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THE FOUNDATION FOR SCIENCE AND TECHNOLOGY

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contents

Nuclear plants given the green light

The results of the Energy Review were published on 11 July. As had been widely expected, the Government sees a role for a new generation of nuclear power stations within the UK's power generation mix. It believes that this is necessary to counter an expected energy shortfall without compromising the strategy to combat climate change.

Trade and Industry Secretary Alistair Darling made it clear, though, that there would be no special treatment for nuclear power. In his Commons statement on the Energy Review, Mr Darling said: "It would be for the private sector to initiate, fund, construct and operate new nuclear plants and cover the costs of decommissioning and their full share of long-term waste management costs."

Energy efficiency and renewables also feature in the report. It states: "The starting point for reducing carbon emissions is to save energy. The challenge is to secure the heat, light and energy we need in our homes and businesses in a way that cuts the amount of oil, gas and electricity we use and the carbon we emit." The target for the share of renewable electricity is to be raised to 20 per cent.

Other major proposals, many for further consultation over the coming months, include:

- Strengthening the EU Emissions Trading Scheme post 2012;
- Measures to encourage carbon savings for large organisations like supermarkets and hotel chains and large local authorities;
- Using Government's purchasing power to drive efficiency standards;
- A series of measures and review of ways to bring on more localised 'distributed' generation;
- Fundamental change to the planning system for all types of energy projects, including timelines for inquiries and a 'high-powered inspector' for complex and controversial projects;
- Measures to facilitate new nuclear power stations - streamlining the licensing process, clarifying the strategy on decommissioning and waste;
- Removing regulatory barriers to carbon capture and storage, intensifying international cooperation with partners such as Norway and further work on the costs of demonstration. ❐

www.dti.gov.uk/energy/review/page31995.html

Proposals to replace RAE

The Government is consulting on a new system to replace the Research Assessment Exercise (RAE) after 2008, with the aim of cutting bureaucracy and increasing efficiency.

A working group, jointly chaired by Professor David Eastwood, Vice Chancellor of the University of East Anglia and Sir Alan Wilson, Director General for Higher Education at the Department for Education and Skills, was established after the Budget in March. Its task was to come forward with proposals which would encourage, identify and reward research excellence in higher education.

The recommendations of the group are:

- In line with the presumption announced by the Chancellor in the Budget, the 2008 RAE should proceed as planned, but the panels responsible for assessing individual subjects should be able to make greater use of metrics - statistical analysis - alongside or instead of peer review where they think this is appropriate. This will not make it necessary to collect any additional information from institutions;
- A 'shadow' metrics exercise covering all subjects should be run in parallel with the RAE;
- The metrics used in subjects like science, technology, engineering, maths and medicine should be based largely on external research income. The consultation proposals include a range of models that might be used;
- Other subjects should use a more differentiated approach which may need to contain an element of peer review and which will be developed from a project currently being taken forward by the Higher Education Funding Council for England and the Arts and Humanities Research Council.

This should lead, says the Government, to a combined, predominantly metrics-based, research assessment and funding system to be phased in from 2009-10 in England. The consultation closes on 13 October. ❐

www.dfes.gov.uk/consultations/conDetails.cfm?consultationId=1404

Incentives and barriers to public engagement

The Royal Society, Research Councils UK and the Wellcome Trust have jointly funded a study to examine the factors affecting science communication by scientists. It will provide evidence to support the development of strategies to encourage scientists and engineers to communicate with stakeholders including the public, policy makers and the media.

When asked to define in their own terms what engagement with the non-specialist public meant to them, scientists who took part said that it was to explain and promote public understanding of science (34 per cent), it was to highlight the implications, relevance and value of science (15 per cent), or it was listening to and understanding the public (13 per cent).

Looking at the barriers to engagement, 64 per cent said the need to spend more time on research was stopping them getting more engaged. One–fifth of those who responded agreed that scientists who engage "are less well-regarded by other scientists".

The primary incentive for engagement was to bring more money to the respondent's department. Some 81 per cent said this would encourage them 'a great deal' or 'to some extent' to undertake more public engagement. ❐

www.royalsoc.ac.uk/downloaddoc.asp?id=3052

Progress on the 10 year framework

The second annual report on the Science and Innovation Investment Framework 2004-2014, published on 13 July, has concluded that the UK research base is continuing to improve, helped by increased investment for the development of both new areas of research and a sustainable capacity for the future.

The overall assessment is that "the UK continues to perform strongly in terms of research output and quality, second in the world to the US, and demonstrates a good balance of strength in its performance across disciplines."

In the G8, the UK is second to the USA in terms of national share of global citations for 2004, at about 12 per cent. It is second to the USA on citation count in seven out of nine research fields, although fourth in physical sciences and engineering (behind the USA, Germany and Japan).

The report highlighted universities' stronger links with business and community organisations as well as strong market debuts for university spin-out flotations. A further 10 university spin-out companies were floated in 2005 bringing the Initial Public Offering value to over £1 billion.

However, the report also highlights key challenges that remain, regarding levels of business investment in R&D and "to ensure that the UK has the continued throughput of trained scientists that it needs."

Sir Tom McKillop, chair of the UK Science Forum, noted: "While good progress has been made, much more remains to be done." ❐

www.dti.gov.uk/files/file31811.pdf

Alcohol and drugs are widely used in our society. Their role today and in the future – and society's response to the challenges – was discussed at a meeting of the Foundation held in Glasgow on 17 November 2005.

What impact will drugs have on society in the future?

Andrew Jackson

Andrew Jackson is Deputy Director of the Foresight programme at the Office of Science and Innovation. He has overseen a number of the recent Foresight projects, covering topics such as: brain science, addiction and drugs; cognitive systems; flood and coastal defence; and intelligent infrastructure. Before taking up his current post, he worked in the DTI in a broad range of areas, including European Union policy, Government department legislation and finance.

Psycho-active substances have always been an integral part of society. The neuro-scientists tell us, time and time again, that the brain is designed to try to improve the situation of the individual. When you take your body to a place which is 'better', the brain gets a reward; if it takes you to somewhere you would rather not be, you suffer anxiety and stress. As long as there are chemicals around which provide that reward or reduce anxiety and stress, people will continue to find ways to use them. The scientists we asked could not conceive of a world in which we would not use these substances.

So, what does the future hold? Well, of course, the old drugs – heroin, cocaine, amphetamines – will always be there but there are also likely to be some new substances on the market. These will come from advances in our understanding of how the brain works, from so-called garage laboratories and many other ways. There are some quite frightening developments, including a drug called methyl-amphetamine, known as Ice, which is very addictive and very damaging. The scientists also tell us, however, that it might be possible to produce a drug which has the effect of alcohol but not the harm.

Certain drugs being trialled as health treatments allow you, potentially, to modify the experience you have with a drug and some think that this allows you to reduce the withdrawal effects of heroin. So we are starting to see people adapting the way they use drugs and becoming more sophisticated in the way that they use them. And, of course, there are new combinations: in Iceland, with the extension of licensing hours, it was reported that people were combining amphetamines with alcohol – the amphetamines were used to stay awake and drink alcohol all night!

There will be treatments for addiction. There are four linked functions which are brought into play when people take decisions – control, reward, drive and memory. Now in the addictive brain, you no longer have the control mechanism telling the individual not to take the drug and the individual becomes locked into a self-reinforcing cycle of behaviour, of finding a way to get the drug and to take it. Can we use cognition enhancers to restore this link? I know there is a serious question about 'should you use drugs to treat drugs?' but if there is a capability to restore this link, using drugs, should we use it?

In terms of reward, vaccines are being developed which bind to the active part of the drug, so that it no longer has the same effect in the brain.

There are advances in both motivational and cognitive therapy, which mean that you could work with individuals to help them take decisions which would be good for their longer term health. The scientists in our project did not think that there would be one 'silver bullet' that would solve addiction: the view was that you need the psychological treatments, you need to think about vaccines, you need to ask whether there is a way in which we can improve the planning capabilities of the individual. But the answer is likely to be a package of measures to help the individual through the addiction.

I have already mentioned cognition enhancers which improve the mental performance of healthy individuals. This is not just something for the future: there is already a website where you can order drugs which the site alleges will enhance your performance in a particular way. There is speculation from the scientific world that we are going to see the development of many drugs which can deliver such benefits to the user, as a spin off from investments to develop treatments for mental deterioration in an ageing society. We need to consider the implications of such drugs on education and work and then put in place a regulatory framework on the use of such enhancements by healthy individuals. There is also the question of the susceptibility of the brains of the young: if you use drugs when you are young, you are far more likely to become addicted.

Once there is a culture for the use of a particular drug, it is very, very difficult to change; so we need to understand the cultural context. A good example of this was in New Zealand, where they managed to stop heroin coming into the country but people just started to inject Tamazepan instead. Therefore, although there was a massive reduction in heroin use, the harm to individuals and society remained. Unless

society is ready for it, any change can have unexpected effects which may be more harmful than those that we were seeking to address. So public engagement and an understanding of the culture are absolutely essential before changes are made.

The project raises a number of strategic choices for society. Do we want to produce, as a society, drugs which are less harmful than those we have today? Do we want to pursue a policy of finding drugs which are less harmful and promoting them?

Advances in genetics are quite fundamental – some recent research suggests that the people who tend to suffer harm if they take Ecstasy have a particular genetic allele. As people start to understand their predispositions to harm, what impact will that have on society?

There is an increasing use, certainly in the USA, of drug tests in businesses to check whether people have taken drugs – would that be acceptable in the UK? If we have cognition enhancers, are we going to see more drug tests in schools? There are many, many other issues. I will just finish with one question about social solutions – is it possible to create an environment where the *desire* to use drugs goes down? ❐

The effects of abuse on family and society

Neil McKeganey

Professor Neil McKeganey FRSA is one of the leading drug abuse researchers in Europe. He is the founding Director of the Centre for Drug Misuse Research at the University of Glasgow. A sociologist by training, he has undertaken research on a wide range of topics including the impact of parental drug use on children, the problem of pre-teenage drug use in Scotland and the link between drugs crime and prostitution.

Drugs and alcohol affect everyone's lives, in many cases intimately and in many instances with enormous adverse consequences. They challenge us in terms of what we are prepared to accept – as a society and as individuals, as families, as communities – and what are we prepared to do to diminish and reduce those adverse effects.

It is said that alcohol is Scotland's favourite drug and, in terms of the level of consumption, that is certainly the case. The consequences of excessive alcohol consumption are very familiar to many people. Currently there is great concern about the links between excessive alcohol consumption and violence. We also know, of course, that there are serious health effects as well. Figures on the role of alcohol in possible causes of death show a steady increase from the early '90s through to 2002. With regard to illegal drug use we have, in Scotland, some of the highest levels of drug use amongst children anywhere in Europe. Just under 10 per cent of 13 year olds, and 20 per cent of 15 year olds, have used an illegal drug in the past month. We increasingly see children younger than 13 using illegal drugs. In Glasgow alone we estimate from recent research that there may be about 50-60 children of 11 and 12 who have already started to use heroin.

The most recent estimate of the number of people using heroin in Scotland would put the figure at around 51,500, predominantly men, amongst whom nearly 19,000 people are injecting drugs. While in the past serious drug abuse was a feature most commonly associated with our urban areas, there are now indications that it is occurring widely in our rural communities. Indeed research carried out by Dr Gordon Hay at the University of Glasgow found that the rate of increase in the scale of Scotland's drug problem over the last few years was greater in the rural areas than in the urban.

The impact of the drug problem in Scotland is enormous. We have carried out research, relatively recently, which has identified that nearly 60 per cent of injecting drug users in Glasgow are Hepatitis C positive; the figure for Scotland as a whole is approaching 40 per cent. Currently, Hepatitis C positive drug users receive relatively little by way of treatment. In part that is a result of a perception that drug users are unlikely to stick to the treatment regime. However, the National Institute of Clinical Excellence has questioned that supposition and has recommended that drug users should not be disqualified from optimal treatment. Such a statement will mean an increasing expectation, appropriately so, that drug users with Hepatitis C should have access to optimal treatment. At £6,000 per patient, with some 19,000 drug users having Hepatitis C, the cost to the NHS in Scotland is likely to be substantial. But will drug users get that optimal treatment?

Drug use affects more than the individual user and my colleagues, Joy Barlow and Marina Barnard, have been looking at the impact on children of an addict parent. Overall we have estimated that there may be as many as 50,000 children in Scotland with one or both parents dependent upon illegal drugs. These children are suffering unimaginable harm as a result of their parents' drug use. They are growing up within the midst of drug-related criminality, very often with daily exposure to the reality of their parents' serious drug abuse. At present, the aim of policy is to provide support for children within drug-using families. The reality however is that we are unable to support anywhere near the number of children involved. As a result, many thousands of children, despite all our protestations to the contrary and well-intentioned policy, remain vulnerable and unsupported. Where children are suffering at the hands of their drug-addicted parents we need to ask how long they should be left within these addict households? There is no easy answer to that question although it is one which services are going to have to grapple with increasingly in the future.

Now, I want to consider treatment. Recently we asked a large sample of drug users across Scotland, 'What do you want to get out of treatment?' Three quarters had one aim in mind: to become drug free.

But what do drug users currently get in Scotland? At the moment we have an estimated 20,000 injecting drug users receiving methadone. That figure represents approaching half of our total addict population and must mean that virtually all drug users in treatment are now receiving methadone. Where we have sought to look at the impact of drug abuse treatment however we have found that only a tiny proportion of drug users receiving methadone are able to become drug free some three years after starting their treatment. By contrast nearly a third of those who received residential rehabilitation were able to be drug free three years after starting treatment. These findings suggest that it is residential rehabilitation rather than methadone which is enabling drug users to become drug free and yet residential rehabilitation is one of our least frequently provided services in Scotland.

In this research we had the opportunity of comparing the success of the Scottish based drug treatment services in enabling addicts to become drug free with the success rate of similar services in England. That comparison showed that the Scottish drug treatment services were enabling a much smaller proportion of clients to become drug free than the equivalent services in England. We need to ask why that is. And we need to ensure that our drug abuse treatment services in Scotland are able to assist a much greater proportion of drug users to become drug free than they appear to be doing at the moment.

The scale of the drug problem in Scotland underlines the order of the challenge we are facing. At the moment there are around 51,500 heroin addicts in Scotland which represents only about 1 per cent of the Scottish population aged 15 to 54. If the scale of the drug problem in Scotland were to increase over the next 20 years along anything like the lines that it has over the last 20, we could see that increase to 2-3 per cent of the Scottish population. In that event we may come to realise that the problem of illegal drugs in Scotland has simply gone beyond our capacity to cope and we may wonder what the impact of that problem would then be. ❐

Providing healthcare to drug users

John Arbuthnott

Professor Sir John Arbuthnott FRCPath FIBiol FMedSci FRSE is a microbiologist of 40 years standing. In 2000, he completed a period of nine years as Principal and Vice-Chancellor of the University of Strathclyde in Glasgow. In November 2002, he became Chairman of Greater Glasgow NHS Board, the body which runs the National Health Services in Greater Glasgow, where he led a team that created a new Centre for Population Health. He was knighted in 1998.

West Central Scotland is an area of high deprivation and the communities with the poorest health are those that are most deprived. There is nothing new in that but, when generalising from the Glasgow area to the rest of Scotland and drawing comparisons of our state of health with that in other countries, we must remember that within Glasgow itself there are wide differences between areas that are very close to each other.

However, while outcomes are improving, the gap between Scotland's health and that of other European countries is still apparent. In terms of hospital admissions, alcohol misuse in two of our most deprived areas is responsible for between 3,500 and 4,000 admissions per 100,000. This is 12 times higher than the city average of 300 per 100,000.

At the level of primary care 4,500-5,000 individuals with chronic alcohol problems were seen by their GPs each month in 2000. For the Greater Glasgow area, between 1996 and 2001 there were 2,500 alcohol-related deaths and 2,000 of these were within Glasgow City.

Just to hammer this home, people from deprived areas are six times more likely to be admitted to hospital with alcohol-related disease than those from affluent areas. If we look at how this affects Scottish statistics, we can say that about 25 per cent of Scottish alcohol-related admissions occur in the Glasgow area.

The impact of this burden on the wider community is considerable in terms of: poor health; anti-social behaviour; concerns about the care and development of children; criminality; and economic deprivation.

Not surprisingly, the abuse of alcohol is linked to abuse of drugs. The figures for the most recent trends are from two studies, carried out in 2001 and 2005 jointly by the Centre for Drug Misuse Research at Glasgow University and the Scottish Centre for Infection and Environmental Health. Over 25 per cent of drug misuse in Scotland is found within the NHS Greater Glasgow Health Board area, with the estimated prevalence being over 13,000 or 2.64 per cent of the population. The main age group affected is 25-34 years of age.

The health and social problems that I mentioned in connection with alcohol abuse are even more evident with drug misuse. For instance, in 2004-5, our Community Addiction Teams were providing support to 2,500 adults with addiction problems who had parenting responsibility for 3,800 children living in these households.

The City Council Social Work Services and the services previously provided by the Alcohol and Drug Directorate of the Primary Care Division of NHS Greater Glasgow have been united in a jointly-run Glasgow Addiction Service. The Community Addiction Teams (CATs) intervene to assist with integrated care plans, parenting and childcare issues, as well as with addiction treatment and probation orders where treatment and rehabilitation form an integrated component. In 2004-5, nearly 8,500 people accessed treatment, care and support through the CATs. This is a 37 per cent increase from the previous year. Preparation for employment is a key aspect of the support package. Glasgow Addiction Service also commissions and contract manages residential services, the Drug Crisis Service, community support and carers services.

The relationship between ill-health and the cocktail of life circumstances that we label 'deprivation', though being well documented, is far from being well understood. Moving from better understanding to action that leads to improvement remains even more challenging. ❑

A meeting of the Foundation on 8 March 2006 considered the economics of energy supply options and the optimum percentages of each source within the UK's energy generation mix.

The challenges for future UK energy policy

Peter Mather

Peter Mather is Head of Country UK and Vice President, Europe, for the BP Group. Before this appointment, he held senior positions in BP's Gas and Power, Supply, Trading and Corporate Strategy departments.

Department of Trade & Industry (DTI) figures for primary energy demand in the UK had gas at 42 per cent, oil at 32 per cent, coal at 17 per cent, nuclear at 7 per cent and renewables at 2 per cent. The country has actually been self-sufficient in gas for around 10 years, a situation which is partly responsible for the enormous growth in gas-fired power generation. Relatively cheap, plentiful gas, with its considerable environmental benefits, has been the obvious fuel of choice and now accounts for over a third of UK power generation.

We currently have sufficient sources of gas supply. The North Sea today is still the major source, but there are others: in particular Norwegian imports; imports from the Continent via the interconnector; storage; and to a lesser extent LNG. It is undoubtedly true that less natural gas will come from the UK side of the North Sea in future, although periodic predictions of the imminent demise of the North Sea have proved premature. With our modest demand growth there is no reason to panic.

However, behind this picture of stability lies much furious activity by the industry – with the aim of maintaining the highest level of production possible in the North Sea, developing resource and infrastructure for pipeline imports, accessing LNG supplies and investing in regasification facilities.

If we are able to bring all our current projects onstream, we may be in the comfortable position of having surplus capacity over and above our future import requirements. The predictions are that we may need an extra 60 billion cubic metres (bcm) a year of imports by 2010 and these projects will deliver at least 76bcm, more if further developments are included.

With regard to policy, the first point to make is that it is both a global and local issue. The climate and the world's resources are things that we share. However, each country or trading bloc, such as the EU, has specific needs.

There are several principles that we believe any energy policy should consider. First, any investment – financial, technical or in human resources – must be made on a sustainable basis. And for these investments to be sustainable, an appropriate sharing of risk and reward between different parties is likely to be essential.

Whilst all energy options must be considered, due priority should be given to options that can really make a difference. Market mechanisms should allow carbon reduction to be made in the most efficient places. The EU Emissions Trading Scheme is a good start, but this might need to be deepened and broadened in order to play a bigger role – and ideally extended so as not to penalise European industry in the global marketplace.

We do not believe governments should be in the business of picking winners, although there may need to be a transitional period where new technologies require an appropriate legislative and fiscal framework in order to be able to compete longer term on a level playing field. Thereafter the market should determine who the winners and losers are, as in any other sphere.

Constant pressure to complete the liberalisation of European energy markets has to be important for this country – liberalised markets will ensure that supplies get to where they are most valued, that demand management occurs where it can be done most efficiently, and that supply shocks can be buffered where possible. Look at the USA in 2005 – the markets reacted very efficiently to the supply disruption caused by the autumn hurricanes.

Finally, it is good to talk; the right relationships with countries that have a role in energy – whether as suppliers, transit countries, or as fellow consumers – are important. And above all, energy policy must be simple, stable and predictable. ❐

Nuclear power – what has changed?

Robert Hawley

Dr Robert Hawley CBE DSc FREng FRSE is a former Chief Executive of British Energy. He is Deputy Chairman of the Foundation for Science and Technology, Chairman of Carron Energy plc and Berkeley Resources Ltd as well as a non-executive director of Colt Telecom Group plc and Rutland Trust plc. He is an international expert on power generation, energy and the environment and he is also the author of books and papers on aspects of power generation and dielectrics.

The UK led the world in developing nuclear power generation but state ownership and bureaucracy did not deliver projects on time and on budget. We were also too tempted to make every new station an experimental design rather than build plants using common components and designs. This led to a legacy of Magnox, advanced gas cooled reactors (AGRs) and one pressurised water reactor (PWR); although it must be remembered that the Magnox stations played a role in our nuclear deterrent programme. They have a total installed capacity of 11.9 GW. While the life of the AGRs might be extended, the UK nuclear power generation capacity could fall by 50 per cent as soon as 2012 and be down to 3 per cent of our generation requirements by 2023.

We are in a situation where the Government must decide how much to intervene in the market to manage the mix of supply and it must decide how much either the consumer or the taxpayer will pay to meet carbon dioxide emission targets or security of supply policy choices – the market itself cannot make these choices.

Today, new nuclear power generation would be built by private companies, not the Government, and electricity would be sold in a competitive market. The expertise to build such a plant would draw on the global experience of nuclear operating companies, large construction and power generating companies. For current designs, there are many examples of projects being completed to time and cost.

In the UK currently, waste spent fuel management and decommissioning costs are less than 4 per cent (after discounting) of the total generating cost and will be even less for future designs that will produce less waste per Megawatt–hour of generation through design improvements.

EEUK, in a report to the Committee on Radioactive Waste Management (CoRWM), who are due to report to Government on disposal options by July this year, estimate that 10 GW reactors, in other words 10 gigawatts, would generate 14,000 tonnes of spent fuel, 9,000 cubic metres of immediate level waste and 80,000 cubic metres of low level waste from operations and decommissioning. That is over a 60 year period; waste from a new build programme is only a small fraction of what the Government has now to deal with – it is less than 10 per cent of what is already in our inventory.

Nuclear electricity generation is rising globally and this is creating demand for increased production and development of new deposits of uranium. The World Nuclear Association puts current usage at about 68,000 tonnes per year and forecasts that the world's present measured resources of uranium in the lower cost category at 3.5 million tonnes. Only using conventional reactors, this would be enough to last 50 years.

They also state that further exploration and high prices will certainly, on the basis of present geographical knowledge, yield further resources as present ones are used up.

I would like to make a comment about carbon dioxide and nuclear. Nuclear is not totally emission free because energy from CO_2-emitting sources is used to make the components for the power station, extract the uranium and, of course, decommission. A comprehensive study of comparative emissions from all sources of energy was published in *IAEA Bulletin*, which shows that emissions of CO_2 from nuclear power are minimal and that nuclear generation can play a major role in meeting the Government's carbon dioxide reduction targets.

In evaluating the policy for our future energy supplies, Government must take proper account of the significant changes that have taken place in the nuclear power generating industry. The new generation of reactors can produce electricity at a lower capital cost with less waste and in greater safety than legacy reactors built in the '60s, '70s, '80s and '90s. Radioactive waste in the UK remains an issue.

The UK Government needs to ask the Nuclear Inspectorate to follow the US lead and begin the process of licensing a suite of reactors for construction on existing nuclear sites in Britain rather than granting a site-by-site licence.

It must end the discrimination against nuclear power by exempting it from the Climate Change Levy since nuclear emits almost no greenhouse gases.

It must designate a site for a long term repository for nuclear waste or at least declare that we are going to bury nuclear waste in a site. ❐

2020 vision – seeing the policy options more clearly

Ross Howard

Ross Howard is a Partner in the Energy, Infrastructure and Utilities group at Deloitte. He has 14 years' experience of providing external audit and transaction advisory services to the corporate sector. In addition, he advises clients across Central Government. Ross led Deloitte's 2020 vision research project into UK energy strategy and the options for achieving energy security, reduced emissions and market effectiveness and has recently been appointed as an expert adviser to a House of Lords Select Committee investigating European energy policy.

There is an urgent need to address the emerging energy gap as existing nuclear and coal plant are retired. Doing nothing to address the likely situation in which the majority of new investment will be in gas-fired technology is not a viable option.

Demand for power continues to increase, and the UK's current power generation portfolio is due to change significantly as existing nuclear and coal plant are retired. Based on our calculations, the energy gap could be equivalent to 50GW by 2020, or two-thirds of existing capacity: importantly this gap starts to emerge in the very near term. While demand-side initiatives, like energy efficiency, can undoubtedly make an important contribution to reducing the gap over time, most of the response will necessarily need to come from the supply side through the construction of new generating capacity.

Without definitive action, it is possible that most of this gap will be filled with new gas–fired plant, potentially leading to a situation where up to 70 per cent of our generation capacity is based on gas. Inevitably, much of the fuel required would need to come from overseas, raising real questions about the level of security of supply and exposing the UK to volatile global energy markets. Also, the carbon dioxide emissions from the power sector (while likely lower than today) would exceed our estimate of the potential 2020 target for emissions. Electricity prices would probably be volatile as they would be prone to the effects of both fuel and carbon price fluctuations, thereby impacting affordability for all.

Our analysis led us to develop a number of illustrative power generation scenarios for the year 2020. We then measured the performance of each scenario in meeting the stated policy objectives using a combination of top-down financial and risk based measures. We defined two scenarios on a 'business-as-usual' basis, where gas is the predominant technology and contrasted these against a diversified portfolio drawing on the full range of the technologies available and a low carbon portfolio which includes a significant level of nuclear new build.

The results of this exercise have provided an insight into the trade-offs that inevitably occur in endeavouring to meet the overall objectives. One of the most important of these is between the level of capital investment required and the level of carbon dioxide emissions.

Capital expenditure of some £50 billion is needed for the diversified portfolio and low carbon scenarios, where significant carbon emission reductions are achieved. As a country, we need to decide if this is a price worth paying. Without this investment carbon dioxide emissions would be well above target levels, and up to three times higher than in the low carbon scenario.

The differing economics and characteristics of each technology (average generation cost, capital cost and level of CO_2 emissions) are key considerations in understanding what policy changes may be required to stimulate appropriate investment and facilitate the achievement of energy policy objectives.

A business-as-usual scenario would have the lowest capital cost and would be the easiest to deliver as it requires little change from the status quo. However, it would demonstrably fail to achieve carbon dioxide targets and would potentially be exposed to significant energy security risks around the requirement for imported gas. In contrast, a truly diversified portfolio, or one which is inherently low carbon, would require much greater levels of capital expenditure and would face significant risks from the extent of change required and the availability of the requisite low carbon technology. However, these scenarios meet, and indeed exceed, likely carbon dioxide targets and have a reduced exposure to fuel risks compared to a business-as-usual approach.

Taking all of these findings into account, our conclusions are clear and, we believe, realistic. Diversification is the only means of meeting energy security and reduced carbon emissions objectives, whilst maintaining market efficiencies and providing affordable energy for the future. Placing a substantial level of reliance in the short term on emerging renewables and Carbon Capture & Storage (CCS) technologies to secure our energy future – in the absence of nuclear new build – would represent a high-risk strategy.

The Government must take the lead in specifying which fiscal and other policy levers will be deployed, and by how much, to signal to the market the structure within which technology choices are to be made. In our view, the carbon price is the key signal requiring immediate reform. ❐

Financing new electricity supply within carbon constraints

Keith Palmer

Dr Keith Palmer is currently non-executive Vice Chairman of N M Rothschild investment bank where for more than 20 years he led the energy finance practice and was involved in financing many energy technologies. He is also Chairman of Cambridge Economic Policy Associates, an economic and financial consulting company which advises governments, regulators and private sector companies and he is part-time Professor at the University of Dundee Centre for Energy and Mining Law and Policy.

To fund capital-intensive technologies, money has to be raised from the financial markets. Those providing the capital need to know the risk attaching to a project, because the cost of capital that investors look for depends on the risk – the greater the risk, the higher the required return.

The really important driver for whether to invest in low carbon emitting technologies is the carbon premium. This is the price premium received by low carbon emitting technologies by virtue of their not having to incur the costs of carbon abatement that must be paid by fossil fuelled generation. Its value is determined by the rules of the European Emissions Trading Scheme (ETS) and other mechanisms that the UK Government has invented, such as the Renewables Obligation.

At Rothschild we have evaluated the expected costs of new electricity supply, looking at different technologies and recognising that some emit lots of carbon and will incur high abatement costs while others emit no carbon and incur none of these costs. Our analysis indicates that if the carbon premium over the next 20 years or so is less than £25-30/tonne then gas fired CCGT plant is cheapest. However if the carbon price is more than £30-35/tonne then nuclear is cheaper because the carbon abatement costs incurred by CCGT (but not incurred by nuclear) are now that much greater. So the economics of new generation is largely about carbon prices – people are being asked to put up billions of pounds of capital and they need to know what the carbon premium is likely to be over the life of the investment. If it is high then nuclear is a good investment, if it is low it is a poor one.

We extended the analysis to other generation options. By a large margin the lowest cost strategy for reducing carbon emissions in UK is to convert the quite considerable amount of coal-fired plant to natural gas. Paradoxically, immediately increasing our dependence on gas has the most direct and important effect on reducing carbon emissions quickly because coal is much more 'carbon dirty' than gas. Carbon sequestration is economic only if the carbon premium is in the range £30-60/tonne. The low end of the range is where gas-fired power stations are already connected to gas fields which are fairly well depleted and the carbon dioxide can be inexpensively flowed back into the same field. Carbon sequestration is only viable at a very high carbon premium if you have to build new facilities to lock it away. Carbon sequestration of coal fired plant is always much more expensive than from gas fired plant because there is much more carbon to be locked away.

Offshore wind is a very expensive way of abating carbon – it requires a carbon premium of more than £70/tonne to be viable it is also a poor security of supply option because you do not know whether or when the wind is going to blow. It seems paradoxical to me that so much emphasis is being placed on offshore wind when all the evidence, and it is very well-documented evidence, indicates that it is more than twice as expensive to abate carbon this way than by other readily available solutions including nuclear.

For investors the key issue is how can they be sure what the carbon premium will be over the life of the investment? It is a price that depends entirely on Government policy, in fact the ETS value depends on decisions of many governments. If there is great uncertainty about the carbon premium over the long term then the cost of capital goes up and investment may not take place.

Is the carbon market fit for purpose, meaning does it provide a price signal that investors can rely on? I think that currently the answer to that question is 'no'. In both the European Emissions Trading Scheme and our domestic renewables market, investors do not have any certainty beyond about three years in the case of ETS and about five years for the Renewables Obligation, so it is extremely difficult to assess the viability of low carbon emitting technologies especially those like nuclear with long lives. Investors in low carbon technologies will be very slow to invest unless ways are found to reduce uncertainty about the carbon premium over the longer term. What is needed is a Government mechanism to provide certainty about the carbon price over a period of at least 10-20 years. The carbon price is a Government-determined number so only the Government can create such a mechanism. ❐

Should the Government intervene in the market to promote innovation, and if so, how? These were the questions considered at a meeting of the Foundation on 25 April 2006.

How should the Government support innovation in the economy?

Keith O'Nions

Sir Keith O'Nions FRS is Director General Science and Innovation, Office of Science and Innovation, in the Department of Trade and Industry, where he oversees an annual budget of around £3.2 billion spent by the eight research councils and the innovation group. He has held academic positions in Oxford, where he was head of Earth Sciences, and also at Columbia and Cambridge.

Although science and innovation accounts for more than half of the Department of Trade and Industry's budget, it has not been a central activity. In the past science has even been called a rather well endowed adjunct to the DTI; but no longer. Science and innovation have become the core business of the DTI, following Alan Johnson's arrival as Secretary of State. In early April, the Science and Innovation Group in the Office of Science and Innovation was formed from the previous innovation group, Science and Engineering Base (SEB). The SEB had primarily been supporting the research councils, and investing through them, while the Innovation Group was more business focussed including the Technology Strategy. The research councils – worth over £2 billion – have been upping their game in knowledge transfer and contributing to innovation, from the other side the business-led Technology Strategy invests around £100 million. There are ring-fenced budgets for both science and innovation and an undertaking from the Secretary of State that these will remain intact.

The idea of supporting innovation seems clear enough, but what exactly do we mean by innovation, and which aspects should the Government support? Innovation is new ideas, leading to new products, services and markets, so it includes far more than investment in research and development (R&D). It involves, among other things, regulation, the regulatory environment, the tax regime, and business processes. So successful innovation depends upon a number of issues which require us to work closely with colleagues in other departments, including the Treasury, Department for Education and Skills, the Ministry of Defence and the Department of Transport. However, I will focus here on what we do in the DTI.

The national research base includes an annual £3.2 billion from the Research Councils and higher education funding councils, with support from the major medical charities, the European Union and business (about 70 per cent of support for the UK research base comes from Government, which is quite low by international comparisons). Innovation and knowledge transfer go on between the UK research base and the business sector.

This is a world-class research base. It is probably too crude to refer to a push from the research base and a pull from business, rather the two are intertwined and interlinked. The key point is that we can get new science and new interdisciplinary science from this base, which may produce some new products. Challenges from business may also feed back into the science base, which is an important part of a user-defined technology strategy.

I am going to focus on the money available for particular sorts of intervention that can promote innovation and knowledge transfer between the research base of the UK and business. Research base funding through the Office of Science and Innovation is around £3 billion a year. There are not separate categories labelled money for research and this money is for development, and this is for knowledge transfer. It is spread throughout the research base with a great deal of effort being made to get more effective and greater knowledge transfer from all parts of that base.

There is an increasing amount of money (about £110 million a year) going into universities via the Higher Education Innovation Fund (HEIF). About three quarters of this is divided according to a formula: this is designed to develop a capacity for all universities to engage in innovation and interact with business. This approach is still relatively new, but it is beginning to work. In our most successful universities with the largest research incomes from business, HEIF provides about £3 million a year – a significant and now predictable sum of money. With around 130 Higher Education Institutions (HEIs) in England the figure drops to £200,000 at the lower end of research income. In a small, newer HEI without much research or business income, £200,000 a year is enough to make a start. The other quarter is distributed in a competitive way for specific high impact, innovative projects over a two-year period.

On the other side of the coin, we have user-defined research funds which can go to

business, to link businesses with other businesses and with academia. The technology strategy will rise to about £178 million a year by the end of this spending review. It includes money for collaborative research determined by the Technology Strategy Board under the chairmanship of Graham Spittle. The TSB is an independent, non-departmental, public body. Also included are Knowledge Transfer Networks (previously Faraday Partnerships) and Knowledge Transfer Partnerships (previously the Teaching Companies Scheme) which pay for graduates to spend time working in business.

R&D tax credits for small or medium-size businesses are worth more than half a billion pounds.

Innovation is an essential part of defence procurement, but only applies to a few billion of the defence spend compared to about £120 billion overall of Government expenditure on procurement. There is clearly a big challenge for Government to use this money to promote innovation. This involves much more than just spending money on research and development. Knowledge transfer and innovation support should be relevant to all sectors of the economy, services and manufacturing alike. While intellectual property rights are extremely important in many areas, they are often over-emphasised: business argues that universities tend to over-value the intellectual property rights that they own.

An interesting comparison can be made between the performance of our large companies in terms of value added (defined as turnover minus the cost of bought-in goods and services) and the R&D intensity of each sector. Banking and finance is the biggest value-added sector in the UK, followed by oil and gas – though recent developments have probably reversed this position. The declared R&D spend of these sectors is not insignificant but they are all less than 2 per cent of turnover. Pharmaceuticals, unsurprisingly, is the sector that spends most heavily on R&D at more than 13 per cent.

It is probably true that, over the past few decades, the DTI has focused heavily on the manufacturing sectors. It is clear that more attention should be given to other parts of the economy, particularly the high-value services such as food producers.

The DTI will continue to invest in the research base of the nation, but will increase the emphasis on knowledge transfer from the universities and research institutes. We will support innovation across all business sectors, beginning with a look at what innovation can achieve in the service sectors. We are also obtaining a better evidence base and analysis of the impact and value of these interventions. While it is easy to deal with inputs, it is harder to measure the impact of what we do. It is difficult to establish whether success in innovation is due to the tax regime, business climate, a regulatory impact or direct intervention of the sort we are talking about here. By disentangling these influences we will be able to focus on the most effective interventions. ❐

Innovation in the service sector: lessons from Tesco

Stephen Heal

Stephen Heal is Director, Business Development, for Tesco. Prior to joining Tesco, he worked for the management consulting firm The Boston Consulting Group in Central and Eastern Europe as well as the UK. He is a non-executive director of start-up companies Market Insight International and Cipello Ltd. He is a member of the advisory board of the Cambridge–MIT Institute and of the Curratorium of the Corvinus University, Budapest.

I had a visit recently from the newly appointed Finnish ambassador. I expected to talk about hypermarkets in Helsinki, or about Tesco Express in Turku. But he wanted to talk about innovation. How did Tesco innovate in its services? What could he and his friends from Nokia learn about the process and structures that lead to innovative service companies?

I reflected on the visit. Two things intrigued me: first, that he came at all and second, how *does* Tesco 'do' innovation? I asked some members of the board for examples and for what they thought was important. Innovation here is not like the rarefied fields of medical research in the pharmaceutical industry where innovations are protected by long-lasting patents. We are looking at innovation in the delivery of goods and services from the manufacturer to the customer: Tesco does this for millions of customers in 13 countries.

By adapting to the changing needs of its customers Tesco has come a long way from the number three supermarket chain in the UK. Ten years ago Tesco had no operations overseas: today we are an international business in 13 countries. We now sell clothes, electrical goods, books, music and financial services. We have developed Tesco.com into Britain's biggest online retailer. We have come up with formats like the Tesco Express stores and have moved into 24-hour shopping – and along the way become a mobile telephone provider. Growth from each of these innovations is based on listening to the customers: they are our both our research base and our judge.

I would like to highlight one of these items for its particular contribution to the process of innovation: Clubcard. This is a loyalty programme used by more than 12 million of our regular UK customers. Loyalty programmes are not, *per se*, innovative these days. Ours was neither the first nor is it the largest. But we have invested continuously in the incredibly rich seam of data that it provides. It is a powerful R&D tool that helps us innovate by better understanding the changing behaviour of our customers.

With the necessary safeguards in place, it can be used to analyse the shopping and eating habits of a broad cross-section of the UK population. It is full of fascinating insights. We noticed for example that just before the summer holidays each year, sales of flowers, chocolates and wine were suddenly going up. The question was why? We looked at the Clubcard data and saw that it was families with children who were doing the buying. They were buying end-of-year presents for their teachers. When

discussion

How can a university find out from a company what its needs are? How can a business find out from a university whether there is a programme, or members of staff, which can help them with their problems? There is no simple answer as universities and businesses are individual entities with very different modes of operation and structure. In many cases businesses need help to formulate their questions; equally, universities fail to understand the cost and competitive demands which businesses face.

we have this sort of information we can act on it, plugging it directly into the business and influencing all of our decisions.

Clubcard helps us test innovations in product, promotions, store format or service. It has helped us with the development of new services such as Tesco.com and Tesco mobile. We can use it to monitor results and responses of consumers before a full launch, and we can target specific service offers to customers with specific profiles. Put this tool in the hands of well-trained and empowered category directors and they can collaborate with suppliers to develop more of the products and services that customers want.

Customers tell us that they want more for less. They have limited budgets or time, or both, so services need to be delivered as simply and cheaply as possible. Tesco does this in part through a large number of small changes, individual innovations and improvements to existing services that make things simpler and cheaper for customers and staff.

These ideas come from the people who do the work. Everyone who works in our stores is encouraged to suggest ways to make their work easier. If their idea is picked up and implemented, that person is given a company award, recognition of the contribution that they have made. Some 6,000 ideas have been generated since last autumn by this distributed network of 'intra-preneurs' and innovators.

Continual change is, and has to be, a way of life. To support this way of life, our values must encourage innovation and risk-taking. Going into new areas makes us more entrepreneurial. There are many start-ups within Tesco: new countries, new concepts, each with their own team. For example, we have a team dedicated to finding a way into the US market.

Where do science and technology come into the picture? One innovative example of a combination of technologies operates behind the scenes in our distribution centres. It is a device strapped to the arms of our mechanical pickers in the distribution centres. The pickers physically move the goods that arrive on lorries from suppliers at one side of the distribution centre to our lorries on the other side, which then take the goods to specific stores. The arm-mounted device is linked to the central replenishment system, telling the picker where to go to collect exactly the right number of a specific product. A barcode scanner built into the glove of the device ensures that the right products are picked. It tells the picker which lane to take them to for a specific store and it checks that they are placed in the right location.

The use of such technologies means working closely with staff to ensure that they are implemented in the right way. The arm-mounted device combines communications, scanning, location and information technologies developed in many countries and combined to meet a specific need.

Where else will we need science and technologies for innovation? Tesco has set aside a new £100 million fund to be used for innovation in sustainable environmental technology. We are also committed to playing our part in tackling climate change by reducing our energy use and emissions. We are faced with the challenge of rising energy prices. We built our first energy efficient store in 2005. It uses 20 per cent less energy than a typical store. Our second model energy store has now opened in Swansea and we are drawing up plans for the first supermarket to be built entirely of recyclable materials. We will be installing wind turbines at some of our new stores alongside solar energy technology, and combined heat and power units. We will also be testing gasification, a technology to turn waste into clean sustainable power.

To generalise from our experience at Tesco: first, service companies make up an important and growing part of our economy. We do not measure R&D in the same way that research-intensive industries do, but we do devote considerable resources to understanding the customer and we use technologies to adapt and so keep pace with them. The message is: follow your customer. Will the Government follow the customer into supporting the service sectors, and how will it do so, given we are structured differently from the research-intensive industries?

Second, service companies will require access to communications and information technologies, and those new and old technologies that will help companies reduce their environmental footprint. How will Government support investment in such technologies?

Third, service companies will need people skilled in the implementation of these technologies; well-trained people, capable of adaptation and change. How will the Government foster the development of entrepreneurial culture through education that supports and rewards risk taking?

Fourth, competition enables the customer to switch between one service provider and another. This pushes each to innovate in order to survive. In our industry, the impact of the judgements being made by shoppers is very stark. Retailer A who gains 1 per cent more customers a year can double his market value compared with retailer B who loses 1 per cent of customers a year. It is customers who make the difference between success and failure: they force providers to adapt and innovate to survive.

In today's environment, global competition is important too. Internationalisation has greatly benefited Tesco's customers at home. As Tesco developed in different countries, it has learnt from different customers and challenges. Some services may not be able to travel across borders, but ideas and innovations can. Will the Government be fostering competition and international collaboration?

Finally, we need a dynamic, innovative and competitive public service sector. After all, we serve the same customers and many of the logistics and technology challenges are common. Continually improving operations in the public service sector might help raise the bar in customer expectations. It would provide a larger market for the development of technologies such as our arm-mounted device. It also develops talent that innovative service companies need to make us more competitive in the global market. ❐

discussion

An entrepreneurial attitude. Service industries have to rely on their staff to generate ideas and implement them more than other industries. They have to be more entrepreneurial and take more risks than would otherwise be the case. Much can be done to achieve this through training programmes within the industry itself. Universities too would do well to foster such a spirit in their science and technical students as well as encouraging their staff to explore opportunities for development with local businesses.

Innovation in food production

Norman Pickavance

Norman Pickavance is Corporate Services Director, Northern Foods. He has responsibility for human resources, communications, technical services, health & safety and the 'Get Fit' strategic change programme. Mr Pickavance has been a director in international businesses undergoing major change including ICL, Perot Systems and Marconi where he managed business transformation programmes. He chairs the Corporate Social Responsibility Committee of Northern Foods.

The food sector employs 650,000 people in the UK. It is the nation's largest single manufacturing sector in terms of people employed, and with a £66 billion turnover it is the biggest consumer spending area. Northern Foods is one of the largest food manufacturers within the UK. We are going through challenging times at the moment, but have a turnover of close on £1.5 billion, supplying all the major supermarkets with a mix of branded and own-label products. We have 35 manufacturing sites.

Innovation in food covers a vast area, ranging from things that are truly new (such as the invention of new categories, application of new technologies and the launch of new brands) down to the continuous improvement environment we see in food on a day-to-day basis.

However, only 7 per cent of innovation in the sector is classified as R&D activity: this categorisation rules out a significant area of day-to-day activity that utilises the creativity of the largest manufacturing workforce in the country as our consumers continue to look for different food experiences.

So today I want to consider innovation in Northern Foods in the recent past, the things that we are doing at the moment and those that we are looking at for the future.

First, in the recent past, the induction wok: we have made the largest wok in the world. We think that it makes the best Chinese food in the world; certainly it is restaurant-quality Chinese food. This wok uses induction science developed in the steel industry to rapidly heat the steel (on which the ingredients are flash-cooked to 300 °C) and to cool it down again very quickly.

We need to consider how best to work with institutions to help us develop more crossover technologies like this.

Second, looking at innovation today, take puddings: for years, the industry struggled to create the 'mouth-feel' that you get from an indulgent pudding in a restaurant. It is all to do with what happens to the chocolate when you heat it. The innovation was to create a chocolate capsule that goes into the middle of the pudding, which only reaches that melt point in a microwave cook. It used existing processes – brought together from different areas of innovation – applied to a problem that the industry had had for years, making a wonderful product in the process.

Next, I want to consider future innovation, projects that we have in hand at the moment. Packaged goods have a massive impact on the environment; yet our ability to create biocompostable, biodegradable packaging is one of the areas where the UK has the potential to take the lead globally. Our innovation has been to use wheat starch as a biocompostable material (previous technology had used corn starch) and this was quite a step forward which we can apply to a range of different packaging environments.

Looking to the future, innovation is about partnership – with customers, with universities and with Government departments. For example, one of the biggest sources of inefficiency in the supply chain is the time needed for machine changeover between production runs. Every time we change the pack format of a cellophane-wrapped item, we change the wrappers and heat seals, incurring expensive machine downtime. We are investigating laser technology for heat-sealing, which would mean we do not need to reconfigure a machine every time we change format. We have proved the concept with Loughborough University and are now working on a system that we can take from the lab into full-scale production.

Another example of an important area for future innovation is the environmentally friendly store, and the environmentally friendly factory. We have targets to reduce our energy consumption by 15 per cent, year-on-year. One way that we can achieve that involves the use of 'trigeneration', which is the simultaneous production of useful power, heat and cooling. We are the largest chilled food business in the country, so there is a massive opportunity for us.

Looking ahead, there are a number of things we can do better. We can improve our management performance indicator process by learning from other industries, working more closely with retailers and talking more proactively with Government and universities.

Finally, some 'food for thought'. Where should the largest manufacturing sector in the UK invest more time and money on truly innovative technical research? I would highlight two areas:

We have talked about the environment; if the UK really wants to be a leader in environmental technologies then should we not be testing that out in the food sector, given the size of the manufacturing footprint?

Second, we have a fantastic R&D base in the UK in pharmaceuticals. Our consumer insight research says that people not only want 'badness' out of food, but 'goodness' in. They want to buy food that will provide their dietary requirements. How can we develop a world-leadership position in the application of biosciences to food? ❐

New insights may be gained by merging diverse datasets. The kind of applications possible, and questions about privacy and regulatory issues, were discussed at a meeting of the Foundation on 9 May 2006.

Data and innovation: the case for experimentation

Frank Kelly

Professor Frank Kelly FRS is Chief Scientific Adviser at the Department for Transport, and Professor of the Mathematics of Systems at Cambridge University. He recently spent a year as visiting professor at the Graduate School of Business at Stanford University. His research interests focus on methods of self-regulation for large-scale complex systems, and he has received many awards for his work on networks.

Government collects and uses a wide range of data to both inform and deliver its policies. This data is generally used for specific purposes and is rarely made easily accessible for other uses. Yet data held by Government for one purpose can offer immense benefits in the delivery of other services, particularly when combined, or 'mashed', with data from other sources.

Advances in information and communication technologies, and the development of more sophisticated and easy-to-use software tools, continue to remove the technical barriers to data-mashing applications. The ability to produce innovative data applications is no longer the preserve of computer scientists, whose role is increasingly to provide the tools and services permitting others to develop highly personalised and specific applications. As a result, a diverse community from the public, private and voluntary sectors is engaged in the development of novel data-mashing applications.

No single data collector or user, Government departments included, can reliably predict how data may be used when combined with data from other sources. Realising the benefits, therefore, requires greater access to data in order to permit experimentation. Among the obstacles to improving access are regulatory and administrative barriers, poor incentives and limited awareness and expertise.

The challenge of realising new data applications is not unique to the public sector. Within the private sector there has been a trend away from a highly-controlled development from concept to finished product, towards a more iterative approach where the rapid development of beta version products is followed by testing and further modification of concept and design. The engagement of a diverse stakeholder community during conception, development and testing is essential to success. Such an approach allows the gradual evolution of a product, shaped by the stakeholder community, and helps identify unforeseen applications for data.

The Department for Transport (DfT) has had to grapple with several of these issues, as real-time and archived data have become more and more important for the operation, planning and use of transport networks. Some early examples are instructive.

The first is MIDAS (Motorway Incident Detection and Automatic Signalling). The most heavily used parts of the motorway network have loop detectors every 500 metres: these sense the presence and speed of a vehicle. A real-time control loop uses this data to adjust a variable speed limit – the aim being to reduce accidents caused by cars approaching a jam too quickly. The data have been archived since 1997. The archive provides insights into complex system behaviour, such as flow-breakdown where, above a certain density of vehicles, flow becomes unstable. These insights have implications for controlling access to motorways, and for public policy in this area. A further recent application of MIDAS has been to the monitoring of the DfT's Public Service Agreement target for reliable journeys, where the data is mashed with data from TrafficMaster, from GPS traces and from automatic number plate recognition cameras to produce estimates of congestion on the strategic road network. Thus data generated for one purpose has later had uses that could not have been originally envisaged.

My next example is Transport Direct, which aims to provide a comprehensive, easy-to-use, multi-modal, travel information and ticketing service. Transport Direct is, in reality, an enormous virtual team incorporating hundreds of organisations and individuals. Over a hundred sources needed to agree to provide their data and also to make it available in common standards and formats. For the first time, a unique number was agreed for each bus stop in the country. Such standardisation is essential if data are to be accessible and useful. And the data have many further applications. In particular, the DfT has funded the development of: *Accession* software, which can bring together bus data from Transport Direct, GIS data from the Ordnance Survey and census data from the Office of National Statistics to help local authorities identify whether people can get to jobs, education, health and other key

activities; and *mySociety*'s travel-time maps, which can help people make decisions on where to work or live in ways that are better informed by public transport options.

Many drivers use GPS devices to warn of the presence of speed cameras. Should the DfT make a database of road speed limits freely available in open format? Such a database could encourage the development by equipment providers of innovative in-car systems to inform the driver of the applicable speed limit, with helpful safety implications. It would not be necessary for the DfT to invent the in-car systems, but only to be aware that there are several promising and innovative technological approaches. The state encourages market demand, of course, by its enforcement of speed limits.

The barriers to the development of an open database are primarily legal, commercial and institutional. Local authorities, which set speed limits and contribute the data, are reluctant to pay fees to the Ordnance Survey for access to the data. The Ordnance Survey is reluctant to allow in-car system providers access to the data unbundled from their other products. There are real issues here about the way we fund data collection and management. The Ordnance Survey and the Met Office have very good data, partly because they have revenue streams that allow them to do their jobs properly. But high data prices can prevent innovation, and Government has several potentially conflicting roles.

We are acquiring many new sources of data in transport. Nearly three million journeys a day in London are made by Oystercard, and mobile phone trajectories are potentially a further source. Such data on origin/destination paths and route choice is important for the planning of new transport infrastructure and for evaluating the impact of pricing policies. In a world of increasing incomes and higher environmental costs for transport, we should expect innovation in the allocation of scarce capacity - an early example is web-based airline booking systems, where prices are adjusted dynamically based on historical and current booking patterns. In the future we can expect the technologies of wireless communication, mobile computing and geographical positioning to transform the economics of transport, allowing better matching of supply to demand with unprecedented levels of precision and speed – an early illustration of the integration of these technologies is pay-as-you-drive insurance. The future will be shaped by the use we make of new technologies, which both resolve some barriers to data access (e.g. better security technologies, access controls, search algorithms) and raise new concerns about data use (e.g. loss of privacy through greater integration of data, data misuse).

The Department for Transport is leading work for the Science and Innovation Ministerial Committee's *Data Grand Challenge* on realising the benefits of data within and outside of Government. We are experimenting with more flexible ways of working, particularly in terms of the commissioning and management of projects. We are not seeking to define final data applications but to allow experimentation and the gradual evolution of applications, and we recognise the potential added value of suitably anonymised official data being made available for mashing with other data sources. An early example of this approach is the *mySociety* travel-time maps mentioned earlier, and this example is helping clarify several of the obstacles to improved access to data. More ambitiously, the challenge hopes to explore how Government can move from its current 'control and communicate' model of data provision to a more decentralised model in which any unanticipated but legitimate user can find, access and use data. It is widely understood that sensitive personal data, and the definition of a legitimate user, are areas where regulation and institutions find it difficult to adapt to rapidly evolving technology. Examples from this talk show that even where there are no privacy issues, and where public policy objectives are served by wide propagation of information, there are formidable barriers to data access. ❐

Extracting meaning from information

Mike Lynch

Dr Mike Lynch OBE is Chief Executive of Autonomy, which has the reputation of being the world's leading provider of infrastructure technology for organisations. He has received many accolades, including the Electrical Engineer's medal for outstanding achievement and the Confederation of British Industry's Entrepreneur of the Year award.

Data come in two distinct types. 'Structured data' are mainly numerical and fit very nicely into a database. A computer understands this and information can be extracted in a relatively straightforward way. However, 80 per cent of Government or corporate information is of the other type – 'unstructured information'. It is in a form that human beings understand, but a computer does not, although it can store this type of information. Examples include an email, a policy document, a health manual, doctor's notes, phone calls, or TV shows.

At Autonomy, we make technology which deals with unstructured information. It is often called meaning-based computing because it involves extracting a meaning from a piece of information. The UK leads the way commercially in meaning-based computing. One of the events that kick-started this was the case of Peter Sutcliffe, the Yorkshire Ripper. It became apparent after he was convicted that all the information needed to catch him much earlier had been available. He killed again because there was no ability to 'tape together' the information and produce a conclusion; what is sometimes now called 'data-fusion'.

The vision sounds obvious: you have vast amounts of information, it is all in a computer, all you have to do is join the dots and you have a solution. However, this is very difficult to do. Two sectors have led the way: large commercial organisations like drugs companies and investment banks, and the intelligence community.

Why does it not work easily? The real world has a series of problems in data-mashing (or data-fusing or data-mining) unstructured information. The first lies in the physical connections – connecting up the computers. You might think that this just happens; but it does not and the Health Service is going through a massive project just to get past this stage. Once there, you have structured information

which you must organise (numbering bus stops, for example). Many Government departments are doing this at the moment.

Then there is unstructured information. Email is difficult because of the huge variation in the way an idea is coded. There is the format: you might have systems stored in different computer formats like Microsoft, Oracle or Lotus Notes. There is the type of information: it may be in text or it may be a recording of a phone call or a piece of video. But all of those types can still have the same meaning. There are linguistic or human formatting problems: rather than Microsoft and Oracle, we may have English and Chinese. Even then, the way in which the same object is described varies: 'dog', 'hound', 'mutt', 'Snoopy' (who is a dog) and so on.

The next layer concerns interpretation differences. We may have a piece of data about the Palestinian Homeland. To one person that might mean the post-1967 area; to another, it might mean Greater Israel.

The last problem, which is a real problem in Government applications, is ownership. Different agencies have data and they guard it jealously. It can be incredibly difficult to get agencies that should be working together to share their data. Take an actual police investigation of serial rape which attracted hundreds of statements from the public. In this particular case, the rapist was walking a dog as a cover. As far as structured data goes, one entry in the database noted that someone was seen, that they were male, they had a canine with them and the relationship between the canine and the male was that he appeared to be the owner. In the real world, data does not get described in the same way, so someone thought it was a retriever, someone thought it was a labrador, and someone else thought it was a puppy. The important point is that the computer needs to understand that all of those ideas are actually representations of something quite similar. By going through lots of statements, the computer can then spot that we are seeing a strange occurrence of the concept of a man walking the concept of a dog and bring that to the attention, proactively, of the people carrying out the investigation.

There are various approaches to solving this kind of unstructured information problem. The most powerful is clustering. The beauty of clustering is that you do not need to know what you are looking for in advance. You feed in a lot of unstructured information and this is organised into self-similar groupings. If you take today's groupings and you take them away from last week's, this immediately tells you what has changed in the world. That has become a very powerful piece of technology for tracking sudden changes.

The second most useful approach is hyper-linking. This is the ability to take any information, read it, understand its ideas, and then write a link to any other piece of information about the same thing. In one instance at British Aerospace, they turned the system on and pulled up a document working on a wing design. It immediately hyper-linked to a document from a group 200 miles away working on exactly the same problem, but one project was in the military area and one was a civilian application. They combined the two groups and saved £7 million. This happens time and time again, that different people are working on the same issues.

The National Patients' Safety Agency has generated a large amount of data on what goes wrong in hospitals: this includes not only medical accidents, but also incidents where people slip on the soap in the bathroom and so on. Although some of this information was structured and could be analysed, a lot was in the form of nurses' notes such as, "Mr Giddings went to the bathroom. I'd just given him his medication so he was a bit woozy and then he fell over." That was actually the useful information, but it was not capable of being used. Now clustering enables you to see where accidents are happening, even from the unstructured data. If you compare those clusters over time, you can see whether there is an emerging source of accidents.

The good news is that there is already a vast amount of information which is accessible. In the case of unstructured information, merely by using automatic methods which require very little investment – like clustering – it is possible to get real returns through understanding what is actually happening. ❐

Using data to improve the nation's health

Mark Walport

Dr Mark Walport FMedSci has been Director of the Wellcome Trust since 2003. He was previously professor of medicine and head of the Division of Medicine at Imperial College, London. He is a Fellow of the Academy of Medical Sciences and a member of the Council for Science and Technology.

Our health affects all aspects of our lives; our employment, our insurance premiums, whether we are able to drive cars, our relationships. Not surprisingly, people are very sensitive about the privacy of health related personal data sets.

A number of reports have recently highlighted the importance of these datasets to medical research and to social policy: the Cabinet Office report on *Transformational Government*[1]; the Council for Science and Technology report[2]; a report from the Department for Health on sharing data between health and social care[3]; and one from the Academy of Medical Sciences[4] on the use of personal data in health research.

The Academy's report said, "We now have the potential to become a world leader through the opportunities afforded by the National Health Service and new initiatives that develop national electronic care records." It went on to say, "However, evidence submitted to the Academy shows that advances in this field are increasingly inhibited by inappropriate constraints on the use of personal health data. These constraints arise through confusing legislation and professional guidance, bureaucracy of process and an undue emphasis on privacy and autonomy."

The CST report reached similar conclusions, noting that data use and management are highly fragmented across Government, and not realising its true potential. For example, a typical family may have over seven points of contact with different Government agencies. Projects such as *Connecting for Health* mean that the time is right to start joined-up thinking across Government on this issue.

The CST concluded that personal datasets are an extremely important resource

discussion

Regulatory strategy. Regulation must be able to look at end use, which could be either beneficial or not, and establish a framework that promotes the first and punishes the second. Only on such a clear basis can difficult questions, such as the ability of individuals to withhold data (thus possibly biasing the data collection), be settled. Many legal questions (involving, for example, human rights) will undoubtedly arise. However, the question of when public benefit should override personal preference is, in the first instance, a political decision, just as it is a political duty for ministers to campaign for the enormous benefits that data use could make to individual lives.

for research and public policy development. Individuals, society and Government could all benefit from a more streamlined and coordinated approach to their use and management. Linkage, access and the effective use of data will all need to be improved if this huge potential for research and public policy development is to be realised.

Linking large datasets on demographics, health (including data, for example, about diet, disease and drugs), housing conditions and the environment could provide important insights leading to better public health policy, and also facilitate the development of personalised medical care.

The work of the Small Area Health Statistics Unit (SAHSU) at Imperial College demonstrates the potential benefits of linking datasets. SAHSU maintains a comprehensive database of post-coded health data including deaths, incidence of cancer, hospital admissions, births and stillbirths. These data can be linked to other datasets, such as environmental pollution levels, location of industry or transport data. One study enquired whether there was any relationship between the location of landfill sites, where people live and issues about health (it turns out that 80 per cent of the population lives within two kilometres of a landfill site – closed or active). SAHSU showed that there was a small excess risk of mothers having low birth-weight babies in populations that live near landfill sites, and there was a small excess risk of birth defects near landfills. At the moment there is no causal mechanism to explain the findings, but studies such as this raise further important research questions.

One of the major R&D sectors in the UK is the pharmaceutical and health industry, and the NHS could be a key partner with industry in developing new drugs, treatments and devices for the benefits of patients. In particular, there is *Connecting for Health,* the IT programme bringing modern computer systems into the NHS. One aspect of this will be the provision of an individual electronic care record for England's more than 50 million users. If it is used effectively, it should be possible to carry out post-approval drug monitoring in a fashion that has not yet been possible anywhere in the world. Rare events in terms of drug interactions can be monitored at a population level and side-effects identified quickly – in ways that clinical trials simply will not discover.

Understandably, there are concerns about the protection of personal information and privacy issues. People may not trust Government to look after their data properly and are worried about unauthorised use. People may also be concerned about cyber-terrorism.

The CST recommended certain principles of data access: data should be anonymised wherever possible; access to data should be facilitated where it is for research or for statistical purposes; and appropriate safeguards and transparent governance structures should be in place before data can be accessed and used.

There are still major technological issues, and the CST recommended that the Government should initiate a technology road-mapping exercise and develop more explicit and proportional confidentiality requirements when procurement specifications are set out.

When it comes to the regulatory framework, it is important to distinguish different issues. One concerns the use of identifiable personal information (which people generally accept when it is a service that they want): for example in the case of law and order, information cannot be anonymous if you want to identify a criminal. However, for the vast majority of biomedical research, researchers are not interested in the identity of the individual; it is aggregated data that they wish to use to help understand patterns in population health. It is important that the regulatory framework distinguishes between these types of data use.

Currently, there is a lack of clarity in the regulatory framework in regard to data sharing and how the Data Protection Act operates. There may need to be legislative changes to promote data sharing and access, and regulatory guidance needs to be consistent. People are very sympathetic to the use of personal information in the context of medical research. However, if we want Government to encourage public trust it needs to give out consistent messages. Publicity from the Department of Work and Pensions in relation to benefit fraud, for example, states: 'We can compare information across Government Departments. So if you're not completely honest, we will find out.' Such messages could seriously undermine public confidence and lead to resources of unique value being put out of the reach of policy makers and academic researchers.

The CST noted that Government needs to do more to engage the public on this issue. Key to public trust will be robust systems of accountability for the management and use of personal data sets.

Linking large datasets presents outstanding opportunities for research and public policy development. To realise this vision we will need to work at establishing trust, improving technology and clarifying regulation. We all stand to benefit if we can get this right. ❐

1. Cabinet Office (2005) *Transformational Government.*
2. Council for Science and Technology (2005) *Better use of personal information: opportunities and risks.*
3. Department of Health (2006) *Making a difference: safe and secure data sharing between health and adult social care staff.* Gateway reference number 5693.
4. Academy of Medical Sciences (2006) *Personal data for public good: using health information in medical research.* ISBN 1 903401 11 9

discussion

Reassuring suggestions. Speakers wondered how to reassure people about the future use of data. A number of suggestions were made which could ameliorate the problem. The Government should accept an obligation to make all data held on individuals open to them (as with credit agencies); it should be made a crime to release information (and retribution should not be limited to any loss suffered by the individual); the concept of reciprocity should be developed so that people could understand what they would actually gain from the use of data. Nevertheless, there was a deep-rooted suspicion that Government would misuse – or at least use for unexpected purposes – any data that it held.

With technology changing so quickly today, how can Government and business plan effectively for a future that may be influenced by unexpected developments? The issues were considered at a meeting of the Foundation on 24 May 2006.

Risk management – getting the balance right

Brian Bender

Sir Brian Bender KCB has been Permanent Secretary at the Department of Trade and Industry since October 2005. He served as Permanent Secretary at the Department for Environment, Food and Rural Affairs from its creation in June 2001, having previously held the same post at the Ministry of Agriculture, Fisheries and Food. Sir Brian chairs the Government's cross-departmental group on risk management.

I believe it was US president Eisenhower who said: "No battle plan survives contact with the enemy", but it is essential to have a battle plan and to use it to build in resilience and flexibility. This is why risk management is so important. I will be looking at technological change from the viewpoint of risk management, examining ways in which we might cope with challenges that may prove disruptive. The Government has initiated two programmes: Foresight and now building on the learning from Foresight, Horizon Scanning, to help achieve this.

Our starting point at the Department of Trade and Industry (DTI) was the 2003 report *Competing in the Global Economy: the innovation challenge*[1] and the 10-year investment framework for science and innovation[2] introduced in 2004. We set out to implement a strategy that would address innovation issues between the science 'push' from the universities and the technology 'pull' from industry.

DTI's role is to create conditions for business success and to help the UK respond to the challenge of globalisation. We work with scientists and those in business to create wealth through knowledge. In the context of our technology strategy, that involves trying to create a business-driven framework in which: market gaps are identified, emerging technologies in which the UK has a competitive advantage are nurtured, and an environment where innovative companies can thrive is created. We have made a commitment to spend £370 million over three years to help achieve these goals.

In managing technological and other change, the Government is faced with five overlapping types of risk:

- *Policy or strategic risk*;
- *Financial risk*;
- *Risk to the public or to groups of stakeholders*;
- *Risk of project or delivery failure*;
- *Risk of damage to reputation.*

These risks are similar to those faced by the private sector, although the latter may deal with them in different ways.

"Risk management – getting the right balance between innovation and change on the one hand, and avoidance of shocks and crises on the other – is now central to the business of good government." With these words Tony Blair launched the Government Strategy Unit's 2002 report on risk management[3], prepared in the light of the fuel dispute in 2000 and the foot and mouth disease crisis in 2001. In 2005 the Treasury produced a set of guidelines on managing risk to the public[4] in which five themes were identified: openness and transparency; public involvement; proportionality and consistency; having evidence for policies, actions and decisions; and responsibility and choice. In addition, the independent inquiry into the Foot and Mouth Disease outbreak led by Dr

discussion

Scientific knowledge versus media pressure. The foot and mouth disease saga alerted the Government to the need for a proper contingency response, which, inevitably these days, depends on scientific knowledge, analysis and communication. There is certainly evidence (the increase in the science budget) that the Government takes the importance of science and its role in policy formulation (stem cell research, flood prevention) much more seriously now than in the past. However, it would be unrealistic to suppose that ministers will not always want to react with immediate measures, which might be damaging in the long term, when faced with a media clamour.

Iain Anderson produced a check list for contingency planning. These documents helped the Government to improve its handling of crises, as shown by the swift response of the authorities to the bombings in London on 7 July last year. The work of Defra on the potential outbreak of avian flu is another example of the Government's increased effectiveness in risk management.

Risk management must not be a 'tick-box' exercise: it involves changing behaviour and means that people are equipped with the relevant skills. The Professional Skills in Government programme is a long-term plan to ensure that all members of the civil service have the skills needed for the public services of the 21st century. I have a role as 'Head of Profession' for policy delivery. In order to make policy effectively, civil servants need to be able to set strategy, design policy options and implement policies. Analysis and use of evidence are core skills we all need.

This brings us back to the Foresight and Horizon Scanning programmes. We might have been better prepared for, or even avoided, the problem of BSE had we addressed issues such as the composition of animal feed and the safety of mechanically-recovered meat. Another area where there are lessons – in terms of anticipation and managing risk to the public – was that of GM (genetically modified) foods, on which customers voted with their feet in the late 1990s. Meeting energy requirements and responding to climatic changes are challenges that lie ahead. Looking into the future, planning for disruptions and ensuring that staff in Government departments have the right skills are all vital aspects of successful risk management. ❐

1. **www.dti.gov.uk/files/file12093.pdf**
2. **www.hm-treasury.gov.uk/spending_review/spend_sr04/associated_documents/spending_sr04_science.cfm**
3. **www.strategy.gov.uk/downloads/su/RISK/REPORT/downloads/su-risk.pdf**
4. **www.hm-treasury.gov.uk/media/8AB/54/Managing_risks_to_the_public.pdf**

Anticipating and managing technological change

David King

Sir David King was appointed as the Government's Chief Scientific Adviser and Head of the Office of Science and Innovation in October 2000. Born in South Africa in 1939, and after an early career at the University of Witwatersrand, Imperial College and the University of East Anglia, he became the Brunner Professor of Physical Chemistry at the University of Liverpool in 1974. In 1988, he was appointed 1920 Professor of Physical Chemistry at the University of Cambridge and subsequently became Master of Downing College (1995-2000), and Head of the University Chemistry Department (1993-2000). He retains his position at Cambridge University as Director of Research in the Department of Chemistry.

I will begin with two examples of change from different fields of science, the first in which the change was anticipated and successfully managed, and the second in which lack of foresight led to a fiasco. The first example is the use of stem cells. By establishing the Human Fertilisation and Embryology Authority we had ensured that we were ready to respond promptly and effectively to advances in this rapidly evolving field. When the biotechnology industry then recognised that therapeutic cloning could be put under the same umbrella, very productive debates took place in both Houses of Parliament. The result is that Britain is now in a strong position to benefit from further advances in stem cell therapy.

By contrast, we have the example of GM (genetically modified) foods or, as commonly known, the 'GM debacle'. By failing to anticipate the public response to GM food products, we have lost potential revenue of more than £2 billion annually. Although we conducted a very detailed review of GM science, resulting in the decision not to ban GM crops, we did not take into account the reaction of the public. As a result, the UK has been left out of the flourishing worldwide GM industry and companies such as Monsanto, Unilever and Astra Zeneca have closed their GM research laboratories in the UK.

It is clear from these two examples that anticipating and managing technological change are vital if we are to benefit. Anticipating changes of that nature is an important part of the Government's work. The Foresight Programme and the Horizon Scanning Centre run by the Office of Science and Innovation have been designed to enable us to do just that.

The Foresight Programme operates on a project basis. It is an in-depth process and a project takes one to two years to complete. For each project we work with around 100 scientists, engineers, technologists, economists and social and political scientists, who are led by one or two consultants. A minister acts as stakeholder minister and chairs a board of stakeholders drawn from the wider community. For example, a project on wealth creation would involve stakeholders from the venture capital community. Our project on flood and coastal defences has the Association of British Insurers as one of its stakeholders. Topics of other projects include: Brain Science, Addiction and Drugs; Detection and Identification of Infectious Diseases; Intelligent Infrastructure Systems; Tackling Obesity; Cognitive Systems; Cyber Trust and Crime Prevention; and Exploiting the Electromagnetic Spectrum. These projects involve more than one Government department and are interdisciplinary in nature.

Some of the conclusions reached during these projects will undoubtedly raise eyebrows. The project on brain science, drugs and addiction concluded, not surprisingly, that advances over the next 20 years including, possibly, therapeutic cloning will revolutionise treatment for mental disorders. However, it also revealed

that new treatments for addiction might include novel recreational psycho-active substances that are less harmful than those in use today – in some cases they may even be benign. How will the public react to this?

The most controversial issue to emerge from this project concerns the development of a drug that can be used to enhance the cognitive performance of healthy individuals. It has been derived from the agent now used successfully to treat people with narcolepsy. Early studies have indicated that, when this novel drug is given to healthy individuals who do not suffer from narcolepsy, they are able to function 24 hours a day, seven days a week, with no need for sleep, no loss of cognitive ability and no apparent ill effects. The Ministry of Defence has expressed keen interest in potential use of this agent to enhance the effectiveness of its troops. However, there are clearly many issues to be considered and we need to ask not only what the public's reaction to this would be, but also how should the Government react?

Now is the time to be asking these questions, as we have a safety zone of 10 to 50 years before this drug becomes available commercially. That is the point of the Foresight Programme – to look into the future, far beyond where Government departments are operating today. We need to ensure that we have prepared the ground for new developments. To do so we need to ask a number of important questions. Are cognitive enhancers a valuable marketing and societal opportunity, or a destabilising and divisive innovation? Should we be feeding them to the Cabinet? (These questions have indeed been asked at Cabinet level!)

We do not claim to be able to predict the future; rather, we examine a number of potential future scenarios in order to inform decision-making today. However, we need to bear in mind that society's behaviour and attitudes will inevitably change over time. For example, conditions that are currently considered treatable, such as depression or schizophrenia, were not always regarded as such. In future, will we view shyness, or the normal ageing process, as treatable afflictions? We must try to answer these questions in order to decide whether or not we continue down specific avenues of drug development.

One of our most ambitious recent launches is the Foresight project on infectious diseases in developed and developing countries. We have engaged 350 scientists, including 50 from China and 50 from Africa, to work on this project. Although 70–75% of human diseases originate in animals, there are no international programmes connecting animal and human disease. We have so far identified four areas for development: international sharing of infectious disease data; genomic and post-genomic systems for rapid characterisation of emerging pathogens; handheld portable devices for detecting and monitoring disease in animals; and new technologies and systems for high-throughput screening at ports and airports.

Perhaps the most exciting potential is offered by the third of these: the use of handheld monitors by farmers who, when faced with a suspected animal disease, could insert the monitor into one of the animal's orifices and receive an immediate readout showing what the disease is. The data would be relayed immediately to a central headquarters, thus enabling us to map the path of an epidemic in real time. We have calculated that if such a system had been available during the 2001 foot and mouth epidemic in the UK, the cost of managing the disease would have been reduced from £7 billion to £50-70 million. The value of such a system in controlling disease outbreaks throughout the world is incalculable. At present it is estimated that it will take 10 years to fully test this system and bring it to market.

Similarly, high-throughput screening of passengers at ports and airports using non-invasive technology could help us to detect, for example, an outbreak of human influenza, identify the source and institute prompt measures to prevent it developing into a pandemic.

Our Horizon Scanning Centre conducts two types of scan. The 'sigma' scan looks at societal variables such as the ageing population, decreasing landfill capacity and water shortages, among others. The 'delta' scan involves asking about 200 scientists from around the world what new technologies they can see emerging from scientific developments over the next 10 or 15 years. Their answers have included the development of active biomaterials for regenerative medicine, quantum chemistry for pollution abatement and more accurate modelling of complex economic systems. By putting the two scans together, we can identify emergent themes.

In summary, our task is to try and envisage future developments in order to best manage new technologies and their impact on society. The Foresight Programme and the Horizon Scanning Centre help us to spot new technologies before they are upon us. By engaging the public as well, we hope to create the best possible future for all our citizens. ❐

Discerning possible futures

Jeremy Bentham

Jeremy Bentham has been in the energy business for 25 years, working in the areas of research and technology process design, manufacturing economics, industry analysis and commercial information technology. He is currently vice president of Shell's Global Business Environment team, which is best known for developing scenarios to support strategic thinking and direction setting.

We have to make decisions now that will have implications in the future, sometimes many years hence. The tool we have used in Shell for the past 14 years is 'scenario development' – the building of storylines, or rich narratives, that help us predict what may happen in the future. The first step in this process is to examine predetermined trends and the drivers of critical uncertainties and to envisage how these may shape developments 20, 30, 40, 50 years or even more into the future.

Demographic change is an example of these trends. Current projections indicate that the global population, currently around 6 billion, will have grown to 9 billion by the year 2050. The population of China is set to increase from 1.3 billion to 1.4 billion, while that of India is predicted to grow from 1 billion to just over 1.5 billion, reflecting the difference in the average age of their populations. Urbanisation is another strong trend that will continue as the economies of the developing world advance, with around 55 per cent of the population there being urban dwellers by 2025-30, compared with just over 40 per cent now.

Carbon emissions and climate change are examples of other issues that have come to the fore over the past decade and are now on the public agenda worldwide, to the point where we are starting to find carbon having a price in the markets.

'Branching points' in scenario development are created by the existence of

discussion

Over-reliance on science? Participants expressed concern about the ability of those in Government and business to think more widely about problems: is there a tendency for scientists or technocrats to believe that all solutions must be purely scientific? Experiences such as that of GM food have shown that this is a dangerous fallacy. The answer must be to encourage wider thinking through the use of techniques such as 'sigma' scanning that aim to capture sociological issues. Transparency of operation and clear, speedy, intelligible publication of results are also needed. A key problem is forecasting changes in public attitudes to issues such as privacy, which affect a wide range of policies such as road pricing and identity cards.

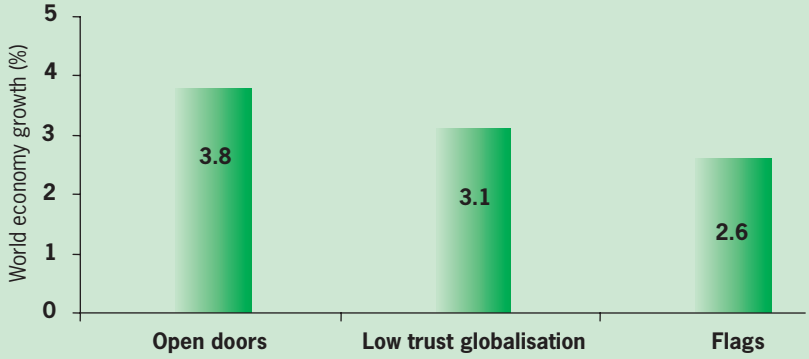


Figure 1. 2025 GDP: 40% higher in Open Doors vs. Flags

specific uncertainties. Currently, the 'dual crisis' of security and market trust is one of these. Terrorist attacks and a loss of confidence in markets caused by events such as those surrounding Enron have had worldwide reverberations and have led to the re-emergence of strong state intervention. If we look back at the 1980s and 1990s, the trend was towards less intervention by the state. Society and markets were seen as the engines of development. However, we are now seeing greater prominence of the state in securing trust and, through regulation or coercion, in achieving its own ends. We have moved from a position where the balance was between market and social incentives to one where the state is recognised as an important force.

As we look at our storylines we see that any one of these three drivers – efficiency (market incentives), social cohesion (the force of community), and security (coercion, regulation) – might be more prominent than the other two. We therefore take three snapshots, each showing a scenario in which two strong forces dominate the outcome of the storyline, with the other having to operate through them. In the first of these snapshots, which we call 'low-trust globalisation', social cohesion takes a back seat to efficiency and security, with non-governmental organisations wielding influence through their relations with investors and with governments themselves. This snapshot shows a 'prove it to me' world dominated by lawyers and accountants, pro-business but with strong state intervention. Currently, much of the behaviour in the developed world and a large part of UK Government policy are consistent with the 'low-trust' scenario.

The second scenario can be described as 'open-doors globalisation', in which the state takes a more passive role, relying on incentives rather than coercion or regulation. In this scenario efficiency and social cohesion are the main drivers. Economic growth is stimulated and reputation is at a premium. This has an important impact on the way that science and technology are funded and the pace at which they advance.

Finally, the third scenario – 'flags globalisation' – shows a more dogmatic, 'follow me' world in which security and social cohesion are the dominant forces.

Having developed these scenarios, we need to understand the global impact each might have. For example by 2025, gross domestic product would be 40 per cent higher in an 'open-doors' scenario than in a 'flags' scenario. Thus, the likelihood of the millions of people currently living in dire poverty seeing improvements in the length and quality of their lives, and those of their children, will depend largely on which scenario forces are most prominent.

In order to identify which scenario aspects are emerging, we look for signposts. For instance, the highly publicised campaign against poverty that took place last year points to an 'open-doors' scenario. Conversely, recent events in Bolivia and Venezuela can be seen as examples of a 'flags' approach. The Sarbanes-Oxley legislation regulating corporate governance and accountability – and its export around the world – is an example of 'low-trust' globalisation.

Scenario development must take place continuously in order to be useful. We have learned that different types of questions need to be raised at different times. This approach helped us to see the emergence of the environmental movement, and the issue of climate change. My former company, Shell Hydrogen, and the Shell Renewables company were formed in response to these developments. We are now looking at issues that may arise in the future, either geopolitically or within individual countries.

Leading a team such as mine is not always easy; very often it is an irritant to those who are focused on immediately urgent operational matters because our work pushes people to consider unfamiliar horizons. Something that was said to me recently shows, I think, that we are hitting just about the right spot: "You know, Jeremy, this department that you're inheriting is tolerated within a company like ours because we appreciate the value of the work, but it is not embraced." And on that note I will end, and thank you all for your tolerance. ❐

discussion

Scenarios: boon or bane? Doubts were expressed about the practical value of scenarios and foresight exercises. Were the results of projects communicated to those outside Government who should be acting on them? The results of a project cannot necessarily be foreseen, and it might well be that those who should know about them are different from those involved in their commissioning. Regarding industry scenarios, there has been a noticeable change in emphasis over successive generations of scenarios and it would be interesting to know how earlier scenarios had influenced industry policy.

The OSI Horizon Scanning Centre and the Foundation for Science and Technology produced a report in advance of the 24 May meeting. The main conclusions are summarised here.

Planning for technological change

Horizon scanning is not solely concerned with long term strategic change. Even in three years, new solutions may make existing approaches obsolete. Attempting to plan – and budget – 10 years ahead is even more clouded in uncertainty. The rate at which technology is changing poses a challenge for planners. Fixing budgets around today's operational processes and technologies may give some financial stability, but the risk is of being overtaken by events and by developments elsewhere.

The challenge lies in building sufficient flexibility into an organisation's structure and culture to take advantage of new opportunities – and respond to new threats. Incorporating this flexibility into departmental and organisational strategies is key to making best use of emerging technology developments.

In trying to discern paths by which organisations can better serve stakeholders in the future, it can be instructive to examine ways in which departments and businesses have already attempted to assimilate technological innovation and maximise the benefits both to them and their customers or clients. The full OSI/Foundation report contains a number of case studies from both Government and private organisations showing how they have adapted to change.

It is important to acknowledge that innovation carries a risk: a risk of failure and a risk of unexpected 'side-effects'. A key part of the process is the assessment of likely and unlikely collateral effects from a project – and an evaluation of the risks associated with entering what may be uncharted territory.

Change itself can lead to unexpected and sometimes undesirable side-effects. The Armed Forces' use of GPS has led to significant savings in matériel and manpower; indeed its introduction has exceeded original expectations. However, as the case study points out, a number of skills and systems in place before GPS have now been lost: in the event of GPS failure, the Armed Forces could be severely disadvantaged.

Choices can also exclude some other options. The pervasive use of GPS has meant that overlapping technologies may not receive investment. In the case of Sharp Corporation's decision to focus exclusively on Liquid Crystal Display (LCD) television, alternative options were excluded in order to commit greater resources to the chosen goal. A decision was made to 'burn bridges' and cease production of certain products.

Sometimes change can be undertaken to reduce risk. BP wanted to better identify the potential of subsalt reserves in the Gulf of Mexico. To do this, it chose to develop its own seismic imaging resources rather than rely on outside contractors.

The pharmaceutical firm GSK has found that "change is often not self-sustaining for a very long time". Many of the technologies being implemented require long-term investment, whether in money, or human resources or organisational commitment. New ways of working will take some time to become 'the norm'. Projects themselves may take many years to come to fruition (for example, the Human Genome Project). For these projects to fulfil their promise, decisions have to be taken in the context of long term commitments.

Integrating change over the longer term requires continued focus and, normally, periodic refreshment of the objectives. For this, leadership is required. It can be dramatic, top-level decision-making such as was displayed by the company president of Sharp which forces an organisation down a specified path. However, Shell's project to develop a series of liquid hydrocarbons took 20 years: it meant that successive boards of directors had to re-commit to the project, and this could only be achieved by having a senior Champion who drove the programme over a long period.

The introduction of GM crops into Europe at the end of the 1990s was originally perceived as a scientific and regulatory issue, with public reaction not being a great concern. In the event, the matter became one of substantial public concern, resulting in a complete re-appraisal of policy and the commitment of substantial departmental resources (Defra). The development of Radio Frequency Identification (RFID) tags has concentrated on technological and commercial aspects, but there is an awareness that full implementation of this technology will depend on addressing consumer perceptions, particularly of the privacy issues.

Ensuring good communications with other interested parties can be vital to success. The strength of public reaction to the introduction of GM foods was not anticipated and this necessitated much greater engagement with the public at a later stage. The BioIndustry Assocation, on the other hand, took a strategic pro-active approach to engaging multiple interested parties in the run-up to changes in the Human Fertilisation and Embryology Act. This approach has produced continuing benefit in terms of creating opportunities for investment and innovation, and maintaining ongoing links established with other organisations. The development of interactive media such as the internet has also provided opportunities for more communication. ❐

key conclusions

1. Understand the drivers for change and the timescales.
2. Identify both the cultural and organisational issues.
3. Communicate: with the staff who will make the technological innovations; with customers; and with other stakeholders who may be affected (or who fear they may be affected) by the change.
4. All change needs ownership by a champion for change.
5. Maintain flexibility in plans and budgets to respond to unexpected change.

Dr Helen Lee gave the 2005 Lord Lloyd of Kilgerran Award lecture, on 19 October 2005 on the application of technology to diagnostic development and the creation of 'test and treat' regimes.

Simple, effective testing for easily treatable diseases

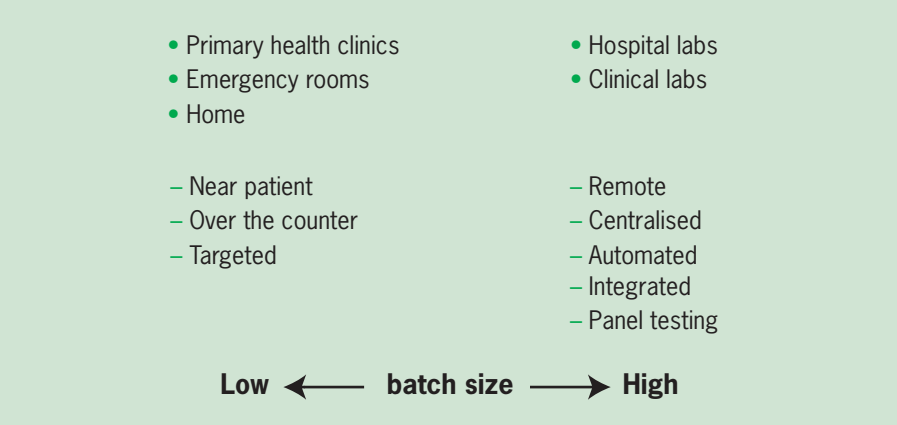
To commemorate the life of the second Chairman and first President of the Foundation for Science and Technology, the Lord Lloyd of Kilgerran, the Foundation awards a prize of £2,000 each year to a person who has applied science and technology for the benefit of society.

The award committee agreed to present the 2005 Lord Lloyd of Kilgerran Award to Dr Helen Lee, Reader in Medical Biotechnology at the Department of Haematology, University of Cambridge, UK, and CEO of Diagnostics for the Real World Ltd, Sunnyvale, USA. The Award was made to Dr Lee for her development of low cost diagnostic testing kits and taking her ideas through to market.

In her lecture, Dr Lee described the journey of a team that wanted to provide low-cost diagnostics to societies where resources were limited. Diagnostic methods fall into two groups – those suitable for centralised laboratories with automated equipment, handling large batch sizes, and those appropriate for near-patient testing. Her work focuses on the latter.

About 20 per cent of blood donors in Kumasi, Ghana are infected with Hepatitis A or B or HIV. Similar statistics hold for other developing countries. This rate of infection is 10,000 times higher than in the UK. Yet in Ghana there is only $1.50 available for all testing on each blood bag, whereas in Germany €3.8 million is spent for each extra case of HIV detected. This imbalance between developing and developed countries holds across the whole healthcare budget. Furthermore, those tests which are available have been developed to detect the viral subtypes which have been prevalent in developed countries, rather than those in developing countries (travel and migration are, however, now causing the latter subtypes to spread to developed countries).

Academia alone cannot tackle the problem of producing diagnostics for resource-limited settings, because academics lack the motivation and expertise for product development. Nor will large companies tackle it, because profit margins are too low and because of difficulties in adapting production procedures which are tightly regulated. Dr Lee and three colleagues therefore went to Cambridge to start a spin-out company, with the help of seed capital from the World Health Organisation (WHO), the National Institutes of Health (NIH) and the Wellcome Trust, bringing together industrial and academic expertise plus access to public research funding.



Diagnostics — increasingly two distinct approaches.

She explained that they chose to focus on an antibody-based dipstick assay as this is a format which can be made to be cheap and stable, and is easy to use and non-invasive. Their first target was *chlamydia trachomatis*, the major cause of infertility and pelvic inflammatory disease in women. Treatment is very effective and simple – one pill taken just once. The assay uses self-collected vaginal swabs for women and the first few millilitres of urine for men. Dr Lee demonstrated (using coloured water!) the award-wining 'FirstBurst' device to collect and retain this urine. Field development work and trials in the Philippines, Amsterdam and Birmingham showed that the assay is even more effective than the 'gold standard' nucleic acid-based test, because the slightly lower sensitivity is more than compensated by people being treated on the spot, after only a half-hour wait, instead of having to return to a clinic after two or three weeks.

By contrast, in the UK national chlamydia screening programme, only about 70,000 people have so far been screened out of a relevant population of 4.5 million, at a cost of many tens of millions of pounds.

Another target is blinding trachoma. Worldwide, 146 million people are infected, and three million are blind or visually impaired. The Cambridge rapid test is as sensitive and specific as nucleic acid testing, and is much better than relying on early clinical symptoms. The technology platform the team has developed ('SAMBA') is simple and cheap, and total assay time is only 1.5 hours.

The team has also developed a dipstick which can detect Hepatitis A, Hepatitis B, and HIV at the same time. In general for HIV, there is a need to monitor patients as the disease progresses, to adjust treatment according to the viral load. The Cambridge team has developed a semi-quantitative dipstick to do this.

Dr Lee said that the UK has a funding gap between research and scale-up when new products are developed. The US has a better funding regime for this phase. The team therefore set up its company Diagnostics for the Real World Ltd in California. She wants the company to become a sustainable business, selling at 'cost plus' in developing countries and at what the market will bear elsewhere. Her 2006 goal is to test and treat one million women for chlamydia. The challenge for a business of this type is to create and maintain a balance between doing well and doing good. ❐

At the Foundation's Christmas Reception on 7 December 2005, Lord Broers outlined his perception of the science and technology agenda in the coming year.

A wide-ranging science and technology agenda

Alec Broers

There has been a steady increase in awareness and interest in the issue of climate change and its implications, especially in regard to energy. Here in particular, the issues are as much to do with economic and security factors as they are with climate change and greenhouse gases. The House of Lords Science and Technology Select Committee has been much involved in energy matters, producing reports in 2005 on *Energy Efficiency*[1] and *Radioactive Waste Management*[2] that followed upon their report in 2004 on *Renewable Energy*[3] practicalities.

Inevitably in discussions of energy the question of nuclear power emerges as pre-eminent. It is not simply a question of nuclear versus the renewables (that is solar, wind, wave and tidal) we must pursue all of the alternatives. In the Royal Academy of Engineering, we have been tackling the economics and practicalities of a wide variety of approaches. I was pleased to see the controversy generated by our report *The Cost of Electricity*[4] about 18 months ago: this highlighted the fact that nuclear may in fact be one of the low cost options if one does not load it with the legacy issue created by the appalling mistakes made in the 1960s with the storage of waste. We must learn from these mistakes but then go on to look where we are now, not where we were 40 years ago.

In 2005, the Committee also produced its report on *The Scientific Aspects of Ageing*[5], a subject that is clearly topical because of demographic changes, scientific progress, economic factors such as the cost of pensions and health care, rising expectations, and the opportunity to exploit the UK science base in ageing-related research. This is an exciting time in biological research into the causes of ageing, and into what can be done to slow the adverse effects of the ageing process, and improve the quality of life for ageing people. The Committee observed that there are problems with the way research is organised with insufficient coordination between Research Councils and a lack of focus on the part of Government. The Secretary of State for Work and Pensions has been designated as the 'Champion of Older People' and yet this Department failed to submit evidence to the Committee. We also observed that we seem to be failing to apply the technologies we already have available to improve the lives of older people.

The Committee also published a report on *Science and Treaties*[6] that emphasised the importance of international agreements on scientific matters especially in the environment field and in the control of pandemics. We felt that the Chief Science Adviser should play a more important role and be given additional support to fulfil this task.

The Committee's report on *Pandemics*[7] outlines our concerns in a number of areas about the adequacy of the present contingency plans. We have been taking evidence in our inquiry into Water - where we are examining the issues of water supply and quality in 2006.

There will be two new inquiries starting in 2006, one on *Science and Heritage* and a follow-up report on *Science Teaching in Schools.* The inquiry on science and heritage will look at the use of science in monitoring the condition of buildings and objects of cultural importance, at the application of scientific techniques to conservation, and at the ways science and technology can enhance public understanding of and access to cultural objects.

I also wish to touch upon the enrichment schemes which support the teaching of science and mathematics in schools and which open young people's minds to careers in science, technology and engineering. In particular I would like to mention the Technology and Engineering in Schools Strategy (TESS). This started with an initiative, pulled together at the request of Lord Sainsbury, by the Royal Academy of Engineering, the Engineering and Technology Board, and 15 of the Engineering Institutions. It has now, again at Lord Sainsbury's request, been broadened to include The Royal Society. The aim is to reduce dramatically the plethora of initiatives, all of which are entirely well motivated (and many of which are extremely good), which inundate schools. TESS will provide a coordinated approach to delivering 'best practice' in these educational support activities, with the hope of more effectively motivating young people to pursue careers in technology and science. Sir Alan Wilson is playing a key role from the DfES in defining this programme.

I expressed my own thoughts about our educational system in the Higher Education Policy Institute (HEPI) lecture that I delivered in November. I advocated a broader curriculum and a system whereby students should not have to choose their professional specialism until their second or third year at university. In this lecture, I went on to say that: "Our four-year science and engineering 'master's courses' – in part justified because of a perceived slippage in our school education standards which leaves entrants less well-prepared for highly-specialised university courses – themselves fall between two stools. They are longer than is necessary for those who are not going to be specialists and too short for those who are. The '3 + 2' format, which was more widespread in the middle of the twentieth century in the UK, and which has now emerged in the Bologna agreement on a European Higher Education Area, is better suited to future needs."

The largest problem that we face, however, is the over-specialisation in schools where, amazingly, it is usual for young people to be forced into a choice where they end up studying nothing but mathematics and physics, or alternatively no mathematics or physics, from the age of 15. This, in my mind, is extremely unfortunate. It seems to be unique in the world in perpetuating a cultural divide that leaves us with few leaders on either side with a balanced viewpoint. ❐

The Lord Broers FRS FREng is Chairman of the House of Lords Select Committee on Science & Technology and immediate past President of the Royal Academy of Engineering.

1. **www.publications.parliament.uk/pa/ld200506/ldselect.ldstech.21/21i.pdf**
2. **www.publications.parliament.uk/pa/ld200405/ldselect/ldstech.89/89.pdf**
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