner discussion on 1 December 2004. Representatives of government, business and research organisations discussed the different aspects of the issue.

Improving communication between the City and science

Paul Myners



Paul Myners CBE is chairman of Marks & Spencer, and was chairman of Gartmore Investment Management until his retirement in 2001. He is chairman of the trustees of Tate, a Trustee of Glyndebourne and a Fellow of the Royal Society of Art. In March 2000, Paul was invited by the Chancellor of the Exchequer to review matters relating to institutional investment. He was appointed a CBE in the 2003 New Year's Honours List for services to innovation in finance.

There is a Chinese proverb which says: "The participants' perspectives are clouded while the bystanders' views are clear." The proverb sums up the situation facing us as we consider the relationship between the business and science communities.

When we put ourselves in the position of the bystanders, the overwhelming majority of British businesses – and investors in these businesses – see that technology and its development via R&D is fundamental to the success of our companies. Yet, despite the commitment from all sides, participating in technology on a day-to-day basis is a difficult matter; as the proverb states, our perspectives become clouded.

On the one hand, the City is castigated for its short-termism that seems to preclude the long-term investment required to bring new technology to fruition. On the other, the financial community can point to any number of over-hyped, expensive, delayed technologies that have failed to deliver commercial applications.

Let me start by reflecting on how I believe the financial community views the issue. There certainly appears to be a gap in understanding between some investors and companies about the impact of R&D spend on corporate valuation. From the perspective of the City, it appears to be the result of two factors.

The first concerns the different accounting standards used around the world which hamper meaningful comparisons between companies. As a result it can be genuinely difficult to be precise about the impact of R&D expenditure on corporate valuation. The introduction of international accounting standards will, in due course, address this issue and there is a significant opportunity for science-based companies as a consequence.

More interesting for us is the second reason, which is a perceived failure to communicate to the investment sector about R&D expenditure. This occurs in two very different forms: on the one hand, not enough information and, on the other, too much hype.

The perception amongst many investors is that, too often, R&D investments are treated as internal management decisions, made with little fanfare and without any explanation to investors about the potential long-term benefits to the business. As a result, these decisions are not understood and the investment is not factored into the share price. In many cases, this reluctance to communicate may be based upon false understandings about the commercial-in-confidence risks that might be attached to a more open dialogue.

The other extreme is where companies succumb to the desire to hype the commercial potential of new technologies. Unfortunately, investors in the past have been seduced by research and development claims where promises have far outstripped deliverable commercial success. Examples include genetically modified food, the internet bubble and nanotechnology. There is an understandable reluctance amongst the investment community to take everything at face value. So it is no surprise that markets will only ascribe value to an as yet unrealised technology if a company has a proven record of success.

However, crediting value on the basis of past performance and assuming that past success will be repeated in the future may well change when the operating and financial review (OFR) comes into being. Amongst the recommendations in the 2002 Company Law Review is the need for companies to significantly enhance information provided to shareholders, which will enable them to better assess the company's strategies, their likely success and the material risks faced by the corporation.

The form and content of the OFR are still evolving. There is an important opportunity here for members of the science community to help frame the way science and its value to the company are articulated in the OFR. There is no precedent in this country for the OFR and there is, therefore, the opportunity for various groups to argue for clear expression of corporate commitment to areas of particular interest.

Let me explain how we create value from R&D at Marks & Spencer. The application of technology for customer benefit is at the heart of our business. Each of our divisions has a specific technology func-

tion and we employ more than 100 technologists across the business. Their job, in part, is to anticipate customer needs and to find technologies that meet customer requirements in a manner that beats market expectations.

We tend not to invest in pure science for the sake of it; our approach is to draw on scientific breakthroughs, on developments in technology and on knowledge in many different fields, and to bundle this together to deliver customer benefits. This approach requires us to reach out into the world of academia to identify potential new breakthrough sciences that may shift our marketplace in the future. If we cannot find what we are looking for, or if we believe that there is a gap in basic scientific knowledge, then we move to address it. For example, we created and funded the chair of farm animal health, food science and food safety at the Centre of Veterinary Science in Cambridge to fill a gap which we saw in our marketplace. However, if a new technology project cannot demonstrate that it will create value for our customers, it does not see the light of day.

Let me describe two new technology products that did get the investment 'green light'. The machine washable men's suit, a rather prosaic example in a world of bioscience and space age technology, is of huge commercial value to us. Our customers were telling us that dry cleaning was a bind – expensive, time consuming and damaging to clothes. So we set our supply chain and technology team a challenge: develop a machine washable suit that would retain its shape, could be washed without any specific instructions and could be sold for £125. It took three years and innovations across literally dozens of fibre components and manufacturing processes, but they stuck to the task and delivered the suit, a world first.

This was not a journey that delivered any sudden step change in understanding, but involved instead the clever and persistent connection of multiple strands of technology in order to deliver the result. This breakthrough has enabled us to sell over £40 million worth of men's washable suits during the last two years in a market characterised, in the past, by a lack of innovation.

My second example comes from our food business and concerns the development of ready meals, now a multi-billion pound market which M&S pioneered in this country. Here, we brought together advances in four key areas of science. The first was in microbiology, allowing us to create new ultra-clean factories. In polymer sciences, we delivered packaging that could be used in the oven or microwave. Colloid science gave us seven-colour printing, allowing customers to see food accurately pictured on the packaging and, lastly, nitrogen-based refrigeration allowed us to create a cold chain from factory to store. Without any one of these developments, ready meals, which we are all now so accustomed to using, could not have been created.

I would like to touch on one other critical issue that affects all who work with new technologies – the issue of consumer trust. In a consumer market, commercial success is not just dependent upon clever technical solutions, it also depends on trust. At M&S, we have done much to develop the radio-frequency identification technology (RFID) microchip to improve efficiency in retail supply chain management and to enhance product availability in our stores. We have already used the technology on three million food distribution trays within our supply chain.

The results have been encouraging; but there are concerns that embedding microchips in products has implications for privacy. The practical solution that we came up with, through dialogue with NGOs involved, has proved relatively straightforward. The microchips are either placed on distribution trays or on disposable swing tickets – a solution that has proved neither difficult nor expensive to implement but was necessary if we were going to continue to foster the huge trust that our customers have in the M&S brand.

We must continue to take this dual approach of developing the technology and managing trust at the same time.

There is undoubtedly a clear need for the City and business to work more closely together, in order to understand the true value of investment in technology and to appreciate its implications for the short and long term commercial success of our great corporations.

questions investors should ask

Paul Myners suggested that investors should ask businesses a number of questions about their R&D effort:

- how well does the business appear to understand technology – i.e. is it a market leader or a follower when it comes to adopting new technology?
- what is its track record in successfully taking technology from the R&D phase to commercial success?
- how well does the business link technology and customers' needs?
- how well is the business connected to its suppliers, to their suppliers and to the world of academia?
- does it have the right people to translate scientific advances into new technology?
- above all, does it seem to understand the wider, swirling debate about trust and how this affects customer perceptions of technology?

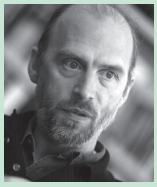
discussion

Fostering knowledge. Some thought the City and the Government should be more concerned about the closure of chemistry departments in universities. There was room for concern if such closures damaged high quality research and meant that students who wanted to do chemistry could not find opportunities to do it. It must be remembered, though, that some chemists were recruited outside the UK; current restrictions on entry of researchers into US universities could provide a valuable opportunity for UK academia and companies to pick up talent.

The Government should concentrate on knowledge transfer, which meant ensuring that the intellectual property rights regime was effective. While there must be some form of market monopoly over research findings for some period, nobody thought the present regime was perfect. But change would mean agreement from a large number of conflicting interests. Patents were not the answer in many cases. Technical know-how was the basis of many profitable technological advances.

Making up our minds about the pharmaceutical industry

Peter Goodfellow



Dr Peter Goodfellow FRS is senior vice-president, Discovery Research, at GlaxoSmithKline. He has worked as a research scientist specialising in human genetics. In 1992, he was elected to the position of Balfour Professor of Genetics at Cambridge University. For the last eight years, Peter Goodfellow has worked in the pharmaceutical industry.

We have a fundamental problem in the pharmaceutical industry. If you have a product cycle time of 25 years, you are hovering at the borderline between what you can support by the market approach and what you have to support by some other means. To put it another way: the high margins that you have to charge for your products have nothing to do with the cost of manufacturing the products. They are to do with the cost of having produced the intellectual property that goes into the product. If society decides to take the short term view that the margins are unacceptable and controls the price, I believe that, as a society, we will have to find some other way of making pharmaceuticals.

That may be a metaphor for the wider question of investing in R&D, but I am going to focus on the pharmaceutical industry in this contribution to the debate. In the UK, pharmaceuticals is the industrial sector which accounts for most (40 per cent) of the country's R&D spend. Aerospace spends 15 per cent, automotives six per cent and IT six per cent. One of the fears that I have sometimes when talking to my colleagues in government is that you end up with no overall gain if you focus on raising small- and medium-enterprise investment while lowering spending in the sectors which are already investing.

Look at the data on R&D spending as a percentage of sales. The pharmaceutical industry spends roughly twice what any other sector does in the UK. If you look at the US, basically the same thing is true: pharmaceuticals look different. So, what is different?

Firstly, making new drugs is very difficult. I believe it is the most complicated thing on this planet to make a new drug. You have to bring together skill sets in chemistry, and in every '-ology' known to man, including that desperately arcane art known as medicine, in order to make a new drug. The cycle time is 14 years to get through the R&D process before you get to the market, and as the average time in the marketplace is only 11 years, the overall cycle time is 25 years.

I work in the pharmaceutical industry, but I am not going to be in it for 25 years to see a complete cycle time. I therefore have two roles: I am the custodian of what people did before, and I am the custodian of the future. Only a few new drugs cover the cost of research and development, so you end up focusing the costs on a relatively few products. It is like spinning a roulette wheel in the sense that only some drugs make large amounts of money (for example, Liptor: a statin for treating high cholesterol, which sells $10 billion a year).

When I joined the pharmaceutical industry, my boss was Jan Leschly. He took me aside one day and said, "Peter, I want to tell you the law of the pharmaceutical industry." He put his arm around me in a fatherly fashion and then he punched me: he had a habit of punching people and as he was a professional tennis player in his time, being punched by him was not altogether a friendly experience. He said, "Man, this is the law. If we make new medicines that treat unmet medical needs, society will give us a lot of money and if we don't, they won't – so go off and make some new medicines." Industry would develop the drugs, and society would allow the profits: that has been the contract that we have been working under. Because of that contract, 91 per cent of drugs are first synthesised in industry and only nine per cent are first synthesised in academia.

We are wrestling with two problems in the pharmaceutical industry. The first is that society cannot quite make up its mind whether to use a market-based approach or not. The Government has been very sincere in discussing investment in R&D with us. However, in the recent negotiations with the Department of Health over pricing, they mandated a cut in the total amount of money that a pharmaceutical company could earn in the UK, in order to cut the bill for drugs in the NHS. That is true for every market in Europe: the government actually determines what the price is.

Paradoxically, because we have a 'free market' in Europe, if the government in Greece sets a very low price, then people in Greece can export that drug back to the UK, where the price is higher! Parallel trading, which undermines the whole commercial structure of sales, is a bizarre consequence of having controlled markets in what is supposed to be a single market – and we have never been able to do anything about that. So the pricing problem is clearly an issue.

The second problem is my problem. Sales have gone up but, since 1994,

the overall success rate in producing new drugs has been going down. We have to become more effective so that we can make more drugs for less money.

So I think that we have a number of choices to make. Society has got to choose whether it wishes to make investment – either in the private or public sector – in new technology for health. We need perhaps to go back to the implied contract and get agreement between society and industry about what the contract actually is, otherwise this industry is going to look very different. Society also needs to decide if it wishes to reward innovation.

I thought I would say something about what actually influences the choices we make in R&D investment. The first is the overall market need. By that I mean unmet medical need: how many people can you actually help? Then what return can be made on that investment and how will it appear to investors: this will have an effect on the share price. If we make a drug and then our customer (perhaps the NHS) refuses to pay for the costs to recoup the investment, then we have a different problem. Obviously, this also poses difficult questions about diseases of the developing world.

There is, as in everything in life, an issue about the cost: if you can do something cheaper elsewhere with equivalent quality, then clearly you will. There is also the need to invest in new technology as opposed to doing things the way that you have always done them in the past. You need, too, to make a decision about whether you really are going to be a pharmaceutical company or whether you are going to be a generic company and copy other people.

It is possible that we could use other models to make drugs and there are, I think, indications that academia is becoming interested in taking on this role. I would like to make it absolutely transparent that, if we change the model and the cycle time is 25 years, then we run the risk of missing out on a cycle's worth of productivity if the people who are going to do it do not have enough experience.

Finally, we should consider the social attributes of R&D investment. I think that the UK has a great science base. I am glad that the Government, in conjunction with the Wellcome Trust over the past few years, has recognised the worth of investing in that science base and I hope that will long continue. We need to have a trained and willing workforce, but the UK is not producing the chemists we need for the pharmaceutical industry. We now recruit 50 per cent of our student chemists from France and Germany. I am not sure if that is a problem or not, but we are not producing the chemists that we need in our economy here in the UK.

We also need staff security. There is reluctance related to the issues of animal rights, and a difficulty in recruiting people with 'in vivo' pharmacology skills and interests, which could also be a barrier to us in the future. There is also the question of a pro-business culture. Clearly, if you decide to develop drugs in academia, you do not need a pro-business culture; if you are going to do it in industry, you definitely need it.

We need a good regulatory environment and long-term stability. We need a contract so that the environment does not change dramatically. I also think that a strong relationship with the health service is important.

The UK could be the best place to do clinical research but it is not. That harms patients in the UK: it closes off an option for improving overall health and clinical treatments here. I am pleased that there have been some initiatives recently to try to address this particular question.

Raising R&D intensity in the UK

Stephen Timms

Stephen Timms was appointed Financial Secretary to the Treasury in September 2004, having served since May 2002 at the Department of Trade & Industry first as minister for e-Commerce and Competitiveness and then as minister of State for Energy, e-Commerce and Postal Services. He worked in the computing and telecommunications industry for 15 years before entering Parliament in 1994 as Member of Parliament for Newham North East. He was elected MP for East Ham in 1997.

Since giving this talk, Stephen Timms has become minister of state at the Department for Work and Pensions.

I would like to concentrate on one strand of our priorities for science and innovation over the next decade: our determination to raise R&D intensity in the UK to 2.5 per cent by around 2014. At the moment it is about 1.9 per cent, and it is going to be quite a tough challenge to bring about that change. R&D intensity is an important indicator of a key driver of productivity. We know that a significant proportion of our productivity gap compared with the US is due to lower levels of R&D spending. If we achieve our goal of 2.5 per cent we will be in a strong position against competitors like the US, France and Germany.

We will need action from both the public and private sectors if we are to succeed. Business R&D is the largest part of the total, so a positive business response is essential. In our Investment Framework, we sketched out one scenario which assumed equal growth in the amounts of both private R&D and public funding going into the science base. That scenario would require a growth in funding on both sides of 5.75 per cent a year in real terms over the coming decade.

In the Spending Review in July we announced a £1 billion funding increase for the science base over the period to 2007-8; this is, conveniently, an average annual growth rate of 5.8 per cent, just on the right side of the figure in the scenario. We set out a ten year framework for investment in the science base: this would increase at least in line with the trend growth rate of the economy, helping to raise science spending as a proportion of GDP.

We are very keen to work closely with R&D employers to understand their investment plans better – and also to understand the barriers in the way of making the investment we are looking for.

There are very good reasons for businesses to invest in more R&D. Harnessing technological innovation will play a crucial role in a business's ability to succeed in the global economy in the future. As globalisation continues apace, competition can only get fiercer; it is estimated that, by 2025, half of all global manufacturing exports will be produced in today's developing countries, compared with a quarter today. At the same time, rising education standards and skill levels are enabling a lot of emerging

economies to move rapidly up the value-added chain. Already, China and India are each producing around two million graduates every year, and in Singapore R&D spending is growing at 15 per cent a year. So the competitive imperative for innovation and investment in R&D is very strong.

Research shows that business investment in R&D generates substantial returns: estimates vary between 10 and 40 per cent. More concretely, according to the latest DTI Scoreboard, the portfolio of R&D-intensive companies on the London Stock Market has seen share price growth of 57 per cent since 1997, while the FTSE 100 as a whole has fallen by 11 per cent over the same period.

R&D intensity in the UK fell in the 1980s and 1990s as GDP growth outstripped R&D growth. That was partly because of falls in defence R&D. There are now welcome signs that the trend is reversing: since the 1980s, investment in R&D has risen in real terms with the biggest increases in the chemicals and transport equipment sectors. There have also been some big increases in the services sector. Overall, though, it is still not rising fast enough, and our investment framework identified four things we need to do to deliver the R&D target.

First, we need to maintain or grow R&D in sectors where the UK is already strong. Second, we need to attract more investment into the UK. We want this country to be the partner of choice in Europe for global R&D. In that regard, overseas business investment for commercial R&D is up by 75 per cent in cash terms since 1996, compared with an increase of all business R&D of just 50 per cent. Third, we want to increase R&D intensity in those firms and sectors where it is not strong and has not been strong historically. Fourth, we need to develop new R&D-intensive sectors and improve the rate of creating R&D-intensive small- and medium-sized enterprises (SMEs).

The principal responsibility of government is to deliver stable economic conditions, with a supportive regulatory environment to make the UK an attractive place for innovative businesses to locate. Building on that, there are fiscal measures we want to use to incentivise greater R&D too: tax credits were introduced for SMEs in 2000 and extended to large companies in 2002. By May 2004, over 10,000 tax credit claims had been received from SMEs amounting to £570 million of support. A DTI technology strategy is focussing resources on key areas of technology potential, funding R&D businesses and encouraging more collaborative work between the science base and businesses. The department has announced an £80 million fund for companies to carry out collaborative R&D in nine high priority technology areas.

We want to work much more directly with businesses than in the past. The DTI has brought together innovation and growth teams for aerospace, biotechnology, chemicals and (one that I launched) the electronics industry. These are looking strategically at the competitive challenges faced by each sector to see how best we can respond.

We need to improve access to finance; this is often a factor holding back growth, especially in small companies. The investments that we are making in science are aimed at supplying the economy with the skills and the research that it needs. In addition, our targeted investments in venture capital and knowledge transfer are designed to close gaps in the private market.

Of course, companies create their own destinies. As shareholders become more assertive, we need the City to explain the case for medium and long-term investment in science much better. The challenge is for the City to persuade investors that R&D is an asset as well as a risk.

There also needs to be greater collaboration between business and our academic base. We want businesses to improve their engagement with universities and research establishments, working to transfer technology from the lab into commercial application, with both sides becoming more responsive to the experiences of the other. We are taking steps to address the barriers Richard Lambert identified in his review of business/university collaboration: this concluded that business, the science base and the economy as a whole would benefit from better collaboration.

Richard also recommended an enhanced role for Regional Development Agencies in funding and facilitating research that is relevant to businesses; that is being taken forward by the RDAs themselves. Central Government will be investing more to help universities and public sector research establishments build capacity in knowledge transfer - for example, the Higher Education Innovation Fund will reach £110 million a year by 2007-8.

So, taken together, the measures that we have introduced to increase R&D investment in the UK do, I think, represent important progress. Many of the measures, the R&D tax credits for example, are already demonstrating positive results, but we know that there is still a way to go and we are determined not to be complacent.

discussion

Trust. Trust between investors and businesses was crucial, but there was some public suspicion of science, and a strong feeling that there were social, as well as commercial, objectives that scientific advances ought to be serving.

For example, did research in the food industry serve the aims of securing adequate nutrition and preventing obesity in children? Were the oil companies seriously interested in reducing the use of carbon fuels?

The answer lay in the need for businesses to recognise public concerns early enough to develop products that would address those concerns profitably. The efforts of the food industry to develop low-salt and low-fat products which customers wanted to buy, and the investment oil companies were putting into fuel cells and solar power, were examples of such responses.

discussion

Making choices. It was suggested that the very large size of pharmaceutical and defence companies might inhibit the development of radical ideas: smaller companies without a bureaucratic structure might be better at giving highly original proposals a better chance. The contrary hypothesis was also proposed, though: that large companies might be able to afford to support original, but perhaps uncommercial, ideas while they might sink a smaller company.

Investment managers probably do not choose investment vehicles by investigating the performance of each company in a sector. They are more concerned with asset allocation between sectors and achieving the appropriate weighting. So any investment manager allocating assets to pharmaceuticals would almost invariably have shares in GSK for example.

A new nuclear generation?

John Maddox, Editor

In the run-up to the general election, the prime minister, Tony Blair, declared that he had "fought hard" to ensure that the option of building further nuclear power stations in the United Kingdom was not foreclosed. Now his newly formed government is gingerly preparing to publish a white paper defining the conditions under which further nuclear power stations might be built. The document should appear early next year (2006).

The issue has been lent urgency by several considerations. Despite efforts to prolong the life of existing stations, the original Magnox reactors are within a decade of being decommissioned. The second generation of Advanced Gas-cooled Reactors (such as that in Dungeness in Kent) will reach the ends of their life within 15 years. Thereafter only the Pressurised-Water Reactor at Sizewell in Suffolk will remain in service. Yet these power stations account for nearly 25 per cent of British electricity production. The likelihood that they could be replaced by renewable energy is not strong. Security of supply is in question.

The past decade has seen substantial improvement in reactor design. Both in the United States and Europe, the use of enriched fuel in water-cooled reactors has led to structural designs which are inherently cheaper to build and which produce less radioactive waste for the energy they generate. Even without considerations of fossil-fuel induced climate change, power generators would be looking to nuclear fission as a source of electricity.

The US design for a modern reactor has been developed by Westinghouse, which is now a subsidiary of the Government's wholly-owned British Nuclear Fuels (BNFL). The European design is the product of a consortium led by Siemens, the German electrical manufacturer.

But climate change is the real driver of the Government's change of tack. The difficulty of meeting the current goal of 10 per cent of electricity generation from renewables (mostly wind power) by the end of the decade is manifest. An accelerated programme of construction to meet a forward projection of the Kyoto Protocol is likely to be a disheartening experience for everybody concerned.

If the abatement of climate change is the urgent goal the Government believes, all pollution-free sources of energy will have to be deployed. The white paper is likely to argue for this. No doubt the need for energy efficiency will again be rehearsed. Wave power is a long-term potential source, on which the Government is spending substantial sums. Solar power serves a niche, but deserves encouragement. Despite decades of experiment in Cornwall, geothermal energy is unlikely to make much of a contribution to British energy supplies.

The nuclear industry has acquired a reputation for being unsafe, but its safety record compares well with that of industrial sectors such as construction or even farming, when measured by physical injuries to, or fatalities among, workers. The explanation lies with the nature of the most common hazard to well-being – exposure to radiation, suffered by workers at nuclear plants directly and by the general population through the emission of radioactive isotopes (of hydrogen and argon) unavoidably emitted from nuclear power stations.

The current regulations limiting human exposure to radiation are based on the assumption that the risk of contracting cancer is directly proportional to the radiation dose received. In other words, there is no 'threshold' below which exposure has literally no effect. The permitted doses are then set at such a level that the occurrence of cancer will be statistically imperceptible.

The nuclear industry and the Nuclear Installations Inspectorate are well equipped with the techniques (and the people) needed to monitor these things. The white paper will no doubt emphasise the rather good record of the past 40 years, although that will not dispel the notion that an invisible agent such as radioactivity in the air or water can cause cancer.

There remains the problem of radioactive waste generated from the fuel in nuclear reactors. The belief that this must be strictly isolated is a central plank of nuclear public health policy, and rightly. But the problem is not insoluble. There is, for example, a general opinion that the safest means of disposing of the most dangerous material is to incorporate it in glass, and then to pour that glass into stainless-steel containers which in turn are stored in an accessible underground repository.

Such procedures are being followed in the United States, France and Finland, among others. In Britain, the government agency NIREX proposed building such a repository in the rock beneath the Sellafield site in Cumbria, but this was rejected following a public enquiry. The outcome is that the Government has handed the question of long-term waste disposal to a working party due to report only in July next year. No doubt the debate likely to be caused by the white paper will still be raging at that time.

The risk of an accident such as that at Chernobyl in 1992 is not a technical but a managerial question. The reactor caught fire after two engineers on a night shift carried out an unauthorised and manifestly dangerous procedure. Even the spirit of glasnost (fashionable at the time) did not sanction experiments of this "let's see what happens" kind. The concern in future may be to ensure the integrity of those who control nuclear stations.

The first generation of British reactors was commissioned by Government agencies (the Atomic Energy Authority and the Central Electricity Generating Board). Now that the power industry is privatised, that route to a new generation of power stations is closed. The white paper will no doubt insist that future developments will have to be conducted within the economic framework that has evolved over the past few years.

The most serious task for the authors of the white paper will be that of devising a level playing field on which several alternative sources of power can fairly compete for the attention of consumers. Even as things are, it is difficult enough to use market mechanisms to strike a balance between oil and gas: the latter has a price advantage because it produces less CO_2 per therm of energy, but who knows whether the price differential is correctly set?

If new nuclear power stations enter the British mix of energy production, there will be further complications. One is that nuclear power stations now operating are subject to the climate change levy by which the government taxes electricity not generated by renewable sources. (The justification, that nuclear stations embody great quantities of energy in their construction, has always been contentious.) Fair play would require this provision to be amended, perhaps even abolished.

The past few years have also provided vivid evidence that the costs of dealing with nuclear wastes, and of decommissioning reactors, cannot be ignored. No doubt the white paper will insist that the new regime should cover these costs, at least in principle, from the outset – speculative though they may be.

The white paper will therefore pose big and subtle questions for industrial contractors and the capital markets on which they depend. But the really difficult questions are for the government itself. Does it have the stomach for building anew the infrastructure for an industry that has been moribund for a quarter of a century? Is it prepared to seek to win the public debate there will inevitably be? And to face the endless public enquiries there may have to be.

It will be surprising if these questions can be decided quickly. In an ideal world, they would need a whole five-year parliamentary term. But that luxury is no longer on offer. The timetable of climate change is too pressing.

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The Education of 14-19 Year Olds

Pauline Cox, Head, Tiffin Girls' School, Kingston
Lord May of Oxford, President, The Royal Society
Julie Bramman, Head of Curriculum, Specialism and Collaboration, Department for Education and Skills

Biotechnology and Biological Sciences Research Council and The Comino Foundation

11 May 2005

Science Policy and Management

Sir Keith O'Nions FRS, DGRC, OST
Sir David Wallace CBE FRS, Vice-Chancellor, Loughborough University
Dr Mark Walport, Director, The Wellcome Trust

BAE SYSTEMS, The Council for the Central Laboratory of the Research Councils and The Natural Environment Research Council

27 April 2005

Can the UK get on, and stay on, a path to a sustainable economy?

Jonathon Porritt, Chairman, Sustainable Development Commission
Anna Coote, King's Fund
Dr Bernie Bulkin, former Chief Scientist, BP
Professor Howard Dalton FRS, Chief Scientist, Defra

Department for Environment, Food and Rural Affairs and The Natural Environment Research Council

23 March 2005

The UK Productivity Gap

Professor Vicky Pryce, Chief Economic Adviser and Director General, Economics, DTI
Professor Jonathan Haskel, Queen Mary, University of London
Professor John Van Reenen, Centre for Economic Performance, London School of Economics

The Gatsby Foundation and The Royal Commission for the Exhibition of 1851

9 March 2005

Transport Policy - How should road congestion be managed?

Graham Pendlebury, Director Road and Vehicle Safety and Standards Directorate, Department for Transport
Dr Archie Robertson CBE, Chief Executive, Highways Agency
Professor David Rhind CBE FRS FBA, Vice-Chancellor, City University
Professor Anthony May OBE, Chairman, Inquiry into Transport and Emeritus Professor, Institute for Transport Studies, University of Leeds, Royal Academy of Engineering

Department for Transport and Lloyd's Register of Shipping

23 February 2005

Identity Management

Des Browne MP (represented by Katherine Courtney), Minister of State for Citizenship and Immigration, Home Office
Ian Watmore, UK Government CIO and Head, e-Government Unit, Cabinet Office
Ed Mayo, Chief Executive, National Consumer Council

Sharp Laboratories of Europe and QinetiQ

1 February 2005

Visit to Ford Dagenham Diesel Centre

Mr Roger Putnam, Director, Ford
Jacqui Smith MP, Minister of State for Industry and the Regions , DTI

1 December 2004

Science and the City

Paul Myners, Chairman, M&S
Stephen Timms MP, Financial Secretary, HM Treasury
Dr Peter Goodfellow FRS FMedSci, Senior Vice President , Discovery Research, GlaxoSmithKline

ARM, Comino Foundation, GlaxoSmithKline (GSK) and HEFCE

23 November 2004

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Sir Howard Newby CBE, Chief Executive, Higher Education Funding Council for England
Pam Alexander, Chief Executive, South East England Development Agency
Tom Swan OBE, Chairman, Thomas Swan & Co Ltd

Engineering and Physical Sciences Research Council (EPSRC), Royal Society of Chemistry (RSC) and South East England Development Agency (SEEDA)

10 November 2004

Science Communication - are we making progress?

Professor Colin Blakemore FRS FMedSci, Chief Executive, Medical Research Council
Professor Kathy Sykes, Collier Chair: Public Engagement in Science and Engineering, University of Bristol
Fiona Fox, Head, Science Media Centre, Royal Institution of Great Britain

Defra, Pfizer and The Wellcome Trust

28 October 2004

Energy Policy — Security of Supply

The Lord Sutherland of Houndwood KT PRSE FBA, President, Royal Society of Edinburgh
Peter Mather, Director UK and Europe, BP
Kieron McFadyen, Technical Director (Europe), Shell Exploration and Production

Scottish Enterprise, The IEE and the Institute of Physics

26 October 2004

The Lord Lloyd of Kilgerran Award Lecture

Dr Richard Durbin FRS, Head of Informatics Department and Deputy Director, The Wellcome Trust Sanger Institute

20 October 2004

Public Health — imposing choice?

Derek Wanless, Inquiry Chairman, Securing Good Health for the Whole Population
Melanie Johnson MP, Parliamentary Under-Secretary, Department of Health
Lucy Neville-Rolfe, Company Secretary, Tesco
Professor Siân Griffiths, Senior Clinical Lecturer, Department Public Health and Primary Care, Oxford University

Gatsby Charitable Foundation and the Kohn Foundation

12 October 2004

Risk Perception and Public Policy

Sir John Krebs FRS, Chairman, Food Standards Agency
Professor Ian Diamond, Chief Executive, Economic and Social Research Council
Professor Nick Pidgeon, University of East Anglia

Defra, Fishmongers' Company, Pitchell Consulting

20 July 2004

Science & innovation investment framework 2004–2014

John Kingman, Director, Enterprise and Growth Unit, HM Treasury
Sir Keith O'Nions FRS, Director General Research Councils, Office of Science and Technology, DTI
Andrew Barker, Head of European Equity Strategy & Managing Director, UBS

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