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CHIEF EXECUTIVE

Dr Dougal Goodman FREng

The Foundation for Science and Technology 10 Carlton House Terrace London SW1Y 5AH

Telephone 020 7321 2220

Fax 020 7321 2221

e-mail fstjournal@foundation.org.uk

Editor

Sir John Maddox FRS **Production Editor** Simon Napper **Sub-editors** Wendy Barnaby, Judy McBride, Charles Wenz **Design and layout** James McQuat

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School students will not be able to pursue science or technology in higher education unless they have good numeracy and reading skills. A meeting of the Foundation on 23 April 2008 examined what can be done to promote these skills in primary education.

Intervention in mathematics in primary schools

Peter Williams

was planning and contemplating a move gently towards retirement and a long summer holiday in July last year, when I received a letter from the Secretary of State, Ed Balls, inviting me to chair a review of mathematics teaching in the early years of formal education. This covered virtually every aspect of the teaching of mathematics in primary and early years, from curriculum and pedagogy, through provision for intervention to the issues concerning parents and families with the associated social and economic connotations.

Best teaching

I want to discuss intervention for those struggling to attain acceptable standards, but in the context of a conviction that the way to minimise the numbers involved is to make each child's first experiences in his or her classroom the best possible.

The main thrust of the review was to focus everybody's attention on quality 'first-teaching' in primary and early year settings in the UK. About 10,000 young people go into primary teaching: however, only 227 in the most recent year had degrees in STEM subjects (science, technology, engineering and mathematics). Therefore the review focussed on Continuing Professional Development (CPD) as a means of taking the whole of the teaching corps with us, and ensuring that we do the very best job we can for all children in all schools.

However, there will always be a group of children who genuinely struggle with mathematics. Over the past 10 years about 6 per cent of children have consistently failed to achieve Level 3 at Key Stage 2. Some children may well struggle because of dyscalculia: an inherent, cognitive learning difficulty. Attitudes to learning, too, undoubtedly condition the young child. There is no doubt that social deprivation and the economic agenda also bear down on the mathematical attainment of young children in our schools. There are vexed issues about the mechanics of teaching - class sizes and administration load. Then there is the sheer difficulty



Sir Peter Williams CBE FRS FREng is Vice-President and Treasurer of The Royal Society and leader of an inquiry for the Department of Children, Schools

and Families (DCSF) on the primary and early years teaching of mathematics. Sir Peter started his career in the Cavendish Laboratory in Cambridge. He is Chancellor of the University of Leicester, nonexecutive Director of WS Atkins plc, Chairman of the National Physical Laboratory and a Fellow of the Royal Academy of Engineering.

of mastering mathematics. There may be many other factors as well.

Intervention works

The review began for me in a wonderful little primary school in Hackney: King's Mead Primary. I was privileged to sit in as a fly-on-the-wall during a one-on-one intervention session with a trained intervention teacher and a young child.

Figure 1 indicates that this approach really does work. The green bars show what happens to a cohort of children in Hackney before intervention occurs, and the grey bars show through how many national numeracy sub-levels the attainment moves just from this careful one-onone intervention.

There are a number of unresolved issues though: the age of the child, the intensity and length of intervention, how you conduct it, the ratio of teacher to children. One has to consider these because at some stage questions of cost and affordability arise.

What is the optimum ratio? One teacher to one child is generally favoured. Yet in Liverpool, Brighton and in various schools, we observed interventions with groups of two, three or four children. It took Oxford University 900 years to perfect its tutorial system in which the ratio is usually one-to-two. Is there some magic in that binary number? I do not know. If it was one-to-three, would the children move at one third of the pace of their counterparts enjoying one-to-one intervention?

What sort of intervention?

Intervention is not cheap. At one-to-one with the under-attaining group number-

Government initiatives. Undoubtedly, discussion the overall direction of Government

policies – the National Curriculum, the Numeracy and Literacy Strategies and increased funding – has been successful in raising standards and achievements. But many initiatives are wasteful or pointless because individual schools, particularly small ones, ignore them in order to get the day's work done. League tables, in particular, are a distraction and misleading. There are differing views on Statutory Assessment Tests (SATs); it is too early to say what the effect of the Welsh abolition of SATs has been. Although confining, and with a tendency to diminish flexibility in teaching, these had been welcomed by many parents. Might teaching assistants be reducing the pool of those who would otherwise become fully qualified teachers?

ing around 30-35,000 children, then assuming a 35-hour working week costs are in the region of around \pounds 70 million. Government is considering providing half of this figure through local authorities direct to schools, with the other half coming from other sources. The programme is less expensive if teaching assistants rather than qualified teachers are used, or if you can achieve the same effect with more than one child.

Does intervention for just three days in the school week rather than five produce the same attainment levels at the end of one term's intervention? This is an important question, for all sorts of issues, not just economically, but also for the way in which you sensitively handle the child.

The length of intervention is normally a term. This occurs daily in the schools I visited, and you can see the effect on the child. You can see their pride when they finally crack an issue in numeracy that they did not comprehend before. One term does indeed show a dramatic progress. The good news is that if a good school with good practitioners and an enlightened headteacher intervenes and provides some sort of intervention, there is usually progress.

Parents are crucial

Parents matter: in Hackney, when a child is selected for this privileged, personalised education, the parent is invited in but the word 'intervention' is not used. It is a rather harsh term with all sorts



Figure 1. Effect of intervention on a group of children in Hackney, East London. The green bars indicate the numeracy level before intervention, the grey bars the level afterwards.

of connotations. The preferred phrases are 'personalised learning', or 'an opportunity to take your child forward'. The parent is then present during the first intervention session. The parent is also debriefed on progress at the end of the term, because the parent spends the most time with that child, far more than the 20 minutes a day of the intervention teacher.

Finally, what about the child? I mentioned earlier the gleam in the eye of the child I saw in King's Mead when she finally 'got it'. I am sure that, like all things in life, mental determination even at that young age is what determines the outcome.

And finally I am absolutely, utterly convinced that what really, really works is the gift of teaching.

Review of Mathematics Teaching in Early Years Settings and Primary Schools: www.dcsf.gov.uk/consultations/conDetails. cfm?consultationId=1532

Improving primary education



Sir Jim Rose CBE FRSA is Leader of the Independent Review of the Primary Curriculum for the Department of Children, Schools and Families, and a former Director of Inspection at OFSTED. He was invited by the Secretary of State to lead the Independent Review of the Teaching of Early Reading (2006), and has recently undertaken an independent review of the primary curriculum.

thought it might help to glance in the rear-view mirror to better understand where we are with aspects of primary education such as literacy and numeracy. I was present at a talk at the London University Institute of Education in 1996, at which the speaker said: "When it comes to education, the Welsh have a love for it, the Scots have a passion for it and the English don't object to it." The following year he became Prime Minister and made the famous declaration that his three policy priorities were education, education, education. What followed was something of a minor miracle for primary education, which it might be said had been long regarded as of secondary importance.

We know very well that children's performance in their primary years is the strongest predictor of how well they perform in secondary education and beyond. To say the least, it is heartening that over the last decade we have seen record investments in primary education and certainly in early years education.

Jim Rose

Challenges

The high level of support has rightly been accompanied, however, by a challenge to primary schools to raise standards of literacy and numeracy. In 1997 the need to do so was urgent and worrying. After nearly 10 years of a National Curriculum designed to raise standards, only 65 per cent of our 11 year olds reached the expected target for English. We were also concerned about marked differences in reading and especially in writing between boys and girls – something like a ten point difference at that time, with girls well in advance of boys.

Most of all we were concerned about the so-called 'long tail' of underperformance which the National Curriculum had done very little to reduce. Obviously something more was needed to raise standards.

Quality of teaching

The National Curriculum set out what primary schools should teach. It did not prescribe how curricular content should be taught; there was a red line between curriculum and pedagogy. How the curriculum was taught had long been the preserve of the school. The bold step that was taken 10 years ago was to engage with pedagogy through national strategies aimed at strengthening the quality of teaching, and that has made a significant difference. We introduced a highly structured, daily literacy hour as well as a maths equivalent: by 2005, 80 per cent of 11 year olds were reaching the target level.

However, around 20 per cent or so of pupils continued to fall below expected levels of literacy and this statistic appeared to be stubbornly resistant to change with little impact on closing the gap between the leading and the trailing groups.

Reading review

The review sought answers to key questions, such as - what are the optimal conditions for learning to read and write? For primary teachers, in so far as it is possible to distil one central message from the review, the answer might be: make sure you give thorough attention to teaching the alphabetic principle - how the alphabet works for reading and writing so that children can apply decoding skills automatically- and give equally thorough attention to helping them to comprehend what they read. In other words, teaching should promote effective learning of both word recognition and language comprehension skills. High-quality phonic work as defined by the review is the best means for securing word recognition – and comprehension is the ultimate goal. All this hangs on a broad and rich curriculum into which these reading behaviours are deliberately taught and embedded.

The first finding from the reading

The geography of failure. The geographical distribution of failure has

not been sufficiently stressed; is it not concentrated in certain areas of deprivation or a concentration of ethnic minorities? If so, this raises the question of what to do if the majority of an age group needs intervention? The answer must lie in instituting rolling programmes, understanding better how interventions on a 1:2 or 1:3 basis work and interaction with families. Social attitudes and habits are highly significant. Television could be both inspiring and damaging – it can promote interest in complex and difficult subjects, but is no substitute for family discussion and encouragement to read. Parents should use it as a basis for discussion on issues raised.



Figure 1. Aspects of reading skills.

review was that reading and writing feed off speaking and listening: this is so obvious that it is often overlooked. So we concluded: "Far more attention needs to be paid, right from the start, to promoting speaking and listening skills in order to make sure that children build a good stock of words, learn to listen attentively, and speak clearly and confidently." The importance of so doing is unarguable for children's progress in all subjects, including mathematics and science. We should be putting much more effort into making sure that these two strands of language development are securely embedded in the curriculum of our primary schools.

The 'simple view of reading' and different abilities

The 'simple view of reading' configured above, shows how word recognition processes and language comprehension processes intersect. There are clearly

discussion

some children who are good at word recognition and at language comprehension. These processes depend on things like inference, working memory and logical reasoning, attributes which also apply with some force to mathematics.

Other children have good word recognition skills but poor comprehension. There are children with poor word recognition and good comprehension. And, of course, we have children who are poor in both word recognition and language comprehension. Some of these children have reading difficulties which are referred to as 'dyslexic'. Dyslexia and its mathematical counterpart dyscalculia are now generally recognised as serious sets of learning difficulties, which sometimes run in families. Intervention programmes are in place, or planned to identify and support children with these learning difficulties.

Last year, McKinsey & Co put out a report which was led by Sir Michael Barber. He was the Head of the Government Standards Unit in the early days of this administration. They came to this hardly surprising, but highly important, conclusion: "The quality of an education system cannot exceed the quality of its teachers. The only way to improve outcomes is to improve instruction". Improving the quality of teaching is a priority that Sir Peter Williams' Review of Primary Mathematics, the Reading Review, and the Review of the Primary Curriculum have in common, and which we are intent on pursuing within the terms of our respective remits.

Review of the Primary Curriculum: www.dcsf.gov.uk/primarycurriculumreview

The view from the classroom

David Fann

started teaching in 1982 in a challenging primary school in Leyland in Lancashire. I taught 40 children and what I taught was up to me. In those days, it was not even necessary to teach Maths and English on a daily basis. The only curriculum we had in the school was Art, and that was because the Head, Geoff Southworth, is and was a superb artist. In those days, though, the children in our schools were getting a 'very mixed diet'.

What is happening in our primary schools now is a real success story. I have concerns, like Sir Peter Williams and Sir Jim Rose, about those children who escape 'below the radar', and we need to target their needs. Yet, generally, standards in primary schools in England have risen because the National Curriculum definitely has had an effect. For the first time, we have a curriculum spanning 10 subjects. People have talked about numbers of pupils; teachers talked about attainment.

When I became a Head of a 250-pupil school in 1993, the National Curriculum was well established. I remember being 'Ofsted-ed' in 1996. We had league tables and teachers were, on a daily basis, talking about children being on a Level 2, Level 3 or Level 4. Most primary teachers were confident in predicting what the children would attain in their Standard Assessment Tests (SATs) at age seven and 11. The fundamental change in teaching came in 1998 and 1999, with the introduction of the literacy and the numeracy strategies.

The Literacy and Numeracy Strategies

The target of the Literacy Strategy was for 80 per cent of Year 6 children to reach Level 4 in 2002. For me, the massive influence of the National Literacy Strategy has been carried on because it was the first time that teachers sat down in staffrooms and watched videos of other teachers teaching. This introduced the three-part lesson - a good introduction (teacher-led), individual or group learning and the plenary. Teachers, I think I am right in saying, are generally confident now with this format. For me, that was the biggest influence of the Strategy (the Numeracy Strategy followed a year after, with the target being 75 per cent of Year 6 to reach Level 4 by 2002).

I saw in those early days, and I still see, a fabulous rise in lesson quality: of the content and of the children's enjoyment of the lessons. I remember going to a Year 6 class in my old school and watching,



David Fann is Chair of the National Association of Head Teachers Primary Committee. He is

Head of Sherwood Primary School in Preston, which has over 370 pupils. He started his teaching career at Leyland in Preston. After a brief spell teaching at another school in Ormskirk, he moved to become deputy Head in a rural school. Another deputy headship followed before he became Head of the 250pupil school in Preston in 1993.

spellbound, Year 6 children dissecting Oscar Wilde's Lady Windermere's Fan. It was wonderful. I had been to grammar school and I had never, ever, studied text at that depth, at that age. I remember another lesson of children where children were studying Shakespeare, and then accompanying them to the local theatre in the City of Preston to see the play performed. Listening to the enthusiasm for Shakespeare at the age of 11 has stayed with me and has given me evidence that the Literacy and Numeracy Strategies were correct. They needed tweaking, agreed, but certainly they raised standards in primary schools.

I also see teachers now delivering plenary lessons with great confidence and, unlike me, with great skill in the use of interactive white boards. They support their lessons on a daily basis with IT.

I do have one concern about the Strategies. I worry about young teachers: I worry that they are almost being taught to be instructors, delivering a set text. I recently had a debate with two colleagues about young teachers – are they better than experienced teachers? There is good and bad, I am sure, but I do worry about some of my younger staff.

When I took over my second school, one of them came to me and said, "Do I have to stick to this? I want to do an extended writing session, but I might have to go more than the 60 minutes. That's more than the literacy hour and I want to do creative writing in history." Sometimes we have had to encourage teachers to think outside the box.

Certainly, arising from the Literacy and Numeracy Strategies, there has been a debate about the pedagogy, about the art and science of teaching. Nowadays a lot of our teachers are very aware of what makes a good lesson, and what is good teaching, and how they can make their teaching better.

Raised standards

I have seen a rise in national standards since 1998. In literacy in 1998, 67 per cent of our children at the top of the primary school got Level 4. Last year the same metric was 84 per cent, nearly 20 per cent better. There is still a discrepancy between boys and girls: boys lag behind girls 81 per cent to 87 per cent. Writing has improved from 53 per cent in 1998 to 67 per cent over the same period. It has gone up 14 per cent, lagging behind reading. There is a question here: why should this be the case? Last year, 60 per cent of boys nationally achieved Level 4 and above, against 75 per cent of girls. Boys' writing is a real issue in many primary schools.

I want to set out a few more figures. Eighty-three per cent of 7 year-olds, that is the top of the Key Stage 1, achieved the National Levels in reading and writing, a five per cent rise over the 1996 figures. Seventy-nine per cent of eleven year olds achieve the national expected levels in reading and writing – a 22 per cent rise over 1996 levels.

We also want people in schools and classrooms that are excited, that excite children, that raise the levels, that create exciting classrooms and that use highlevel language.

Concerns

The worry, however, is this: it is estimated that 16 per cent of adults in England are not functionally literate. However, that is an improvement of 8 per cent over the 1999 figure. I think we realise in the primary sector that we are educating children for the workplace; if children slip through the net at the primary stage, they very often have problems in working and in finding economic success later in their lives. We need to target that level of under-achievement.

As regards numeracy, we still have concerns. The SATs in 2005 just about reached the 2002 target of 75 per cent. In 2005, 75 per cent of children got Level 4, and in 2007 it was 77 per cent nationally. However, surveys such as the Early Childhood Forum Survey in March this year say that one in four adults have problems in mental maths. At graduate level entry into teaching, only 227 of the 9,937 teachers have science, technology or maths as their first degree. The Government published a White Paper entitled Innovation Nation in Spring 2008. A meeting of the Foundation on 7 May considered the issues raised in it.

A fundamental component of our future prosperity

would like to present two arguments drawn from the White Paper Innovation *Nation* and conclude with an important message.

The first argument is that innovation is fundamental to the UK's future economic prosperity and social well-being - at no time since the beginning of the Industrial Revolution has innovation been more crucial to this country.

When The Royal Society was founded 350 years ago, academics, scientists and engineers were pioneering innovation across the globe. It helped drive the Industrial Revolution. Innovation and our ability to trade globally formed the country we are today and cemented our reputation as one of the world's leading economies. However, the days are long gone when we could simply mass-produce goods. We cannot compete on price with many countries in the world today, but we can compete on innovation.

Collaboration

My second argument is that, in this first half of the 21st century, nations, businesses, scientists and technologists will need to collaborate if we are to have a successful economy and society. When we talk about major global challenges such as climate change, an ageing population, food security and adequate supplies of energy, we are talking about areas where scientists need to collaborate. Increasingly, businesses need to collaborate as well. A 'networked' Britain will be part of the bedrock of our future success. So innovation and networks are fundamental and Innovation *Nation* has begun to explore these ideas.

Innovation is not solely the province of entrepreneurs and inventors, although we have our fair share of those. It includes, for example, the doctors who put heartbeat tracks on iPods for their medical students, thereby doubling the recognition rates for heart arrhythmia. One of the important messages of Innovation Nation is that innovation needs to occur - and is occurring - in the public and voluntary sectors as well: West Berkshire Mencap closed their charity shop and sold their goods on eBay instead - now they are providing training courses in online auction trading for others in their sector.



Dr Ian Pearson MP was Minister for Science and Innovation at the Department for Innovation, Universities and Skills (DIUS) before becoming Economic Secretary to the Treasury in October 2008. Dr Pearson entered the House of Commons in December 1994. He was appointed a Minister in the Northern Ireland Office in November 2002, having previously served as a Government whip and as a member of the Education and

Employment Select Committee.

Our understanding of innovation, both within and outside Government, has been changing. Companies are looking beyond their own structures in order to innovate. Last year I launched the NESTA Proctor & Gamble Open Innovation Challenge. Proctor & Gamble is an innovative company that sources 35 per cent of its new products from outside.

Innovation is not just 'open innovation', where an organisation brings in innovation from outside. Nor is it just about the traditional, linear model of innovation that we have seen in the pharmaceutical industry – even there, we are seeing change. The idea that you should start in a research lab, go through clinical trials to licensing and approval and then put products onto the market is breaking down because companies are finding different ways to innovate. They are doing this through new products, through new processes and business models and by pursuing innovation that is user-driven. The area of medical devices is a classic example of this, but user-driven innovation occurs in many different sectors of our economy.

We start from a very good base. The 2007 UK Innovation Survey shows that 64 per cent of companies say that they are 'innovation active'. Companies such as Toyota have driven innovation down their supply chain, producing some impressive results: a 14 per cent increase in output,

Ian Pearson

a 25 per cent decline in inventories and 50 per cent fewer defects from their suppliers.

The Government's role

'Innovation Nation' takes the Government's role a step forward. Departments will henceforward produce annual innovation plans as part of their commercial strategies. The Government is also reforming the Small Business Research Initiative. These two initiatives will enable us to bring together key components of innovation by building in the vital element of procurement.

We fund world-class research through the research councils. The science budget has doubled: it will have tripled by 2010-11, rising to £6 billion a year. We have the Technology Strategy Board, a body that will coordinate £1 billion of Governmentfunded support over the next three years. We have the Energy Technologies Institute as well, providing significant funding to major projects that bring together blue-sky and applied research with procurement, including awarding contracts to companies. The challenge for the Government is to 'join up' that innovation chain. If we can harness the £150 billion a year that we spend on procurement, ensuring that small businesses achieve a proportion and that procurement is driving innovation, then we will have made major steps forward.

The science base

We must continue to invest in the science base. Recently we announced major funding for a new molecular biology laboratory: this is a field that has produced 13 Nobel laureates and a great deal of world-class science. Much of their work is reflected in products that are in the marketplace today.

We are establishing the UK Centre for Medical Research and Innovation, which will be Europe's largest research institute. It is founded on a partnership between the Wellcome Trust, universities, research councils and Cancer Research UK. It will be seeking solutions to some of the most important challenges in cancer and heart disease. In addition, we will be funding a £2.3 billion programme for the next gen-

innovation

eration of low-carbon further education colleges.

The Technology Strategy Board will be launching five new innovation platforms over the coming years, doubling the number of knowledge transfer partnerships. All of this will help make a difference and provide Government support to drive innovation.

Finally, we will publish an annual innovation report. Some might ask, 'Yet another document – what's the point of that?' However, I believe that 'what gets measured gets done'. The report will benchmark innovation performance, looking critically at how business and the public sector in the UK compare with their counterparts in other countries and identifying where we can improve our performance.

Although the Government can provide support for innovation, it will be innovative people within business and the public and voluntary sectors who will drive

Does the Government understand how innovation works? Although

there was praise for many of the points made in the White Paper, there was an underlying scepticism about the Government's understanding of how innovation works and the link between innovation on the one hand, and entrepreneurial success and economic growth on the other. This was succinctly summarised by the speaker who noted that the word 'innovation' occurred 135 times in the White Paper, but 'investment' only 11 times and 'growth' only once.

innovation in the UK in the future.

The key message

Make no mistake: without innovation and without strong international links the UK does not have a credible future strategy. That is why we must build on the White Paper, looking at the next challenges ahead of us. If we can do that, we will make the UK the best place to run an innovative business, the best place to be a voluntary organisation and the best place to deliver public services.

Innovation Nation: www.dius.gov.uk/publications/innovation-nation.html

Delivering greater productivity Vicky Pryce

he Government has set up a number of public service agreements (PSAs). The Comprehensive Spending Review reduced the number of PSAs very substantially and now there are just 30. The Department for Business, Enterprise and Regulatory Reform (BERR) is responsible for three PSAs. The first is PSA 1, and its aim is to raise the productivity of the UK. The second is PSA 6, to deliver the conditions for business success. The third, PSA 7, focusses on improving regional performance and reducing gaps in regional growth rates. We depend on improvements in innovation - innovation being one of the five drivers of productivity - in order to achieve our objectives.

Currently there is a gap between the UK and some of its competitors in terms of productivity. The gap has been narrowing, however, and there has been substantial change, including the productivity per worker. We are closing the gap with our main competitors, although we still lag behind the USA.

Innovation is a key driver of productivity because of the high added value from new products, services and processes. The contributions of innovation and technological progress to productivity are broadly captured in what the economists call 'total factor productivity'. Essentially, this means bringing together all of the factors in production – labour, capital and so on – to produce something that



Professor Vicky Pryce is Chief Economic Adviser and Director General, Economics, at the Department for Business, Enterprise

and Regulatory Reform (BERR). She is also Joint Head of the Government Economic Service. Professor Pryce was previously a partner at London Economics, a partner and chief economist at the accountancy consultancy KPMG, corporate economist at ESSO Europe and chief economist at Williams and Glyn's Bank, later part of the Royal Bank of Scotland.

has a higher added value than that of our competitors. Innovation has contributed around a third of the growth in UK labour productivity over the past 10 years, so it is very significant.

Knowledge-intensive services and industries now account for more gross domestic product (GDP) in the UK than in all our Western competitors except the USA. These sectors tend to score very highly in broad measures of innovation. It is interesting to note that sectors such as business services, finance, wholesaling, electronics and telecoms have accounted for half the growth in labour productivity in the past 10 years. There has also been a shift to high-tech manufacturing that has been very positive.

Variation

Overall, though, we still have a problem with innovation activity. There is substantial regional variation and there are marked differences between sectors. The majority of firms in the manufacturing sector that are innovation-active are goods innovators. Manufacturing was always thought to be the most innovative sector since it was easily measurable; for example, it has been responsible for 75 per cent of spending on research and development. Services and processes are much harder to measure and we are addressing this problem now.

In other sectors, in particular for knowledge-based services, the overwhelming majority of innovation-active firms are service innovators or process innovators, so there is quite a distinction between them. We need to broaden measures of innovation.

The agenda

What does all this mean in terms of BERR's agenda on innovation and links with other departments? There is a wide variety of activity pushing the innovation agenda forward. We are working to promote innovation in the regions. At the same time as the Innovation White Paper was published, an enterprise strategy was produced, and the two are perfectly linked.

discussion

innovation

Too many bureaucrats, not enough engineers? Some speakers had con-

discussion

cerns about possible bureaucratic empire-building. Is the innovation index really worth the trouble? Is it sensible to focus on reducing disparities between regions, and rely on regional development agencies whose effectiveness in some regions is doubtful? Does the Government have the expertise to manage programmes where innovation plays a large part? How many engineers does BERR or the Department of Transport have? If the Government cannot recruit the expert staff needed, then it should not plan over-ambitious programmes.

Our enterprise strategy contains an entire agenda on innovative entrepreneurs and what we need to do to encourage that.

We are now developing a manufacturing strategy, working very closely with the Department for Innovation, Universities and Skills (DIUS) and the emphasis is on innovation. We are also looking at the likely drivers of demand. Ian Pearson spoke about procurement and we are examining that very carefully. We are also studying the impact of regulation on innovation, in order to make sure that we have a regime which promotes innovation rather than hinders it.

The rise and fall of the 'ideapreneur'

BERR is active on a number of other fronts. For example, we are looking closely at the 'public service industry', by which we mean all of the private sector companies that are contributing to the delivery of public services. We are investigating ways in which we can influence procurement to encourage innovation through the use of private sector firms to deliver public sector services.

We are working very closely with BERR's regulation executive, looking at case studies and evidence that might support the innovation agenda. In addition, we are helping the National Endowment for Science, Technology and the Arts (NESTA) with the development of an 'innovation index'. We take an active part in their expert and advisory groups and will be working very closely with the Department for Innovation, Universities and Skills (DIUS) as we progress the innovation agenda.

Andy Goldberg

ealthcare is believed by some to be the world's largest industry, worth \$4 trillion. The medical device market alone accounts for nearly £250 billion. The National Health Service itself is an innovation: healthcare in the UK prior to 1948 was a patchwork quilt of private, municipal and charity systems. The world has changed a great deal since 1948, as has the NHS, and there have been a number of complete structural reorganisations (in 1973 under Margaret Thatcher, in the 1980s, again in the 1990s and then the NHS plan in 2000). There is yet another review taking place now, led by Lord Darzi, called 'The NHS Next Stage Review'.

Innovation features very highly on the agenda for the Review. As a result, Lord Darzi has created a Health Innovation Council to bring together all aspects of innovation – from discovery through to adoption, procurement and world-class commissioning – and to look at ways to ensure uptake.

The NHS has 1.3 million employees, a number exceeded only by the Chinese Army and the Indian Railway. It has an annual budget of £100 billion and carries out 17.3 million interventions a year. Each week one million people are seen in outpatient clinics. The NHS spends about £1 billion on research and development.



Andy Goldberg MD FRCS(Tr&Orth) is Honorary Fellow at the Nuffield Orthopaedic Centre in Oxford, and founder of Medical

Futures. He is both a successful entrepreneur and an orthopaedic surgeon who practises in the NHS. He founded the Medical Futures Innovation Awards. The Awards are supported by industry, the Department of Health and the Medical Research Council, and are run in partnership with the medical Royal Colleges.

The Department of Health media centre handles 2,500 calls a week, resulting in 92 articles in the major nationals every day. In 2006, 14,893 Prime Minister's questions were answered – more than twice the number for any other Government department.

I was interested to hear Ian Pearson say that 'what gets measured gets done', and while I agree with that, I sometimes think it creates a perverse incentive for innovation, and in peculiar things. The NHS is very good at innovating around targets. For example, the 48-hour target set for GP appointments led to people being unable to book to see their GP after that time period. It reminded me of what took place about 10 years ago when a target was introduced that no one must wait longer than four hours on an NHS trolley: as a result staff removed the wheels from a trolley and called it a bed!

Implementing change

The word 'innovation' has been bandied about a great deal but I wonder how clearly people understand its meaning. I will be crystal clear about what I mean: innovation is 'implementing change'. It is not necessarily about doing something new. You will recall that in the 1970s a no-frills airline was introduced. By the1980s it had failed and no-frills flying was considered by people in the City to be a disaster. Yet that wheel was re-invented not long afterwards and this time it has become a thriving industry.

Following an accident a few years ago I had some time off work recuperating. During that time I made a study of every healthcare innovator who had made a real difference – a contribution to mankind. I noticed that some common themes emerged, as the following examples show.

Anyone who have had an operation within the NHS during the past 15 years

and been under general anaesthesia will have benefited from a laryngeal mask. Before its invention, people were put to sleep using a tube passed down into the lungs and inflated. A young junior doctor, Archie Brain, started experimenting in his bedroom and came up with an idea. (I note that the White Paper says innovation does not happen in people's sheds – in fact, it does.) For some years he knocked on every industry door and each time was told to go away. Finally, Archie had a chance meeting with a successful businessman which led to the realisation of his idea and the creation of a new company. Since then 300 million people have benefited from this innovation. He and the company are now based in the Seychelles.

Another example from across the water is the heart stent. Whilst open heart surgery was the mainstay of treatment for blocked heart vessels, in the 1990s a technique called angioplasty became mainstream. In this technique a vessel that is blocked is blown up using a balloon. It was found that 95 per cent of people did well after angioplasty, but in some people the vessel closed down again soon afterwards. Hearing this, a junior doctor from California started experimenting in his kitchen with bits purchased from High Street electronics shops, and developed the first stent. He too spent 10 years talking to industry, but no one was interested - his idea was ill-formed. Then a chance meeting with a successful businessman led to a deal with Johnston & Johnston and the creation of a new company, which is now the market leader in a \$5 billion market.

I could list 20 or 30 more examples, but the common theme running through them is that there is a gap of around 10 to 15 years between the concept emerging and the clinician finding someone interested in helping them develop it. When the commercialisation lag is added, it may be 15 to 25 years before patients ever benefit. Note that most of these innovations did not take place in centres of excellence, were not necessarily linked with research institutions, and were considered too risky for venture capital investment until someone had spent time and money developing them a little more.

'Ideapreneurs'

I categorise people as 'ideapreneurs' or entrepreneurs. 'Ideapreneurs' come up with ideas, identify unmet needs and devise technical solutions. In reverse, entrepreneurs are not necessarily good at ideas but they are tenacious and visionary executors of ideas. Incubators and collaborative research centres have often failed to generate any big commercial winners. The reason for this is as follows: they are formed on the basis that if you put togeth-

Fostering individual talent. It is the talented individual who needs

discussion

to be encouraged and different people have different talents. The Government should not try to force innovation top down and should not get involved in calls for ideas, where only the usual suspects apply. Sadly, experts that know how to fill in the forms can take all the public money, whereas those with ideas for the jet engine, penicillin or hip replacements do not even know that such calls exist. It is those very people that need the support and there is a mismatch between Government activity and innovation. These 'ideapreneurs' need secure employment, time, cooperative assistance and help in making contact with entrepreneurs. The entrepreneur needs access to customers and contact with the 'ideapreneurs'. The Government should be prepared to risk some finance to exploit the opportunities created by these individuals and be prepared to face criticism if some do not work out.

er ideas, with management, designers, and engineers, then success will follow. In the same way, if you put together egg, sugar, flour and water, you will still have a bunch of ingredients and not necessarily a cake. An entrepreneur is akin to a brilliant chef, who herds resources until they reach critical mass. In the case of my analogy, they create the cake and in business terms they create value.

People working in the NHS are vocationally trained and most are 'ideapreneurs'. There is a gap between the intellectual capital that exists in this country and the people with the skills, money and know-how to turn ideas into reality: there is a lack of entrepreneurs. We created Medical Futures to bridge this gap in the healthcare world. We use a model that matches unmet needs with validated solutions that could improve patient care. We are working closely with the Department of Health to determine whether there is a better way of focusing research funds. At the moment many of the ideas we see are poorly mapped out, not well understood by end users and lack commercial focus; hence they are perceived as high-risk investments.

One example of this is a new technology to diagnose carpal tunnel syndrome. This occurs when the nerve in the wrist is blocked causing a very unpleasant tingling sensation; it is a very common disorder. A group in Finland developed a handheld diagnostic device, but owing to their small population they needed access to the NHS in order to validate it. They looked at the current care pathway in the UK. From initial diagnosis to treatment and cure takes on average 62 weeks and costs around £1,400. By connecting them to a surgical team from the NHS, the entire patient journey was transformed. Using their handheld device together with a dentist's chair and some innovative surgical equipment, diagnosis and treatment was carried out on the spot. In a pilot study over 800 operations were carried out in a year. The cost of the new-style treatment was around £130 and was much better for patients. Extrapolating that nationally, they worked out that it could save the NHS £72 million. This is the kind of project in which we get involved and it admirably demonstrates that if a new technology can be shown to demonstrate efficiency gains, it can be adopted by the NHS.

The largest source of intellectual capital

I commend the Government for producing the White Paper. The NHS is the world's largest single source of healthcare intellectual capital and offers huge opportunities, especially in services where 90 per cent of innovation takes place. Yet innovations have to be linked to efficiency gains and that can only be achieved by freeing people to innovate and take on risk. In that sense the public sector is no different from the private sector. Everyone has to go through proof of concept and obtain funding using the same route, yet for some reason business plans and profits are dirty words in the public sector: we need to start thinking commercially about the public sector.

I commend the Innovation Index, but we have to measure the right things. The Government can create the right environment for people to use their talents, and it needs to be able to fund blue-sky ideas where no one else will take the risk. Ultimately, the White Paper, like the examples I have given, is just an idea – a concept – and its true significance will be seen in its application. The Government has set an ambitious target for carbon emissions reductions. Some of the policy initiatives to achieve the savings were considered at a meeting of the Foundation for Science and Technology on 4 June 2008.

Improving the energy efficiency of the existing building stock

Adair Turner

hat are the sources of emissions in our homes? Well, about 90 million tonnes of carbon dioxide comes from gas consumption and 65 million tonnes from electricity. Gas is used almost entirely for heating – space or water heating and some cooking (but that is a form of heating too). The electricity load includes some heating, but is mainly for appliances. Looking at the nondomestic sector, once we move beyond energy-intensive industries to the banks, the retailers, the public sector and most of the SMEs, the majority of emissions are from operating buildings - heating, lighting, IT, etc. In fact, over a third of all our emissions come from buildings.

Cutting emissions from buildings

What can we do about it? We can improve energy efficiency, we can decarbonise energy, or we can change behaviour. There are many ways to improve energy efficiency - more insulation, more efficient appliances, double glazing, more efficient boilers, etc. None of these things involves changes to lifestyles. We do not need to persuade people to do things differently. Small lifestyle changes such as switching off the light or setting the thermostat a bit lower in winter can make a difference too. Finally, we can decarbonise energy. We could have the same lifestyle as before and be as inefficient as before, if we can decarbonise energy with nuclear electricity, wind-based electricity, district heating, solar thermal, etc.

I want to focus on how we improve the energy efficiency of buildings. It is relatively easy to improve the efficiency of new buildings – we establish very tight building controls, requiring developers to meet very strict standards. We now have a policy that by 2016 all new residential buildings will be zero carbon. In order to get them truly zero carbon we not only have to massively improve efficiency but we also need some category of microgeneration, combined heat and power, windgeneration or solar PV on the housing estate.

The problem, though, is that the 240,000 houses we are building each year



Ecchinswell is Chair of the Committee on Climate Change. He became a cross-bench member of the House of Lords in 2005. He was Chairman of the Pensions Commission from 2003-2006, and of the Low Pay Commission from 2002-2006. Lord Turner is also Chairman of Financial Services Authority and the Overseas Development Institute. He is a Visiting Professor at the London School of Economics and at Cass Business School, City University.

Lord Turner of

are almost entirely additions to the housing stock. The majority of our buildings were constructed before 1959 and many are pre-1918. New buildings, even to very high standards, will only improve the energy efficiency of the overall stock very slowly. The older our housing, the less efficient it is.

Older housing

One crucial issue is, therefore, how do

we improve the energy efficiency of older housing? First, we need to work out the economics of improving the efficiency of existing buildings for many homes. The analysis paints an encouraging picture. Putting extra insulation in the roof or installing cavity wall insulation gives a payback in lower gas bills, and this is a very good return on the capital investment. There are many things that according to this analysis have negative cost. These are almost entirely energy efficiency measures, whereas those that have a positive cost are decarbonisation initiatives. If we want to cut carbon cheaply we should improve energy efficiency.

This is, I have to tell you, quite bewildering for pure economic theorists who believe that if such actions give a positive rate of return, they would be done already. Why are there opportunities for people to get richer which they have not seized? Well, for many people it is just not worth the hassle. Energy bills are important for poor people, but they do not have the capital to invest. Conversely, middle and high income people do not spend a lot of time worrying about the energy bill. Even with higher energy prices, electricity and gas represent a relatively small proportion of annual spending. Since they will



UK CO₂ emissions by end-user in 2006.

not happen naturally, we need policies to bring efficiency improvements about.

Government initiatives

In terms of the building itself, we have three new programmes. First we are introducing Energy Performance Certificates so that when a house is sold or rented - this is also true for offices there must be an estimate of its energy efficiency. The theory is that buyers will pay attention to that. They will wish to pay a lower price for a less efficient house, so there will be an incentive for the owner to improve the energy efficiency before they sell or rent. For the buyer or tenant, the information about energy efficiency should stimulate them to improve it. So the information should produce behavioural change.

Second, we want better billing, smart metering and real-time displays, as we believe that more information will mean people are more careful about energy use. Third, we are putting an obligation on electricity and gas suppliers to spend money improving the energy efficiency of some of their customers and in particular those in fuel poverty.

Is it enough, though? Do we need extra incentives, such as variations in stamp duty or council tax according to the energy efficiency of a house? Can we tighten the Building Regulations? Can we create a one-stop-shop, where a householder can simply ring and say 'OK, for £2,500 do my house, turn up, get it all done?

Non-domestic buildings

On the commercial side, the service sector in particular, a great deal of energy is used on space heating, lighting, cooling, information technology and to a lesser extent hot water; the same categories as those that matter in the residential sector but in

a different relative balance. A commitment to zero carbon buildings in the commercial and public sectors was announced in the Budget this year.

For existing buildings, we are introducing the Carbon Reduction Commitment. This is a cap and trade system for carbon emissions which is expected to save 3.7 million tonnes of CO₂ by 2020. It covers firms consuming more than 6,000 megawatt hours of electricity a year - that represents an energy bill of about half a million pounds - companies which are not in energy intensive sectors covered by the European Emissions Trading Scheme. The CRC includes banks, building societies, hotel chains, universities, schools and hospitals. It has been designed to be revenue-neutral, but with the revenue returned according to league table performance. \Box

Climate Change Committee recommendations: www.theccc.org.uk

Engineering a strategy – a personal view

here is plenty of solid science on climate change, but where is the sober, robust and integrated engineering response to the challenge?

The Government will commit to an 80 per cent reduction in carbon emissions by 2050. Today 45 per cent of all carbon emissions come from existing buildings and 87 per cent of those buildings will still be here in 2050. So it is my opinion that while all the work on eco-friendly new-builds is fine, the 'bull in the china shop' is the existing building stock.

The Department for Communities and Local Government (CLG) has the lead responsibility for planning, building regulations and codes, but we share with BERR, Defra, DECC and others, the overall responsibility of 'squaring the circle' that is implied by the figures I have quoted.

Improving the fabric

In 1990, 154 million tonnes of carbon dioxide equivalent came from housing. Taking a small set of improvement actions - three inches of loft insulation, 60 per cent of windows double glazed, 60 per cent of rooms draught-proofed and, where appropriate, cavity walls insulated to modern standards - 35 per cent of properties had been so treated. By 2005, 147 million tonnes of carbon dioxide were emitted from housing, but by now 65 per cent of properties had those interventions to the fabric installed.

The nominal target for the building



Professor Michael Kelly FRS FREng is Chief Scientific Adviser to the Department for Communities and Local Government. He is Prince Philip Professor of Technology at the University of Cambridge, where between 2003-5 he was also executive director of the Cambridge-MIT Institute. He was a member of the research staff of GEC 1981-1992, and professor of physics and electronics at the University of Surrey 1992-2002, and head of its School of Electronics and Physical Sciences 1996-2001.

sector for 2020 is to reduce that to 114 million tonnes. Now whatever we do we will have to achieve savings at six times the current net rate from now until 2020 if we are going to meet that target.

My best estimate, which I have discussed with colleagues at BRE, UCL and others, is that there is a maximum of 20 per cent in further reductions that could be achieved from the exhaustive completion of those measures to current standards. I have been brought up with the second law of thermodynamics which says that you do not assume 100 per cent efficiency and work down, you start from

Michael Kelly

30-40 per cent and work up. So when I look at measures which are assumed to have 100 per saturation and 100 per cent installed efficiency, then I start to worry. So I have been particularly concerned over the last few months on the robustness of some of our calculations.

Lord Turner noted that there are only two ways to reduce carbon emissions from existing buildings; changes in personal behaviour and re-engineering the fabric and the energy sources used in the buildings. Looking at the range of measures to achieve this from ourselves, Defra, BERR and HM Treasury, I have to ask the following three questions as an engineer: first, what do these measures really add up to in actual carbon savings? Secondly, what data, in the year 2010, would convince us that we are actually on a satisfactory trajectory for 2015, let alone 2020 and 2050? And finally, do we have the sensors in place to do the measurements in 2010?

I want to focus on three projects which approach the concrete task of reducing emissions from buildings.

Route maps

Many aspects of Government policy are devolved to local authorities and the question I have asked in the context of climate change is: 'What are we going to do to Buckingham Palace, Bath Crescent, Balham, Basingstoke, Birmingham and Bristol?' because the buildings in these

energy efficiency

places are here now and will be here in 2050. Somehow we will have to run them on 80 per cent less carbon by then. So, what would the Borough Engineer of Balham need so that in 2015 he knows that he is on-track, three years behind, or exactly where he is?

I am hoping to work with four or five local authorities to produce a series of route maps of how they can get from where they are now to where they need to be in 2050, making reasonable but clear assumptions about the collateral movement on the decarbonisation of the grid and population movements.

Achieving critical mass

Second, when you talk to people involved in the renovation of existing buildings it appears to be a totally balkanised valuechain. There are no great leaders at any part of the chain, there are lots of suppliers (many of them small), most of the work is done by small companies and there is noone with the kind of influence of the Home Builders Federation in new building. Just to put a scale on the project, if every household at some point between now and 2050 spent £15,000 on retrofit measures on their property, the total budget would equivalent to an Olympic Games every year between now and 2050. £23 billion are spent every year on renovation in buildings.

I want to bring together people who own the estates associated with the MoD, the Department of Health, education, local authorities and the Housing Corporation to see if we can pool our renovation budgets. Then we can negotiate with the suppliers, improve the quality of the materials and more particularly the ease and efficiency of installation, and so drive the market forward.

We have £1 billion for the Research Councils' Living with Environmental Change programme, we have £1 billion in the Energy Technology Institute, and between the Technology Strategy Board and the Environmental Transformation Fund there is another £0.5 billion. This money will be given out in very large chunks for research, development and demonstration. Most will go to support the agendas of the oil majors for carbon sequestration or to the nuclear companies, but I am hoping a group of large property owners will use some of these funds to tackle the problem of existing buildings.

The education sector

Finally, what would happen if we funded the Further and Higher Education Sector to achieve our carbon reduction targets 10 years ahead of the rest of us? Student residences are a good proxy for domestic homes and most students (who will only be in the accommodation for eight months anyway) would be willing participants. Many engineering departments would welcome the opportunity for them to showcase on campus what they are doing, and the psychology and sociology departments can help us in engineering changes in perception and behaviour around the profligate use of energy.

Investing in technology to achieve improved efficiency

ur sister company, Owners Provident, owns 300,000 freeholds throughout the UK, and we also manage a further 300,000 properties. We have contracted to triple that figure within the next 10 years; we will own something in excess of 4 per cent of the housing stock in the UK. We issue a Green Survey to all our property managers. This has a wide variety of questions, for example: are there leisure facilities on site? Is common-area water use separately metered? Is external lighting controlled by daylight sensors? The answers to all those questions determine what actions we can take to reduce carbon emissions within that particular building.

Let's consider, for example, common parts lighting. Artificial lighting accounts for 19 per cent of worldwide electricity consumption and 27 per cent of UK CO_2 emissions. On one of our sites, where we piloted the Green Survey, we were able to reduce CO_2 emissions by 127 tonnes per annum. That is the equivalent of a 13.6 per cent saving: in financial terms £35,000. As we follow this through to other areas we can bring down consumption and emissions and increase savings very quickly.

It is now beholden upon utility com-



James Rae is CEO of Consensus Environmental, Real Estate & Technology (CERET), part of the Consensus Business

Group which invests in housing, land and asset-backed opportunities under a green, environmentally friendly banner. In 2003 he was asked to join Consensus Business Group to create and head the Commercial Division of the Owners' Provident ground rent company. He has since gone on to help create CERET.

panies to provide, through research schemes and supplies, large sums toward reduction in CO_2 emissions: typically, lighting, heating, insulation and white goods and investment in green technology. Unfortunately, this is not their core business and they really are not geared up for it. Through our investment in green technology, we are.

As a consequence of our freehold portfolio, we have developed the largest proportion of residential property manage-

James Rae

ment in the UK. We are also involved in sales and letting and in green technology.

Let me explain how we can take infrastructure into the retrofit area and make a bigger difference. Mr and Mrs Smith have bought a flat (leasehold) in a building that we own. We also own the land around it. Our income arises from items such as: ground rent, service charges, management fees, insurance, lease extensions and licence fees. Our main focus is to increase the number of revenue streams and we can do this through providing tenants with ecologically sound technologies like combined heat and power (CHP).

CHP is green energy and it gives us another revenue stream because we link it to the 125 year lease that Mr and Mrs Smith already have. As a result Mr and Mrs Smith have the benefit of discounted heating and power, because the cost of supply is linked over such a long period of time. It also helps the house builder, who is required to include this in a new planning application but could not fund it otherwise.

That is providing energy: the next step is to tackle wastage. We produce 333 million tonnes of waste every year in the UK, although only 33 million tonnes come from residential homes. But we

energy efficiency

could apply the same logic here by giving Mr and Mrs Smith a discount on waste removal (it is inevitable that all householders will eventually be charged on an individual basis for the removal of waste). Currently we are looking at one waste-to-energy technology which

can produce huge amounts of electricity from something like 1.5 million tonnes per annum of municipal waste. If that technology is validated, the benefit to the householder and the environment will be significant.

This particular technology can then

utilise landfill gas to top-up that energyfrom-waste. The result is that we can bring back to commercial use land that is at present redundant. Again this is all funded through long term funding, bringing discount prices to the householder and tenant.

How does the UK achieve its carbon reduction goals?

approach the issue of energy efficiency from the consumer perspective. People are wealthier than they have been, looking back even one generation, but they are beginning to feel the pinch. We have 25 million households with an average income of about £27,000, debt of about £55,000 and gas bills of around £1,000 – a figure that is smack at the centre of the bell-curve – and for some that gas bill represents a very considerable proportion of their income.

Figure 1 shows the cost per customer of the various supplier obligations and we see it jumping to around £60 per customer with the Carbon Emissions Reduction Target (CERT), the Renewables Obligation and the Emissions Trading Scheme. So customers are already paying dearly and our consumer research is showing a very alarming trend. Over the last six months we have seen a steady decline in the interest in green energy: people are either bored or they are pricesensitive - price is the key.

 $\pounds 1$ in every $\pounds 3$ is wasted through heat loss, but only one in every five homes has a condensing boiler. Yet this can save, on average, 875 kilograms of CO₂ a year. So it is certainly worthwhile getting a new boiler. Overall about 28 per cent of



Eddy Collier is Managing Director of British Gas/Centrica's new-heating business. British Gas is the largest installer of heating systems in Europe - installing around

125,000 high efficiency heating systems per year in the UK. Previously he was Director of Residential Energy in British Gas. Prior to Centrica, Eddy was CEO of Logica Consulting, the global management consulting arm of Logica plc.

total UK emissions come from the home. There are 9.1 million homes that still have unfilled cavities and much of the existing insulation is only partially effective.

We can measure trends in heat loss from our customer base. From 1970 we saw a rapid take-up in loft insulation. Overall, heat loss has gone down by about a third. CERT (which is largely what the £60 is paying for) will yield a further 11 per cent in savings. Condensing boilers will bring about another 9 per cent of benefit. That is



Figure 1. The cost of carbon reduction policies to UK energy consumers

Eddy Collier

very good news: nevertheless we do not think that this will be sufficient because power consumption (for appliances, etc) will not diminish enough, and thus we could miss our targets by a substantial margin.

That means we need to do something else. What about renewables? There are around 93,000 renewable energy installations in the UK. But compared to Europe we are not doing well. We will need to be the leader in these technologies if the UK is to have a hope of catching up.

Professor John Chesshire has just published a study with Element Energy on microgeneration. Under existing conditions we might get to one million installations by 2020. That would give absolutely no annual saving on abatement at all. He also looked at various subsidy models and showed that these can stimulate real growth in this area. The crucial point is that without subsidy we will not reach our targets. So, what sort of subsidy is possible? There have been countless discussions about rebates on Council Tax, on feed-in tariffs and (more) obligations on the supplier. The trick will be to get the balance right.

In terms of carbon abatement, we could expect around 3 or 4 million tonnes of carbon savings through these microgeneration technologies. The reductions are actually greater when you factor in the savings from reduced losses at power stations and through the transmission grids.

To sum up, the existing CERT carbon abatement mechanism together with accelerated rollout of new condensing boilers could achieve around 20 per cent carbon savings. We will however miss our targets for carbon abatement on this basis not least because of growing demand for power. At the same time I think we can safely say that consumers are unlikely to jump at further expenditure in new technology without material incentives. Decisions still have to be made about the nature of these incentives and their provenance. What can a multi-Research Council, multi-Department research programme achieve that more conventional approaches cannot? A meeting of the Foundation for Science and Technology on 18 June 2008 considered the issues involved.

A programme that enables us to ask – and answer – some of the big questions

he Living With Environmental Change (LWEC) programme has six key scientific objectives. The first concerns mitigation, adaptation and resilience to climate change. The second is largely to do with ecosystem services and human well-being. The third is poverty alleviation, specifically by securing safe food production and water supply. The fourth is concerned with how to protect human, animal and plant health. The fifth objective focuses on ways to make the built environment and transport more resilient to environmental change and methods of reducing their environmental footprints. The last objective is to develop thriving, cohesive and informed communities.

Interactions

The key point is that these all interact: climate change, for example, has a major impact on natural resources and ecosystems, has a major impact on human health, plant and animal diseases. Clearly we have to understand human behaviour and its implication for climate change from a sociological standpoint. Equally we have to understand the built environment and transport and its implications on climate change. Food and water security are critically dependent on climate change and ecosystems, but also relate to animal health and to human communities. In other words, all of these issues are interdependent. One of our greatest challenges is to devise research programmes that address key questions within each of the six objectives but also cut across them.

One of the conclusions of the Stern Report shows that if we were to stabilise greenhouse gases at 400 parts per million of CO_2 equivalent, we could end up with, at one end of the scale, a temperature rise of less than 1°C. At the other end, though, the rise is almost 3°C – that's a huge difference on the impact this concentration could have on ecological systems, socioeconomic systems and human health. So we have to learn more about the impact of climate change on food, water, ecosystems. We have a general picture of what



Professor Bob Watson is Chief Scientific Adviser at the Department for Environment, Food and Rural Affairs (Defra). He is also Chair of Environmental Sciences

at the University of East Anglia, Director for Strategic Development for the Tyndall Centre and Director of the International Assessment of Agricultural Science & Technology for Development (IAASTD). He has chaired many international working groups including the Intergovernmental Panel on Climate Change (IPCC).

will happen to food, water and ecosystems, but many of the details are missing. A programme like LWEC can look at the true impacts of climate change on these systems and we can then come up with better adaptation strategies.

Other fundamental questions on climate change include the issues of potential physical and behavioural limits to adaptation. And then there are the technological issues, for both mitigation and adaptation strategies.

With respect to ecosystems, we need to understand the relationship between ecosystems and human well-being. What is the value of ecosystem services, both in economic and non-economic terms? One key question is to what degree do we understand those services? To what degree do we understand the changes in those systems?

And then there is the role of the market. It is clear the market works for provisioning services – we pay for food, we pay for fuel, we pay for wood – but there are no markets for the regulating cultural and supporting services.

Food, water and energy

How can we achieve food and water security in a world where the Earth's climate

Bob Watson

is changing and there are other multiple stresses on these systems? There is more demand for food and more demand for water, so can we increase agricultural productivity in a way which is both environmentally and socially sustainable?

Can biofuels be sustainable environmentally, economically and socially? There is a real debate here and indeed we have the ongoing Gallagher Review which the relevant departmental Chief Scientific Advisers are jointly studying. There is a whole range of biofuels – bioethanol, sugar maize, other food crops, biodiesel, palm oil soya and rapeseed – but are they sustainable? Rarely economic, they tend to be heavily subsidised. Only Brazil, which has invested for 20 years in 500 different cultivars of sugar cane, has made them economically viable, but serious questions remain about environmental sustainability.

How will climate change affect water stress? One third of the world is already either water stressed or water scarce. With climate change more than two thirds of the world's population will live in such areas – that affects not only human health, but also agricultural productivity.

Agriculture must no longer be thought of as production alone, it must be viewed as multifunctional; we have to look at agriculture with respect to the environmental issues, the economic issues and the social issues. We should reward farmers for looking after the social dimensions and the environmental dimensions.

Conflict is a major issue: climate change and other stresses could significantly affect conflicts, especially in regions such as sub-Saharan Africa.

LWEC provides an incredible opportunity to address policy-relevant issues through world-class scientific research. It can provide the scientific knowledge to increase the resilience and decrease the vulnerability of ecological systems, socioeconomic sectors and human health as projected changes in the environment occur at local, region and global levels.

www.nerc.ac.uk/research/programmes/lwec

Predicting possible futures to inform sound policy

Alan Thorpe

he Millennium Ecosystem Assessment found that around 60 per cent of ecosystem services have been degraded and a very recent study of 1,000 vertebrate wildlife species found that each of the species had diminished by up to 30 per cent since 1970. The planet is under severe stress and the more we measure and understand this, the better. We are committed to a great deal of monitoring research in order to understand it, which is often very difficult and expensive, such as the programme on the state of the thermohaline circulation in the Atlantic Ocean. The circulation is one of the key indicators of change for the climate system and the programme will involve measurements year-on-year for decades.

Living With Environmental Change (LWEC) has brought together the main organisations involved with the research base and also the policy departments. We are becoming increasingly experienced working across disciplines. The Rural Economy and Land Use (RELU) programme, for example, involved several research councils - social science, natural science, economics, etc. LWEC will need to involve the public as well, not least because ultimately it is the public who have to live with environmental change. One of the key actions that the LWEC partners' board will implement is a programme of public engagement.

The planet as a whole

The primary goal of LWEC is to look at the system – planet Earth – as a whole and to make set of risk-based predictions of environmental change and its effects. It is concerned with environmental change in the round; it is not exclusively about climate change.

The term 'prediction' causes a lot of debate. Some people think of, for example, climate change predictions as being rather similar to Mystic Meg's and I think we need to explain better how we are able to make forward projections about the state of the environment. They are based on the best available science. But we have to make assumptions about underlying factors such as population growth (which gives us a range of possibilities), we have to make assumptions about the amount of greenhouse



Professor Alan Thorpe is Chief Executive of the Natural Environment Research Council (NERC). His research involves the basic

dynamics and predictability of weather and climate. From 1999 to 2001, he was Director of the Met Office's Hadley Centre for climate prediction and research. Then he became the first director of the newly-established NERC Centres for Atmospheric Science. He became Chief Executive of NERC in April 2005.

gases we are going to emit and about the changes to land use that will happen in the future.

So these are 'what if' predictions: 'If we continue to live this way or that way, the future might look like this'. This is the sort of information that will allow society and policy makers to make decisions now – they can examine possible futures to see the interactions between one set of interventions and another. This is not crystal ball-gazing, it builds on our current state of knowledge about planet Earth and how it works. Our state of knowledge is imperfect, but we try to factor in all of the knowledge that currently exists.

The Millennium Ecosystem Assessment judged that by 2050 we would have a 10-15 per cent loss in the number of species across the planet. For water withdrawals, it predicted an increase of water abstractions of by between 30 and 85 per cent, and in terms of food demand a substantial increase is expected – something between 70 and 85 per cent. These predictions are based on our current imperfect knowledge about these areas and they have to factor in a whole set of uncertainties.

Economic analysis

One priority is to bring some serious economic analysis into our study of ecosystem services: this programme is very much about natural science economics. The controversy about the economics in the Stern Review shows that we need to continue with this sort of research. We need confidence in economic analysis: ecosystem services look completely different from one another and somehow we have to make some comparative evaluations.

We have already made a start with some of our programmes. At NERC, we have joined up with the social scientists and economic scientists in the Rural Economy and Land Use programme, for example. In the farming arena we have to come to grips with the impact of intensive agriculture. More than 50 per cent of all synthetic nitrogen fertiliser usage has taken place since 1985: the human input of nitrogen is far exceeding the terrestrial component.

Making the programme effective. While many participants welcomed

discussion

the LWEC initiative, which could lead to a more systematic and strategic approach to the problems of environmental change, a number of concerns were expressed: what were the funding resources available; what were the pressures that would encourage researchers (and Government departments) to leave their silos and cooperate effectively; were there any particular priorities which should be followed urgently?. One speaker said the whole programme sounded long term, but actions must be taken now if they were to be effective within the next decade. And ultimately, how is the success of the programme to be measured?

environmental change

New technologies for a sustainable world

t is always useful to start with some key facts. Something like 30 per cent of all of the energy available at source is actually lost in generation. Some of that is determined by the laws of thermodynamics, but it gives an indication of one of the issues we have to address. In non-transport energy (in other words power and heating) around 42 per cent is used to heat buildings with a third of that figure lost through windows. Some 74 per cent of oil usage is used in transportation and that represents 25 per cent of carbon emissions. The EU Renewables Directive requires 5.75 per cent of transport fuels to be substituted with biofuels which would mean about 19 per cent of arable land will need to be used for biofuel crops.

I believe the chemical sciences can provide security, affordable energy and sustainability while at the same time addressing climate change. It is striking that, despite all the talk about climate change and the need to reduce the use of hydrocarbons, 80 per cent of global energy provision comes from fossil fuels and it is all carbon positive. How can we move towards what is essentially a hydrogen/electricity economy in the longer term?

Today's global energy consumption is about 11.1 gigatonnes per annum of oil equivalent, with some 8.8 Gt being oil, gas and coal. That represents about 7 Gt of carbon. Add in other items - land clearance and so on - and we have a figure of about 8.8 Gt of carbon emissions. Roughly 40 per cent resides in the atmosphere with the remaining 60 per cent going into the oceans or being taken out by other sinks on land. That accounts for a 0.6 per cent per annum rise in the carbon content of the atmosphere (if you were to recycle just 2 per cent of all the carbon in the atmosphere you would be able to provide all the energy the world needs today; which makes ideas like artificial photosynthesis very interesting).

Now, global energy strategy cannot be based on fossil fuels running out: they will not run out for well over 100 years and maybe considerably more given our coal reserves. But why burn oil and gas when you can use them for higher-value applications? We need to look at utilisation and efficiencies and we need to innovate.



Different approaches

There is no one-size-fits-all way for a country to handle energy and environmental issues. It could, for example, continue to use a lot of hydrocarbons, but with carbon capture and storage (CCS), and then have a relatively small amount of renewable use. That could work in a centralised economy relying on a relatively small number of large power stations. Conversely, it could choose low fossil fuel usage, still with CCS, and a high level of renewables: that type of energy economy is more decentralised and diverse. So two countries could employ quite different approaches in the development of a green economy.

Carbon capture and storage can take place either pre- or post-combustion. That means processing tens of millions of tonnes a day globally. Even the world's largest Liquefied Natural Gas (LNG) plants only output about 10 million tonnes per year, so there would need to be thousands of CCS plants around the world. The key technologies are efficient capture technologies and effective storage – underground or even on the seabed in a liquid or solid state.

In nuclear energy, typically 96 per cent of the fuel is unused. The key question, therefore, is how we deal with radioactive solids. For solar power, there are already concentrated solar stations where sunlight is focussed onto, essentially, a transparent pipe in order to generate steam. This then generates electricity. Photovoltaics can be used, because the output is direct current, to electrolyse directly to hydrogen or convert to alternating current.

Richard Pike

On an area/time-average, the total energy absorbed by the Earth's surface is of the order of 174 watts/m² and that is the benchmark that we need to consider in looking at alternative technologies.

Key issues here are transmission efficiency, storage of electricity and hydrogen and of course conversion rates. For tidal and wind energy we would need technologies like anti-corrosion coatings – a chemistry discipline.

An integrated approach

Energy integration will be very important. Take the balance between power and waste heat. Most generating plants in the UK are a fair distance from population centres and therefore there is a lot of waste heat (which is essential, thermodynamically, to generate power). A great deal of waste heat goes literally to waste, whereas this is used to heat homes in places like Scandinavia.

Should hydrocarbons be burned or kept for value-added products? Recycling needs be considering at an early stage of product/process development rather than as an afterthought. There is the issue of resource optimisation: as an example, with biofuels the yield - in terms of fuel related to the sunlight actually absorbed by the plant - is far less than 1 per cent, typically 4 tonnes per hectare. Technologies like photovoltaics and concentrated solar power achieve 50 to 100 times that yield. So given a certain amount of land, the solar route could provide up to 100 times more energy.

Carbon dioxide has to be stored for literally thousands of years so there is a legacy issue as is the case with nuclear– whatever we capture has to be kept out of the atmosphere for thousands of years. Using CCS for biofuels would, however, lead to a net reduction of the gas in the atmosphere.

Finally, science cannot be left in isolation. These issues should be covered in the education sphere much more effectively than at present. We need more teachers. These issues need to be seen as business opportunities; they must not be promoted as just problems.

Chemical Science Priorities for Sustainable Energy Solutions: www.rsc.org/ ScienceAndTechnology/Policy/Documents/ SustainableEnergySolutions.asp The Olympic Games come to London in 2012 but will there be anything to show for it once the athletes have returned to their own countries? A meeting of the Foundation for Science and Technology on 9 July 2008 considered the issues arising.

What will be the legacy of the 2012 London Olympics?

Tessa Jowell

arlier this year I visited Vancouver, the host city for the 2010 Winter Olympics. We had much to talk about because both our cities share an ambition to use the Olympic Games to accelerate and enhance physical regeneration plans. Vancouver plans to use the Games to regenerate the docks, to put their city on the map, and to boost the economy of British Columbia.

Looking back at past host cities, it is easy to understand what the Games meant to them. For Sydney it was the tourism dividend and the chance to raise their profile. For Barcelona it was regeneration. And Beijing 2008 confirmed China's arrival on the global stage in economic and cultural terms.

Our ambitions for the 2012 Olympics centre on the legacy for 2013 and beyond. Inspired by the International Olympic motto of "faster, higher, stronger", we are targeting faster progress towards a healthier nation, higher aspirations for young people and a stronger community bound by self-belief and the knowledge that Britain has hosted the greatest ever games.

To achieve our goal of a healthier nation we want to give people more reasons to participate in sport and to be physically active, through improved facilities, more coaching and better information about how to keep healthy.

A decade of sustained investment

The Olympics will represent the pinnacle of over a decade of sustained investment in sports facilities, and will leave world-class venues for swimming, cycling, athletics and more for elite athletes and local communities alike. Our commitment is towards a healthier 'nation': we are not just talking about London. In the light of the 2012 Games, we have reviewed the way in which sport in England is delivered at a community level so that everyone can benefit. At the same time we are challenging local authorities to use the inspiration of 2012 to accelerate their work.

Creating higher aspirations for young people in their work and play is about unlocking talent. Back in 2005, we



The Rt Hon Tessa Jowell MP is Minister for the Olympics and London. She has direct responsibility for delivery of the Government's overall

Olympic programme and reports to the Prime Minister. She also continues to have responsibility for humanitarian assistance, which involves providing care and support to victims of major disasters both at home and abroad. She has been MP for Dulwich and West Norwood since 1992.

impressed the International Olympic Committee by showing that we understood the unique motivational power that the Olympics, and sport more widely, can have. One of the reasons why we won the right to host the 2012 Games was our promise to transform the lives of a generation of young people through sport.

In March the Government announced £30 million of investment to extend enterprise education in schools. The 2012 Education Programme will inspire young people in schools around the country through topics such as enterprise and healthy living.

Matching skills and investment

We will identify the skills the Games will need and support this with investment. In construction there has been £50 million more investment from the sector; a new National Skills Academy on the Olympic site; 2,000 new training opportunities for local people and more targeted placements.

The 2012 Business Network incorporates initiatives inspired by the 2012 Games. These represent a continual drive to develop 'value-added' from the Games. The Olympics are helping us change the way we do business for the better and for the long term.

The third pillar of our Games is the drive to bring people together in a celebration of national pride and confidence. The Cultural Olympiad launches in September 2008.

We will only succeed if we listen to local people when they tell us what their community needs from the legacy of the Games. For the people who live in the Olympic boroughs and areas immediately around the park, we will fail if the Olympic juggernaut is imposed on their lives.

Coming together

The 2012 Games will be an opportunity for people to come together and share an experience. We are planning "Live Sites" — giant TV screens in towns around the UK — where people can enjoy the sporting and cultural spectacle together.

Hosting the Olympics is a remarkable opportunity to examine who we are as a nation and how we want to define ourselves when the world comes to visit us in 2012. After seven years of preparation the summer of 2012 will be over in a flash, which is why we have placed such importance on embedding these aims and values in all our planning.

discussion

An enduring legacy. Perhaps the most important legacy would lie in

raising skill levels and employment in London's East End. This might be achieved through the new construction and civil engineering academies. It was recognised that many young trainees would be starting from a low level of achievement and coming from families with no recent history of employment. It is imperative that lasting jobs should be created.

Building the London 2012 Games' legacy

ondon has had the Olympic Games twice before. In 1908 Vesuvius put paid to Rome's Olympic plans and London responded by building a 150,000seat stadium in 10 months. In 1948 the post-war global depression meant no-one wished to host the Olympic Games and London stepped into the breach, accommodating athletes in temporary and military accommodation, making use of the facilities in Wembley and asking athletes to bring their own food.

In 2012 the world will face new challenges: of equity, of people, reduced natural resources and climate change. London has responded by presenting to the International Olympic Committee proposals that will bring about the regeneration of the largest piece of an inner-city which has ever been attempted.

The major challenge is time. The Lower Lea Valley at Stratford has been carved out of the historic landscape by successive generations over 2,000 years - but mainly over the last 300. We are attempting to deliver the same scale of change in just five years.

One legacy of the industrial revolution and the twentieth century is a scar across a wide swathe of East London, centred on Stratford, on a scale that only an event the size of the Games could attempt to heal.

Innovation

In every instance, the Olympic Delivery Authority (ODA) teams are planning their



John Armitt CBE FREng is Chairman of the Olympic Delivery Authority. He was previously Chief Executive of Network Rail from October 2002 and Chief Executive of Railtrack plc from December 2001. He has extensive experience in the building, civil engineering and industrial construction markets. He is also Chairman of the Engineering and Physical Sciences Research Council and a Non-Executive Director of the Berkeley Group.

buildings, the materials that they use, the wiring, the procurement of the contracts, the methodologies to accommodate changes in the contracts, knowing that there will be changes in the future. The needs of the future are not precisely defined, but we must ensure we lay foundations that can accommodate those changes.

We must begin by cleaning the Olympic Park site. The ground contains hydrocarbons, heavy metals, arsenic and other toxic materials. A million cubic metres of material are being washed to clean away the by-products of past industries: we are recovering about 85 per cent of the material we are washing, so we can reuse the maximum amount.

From the buildings which are being demolished, we have so far recovered 90 per cent of the materials for reuse, taking a sustainable approach to demolition. Today the site is scarred by 52 pylons carrying overhead power lines. These lines will eventually be moved underground. The new power station will create 20 per cent of its energy from biomass; it is a combined heating and cooling power station that will serve the Village with electricity, and also with district heating and cooling.

John Armitt

In the new Park we are installing 30 new bridges and 20 km of new walkways and roadways. The Olympic Stadium will accommodate 80,000 people during the Games, the figure reducing to 25,000 after the Games so that it can be used by the local community. We are designing it with maximum flexibility.

Transport

Stratford will be the best connected Games in recent times. There will be seven train lines to the Park, and upgrade work on these lines as well as increasing capacity and access at Stratford Regional Station will mean that the Games will leave behind a great legacy of improved transport for East London.

By the time we have finished we will have spent over £6 billion in creating the Olympic Park: 75 pence in every pound of that sum will be providing for the future, not just for the London 2012 Games.

Choices and priorities for the **Olympic legacy**

s a member of the Olympic Legacy Directorate, I am constantly aware that the word 'legacy' means different things in different contexts, so I think we need to understand it better and avoid confusion.

There is a legacy in the reclamation and development of over 500 acres of post-industrial land in the Olympic Park. Without the Olympics and what the Olympics means in terms of investment and development and jobs and in the change in perception of this area, it would be very difficult to envisage success for other aspects of legacy.

There is the legacy for East London: nothing less than the comprehensive physical, social and economic renewal of one of the most impoverished and deprived parts of the country. This is at the core of London's vision for what it wants to achieve through the Olympics: the transformation of people's lives.

My role is primarily focused on these aspects of legacy: the Olympic Park and the wider East London area. These two are inextricably linked. During 2009 we will be publishing a strategic plan for East London. This has to be comprehensive. It has to address social and economic

Tom Russell

issues as well as the physical transformation of the area. But it must not be too prescriptive: we need a framework, not a blueprint; in the real world if we are putting a plan into place which we intend to have currency for the next 20 or 30 years we cannot possibly predict all of the changes that will take place. We have launched a public consultation on what should go into the strategic plan.

Delivery

The delivery structure needs to address three interlocking imperatives. First, the development of the Olympic Park post2012. Second, a management regime for the Park and the venues which will safeguard the enormous public investment in this area. And third, quality of life issues in the wider area; social and economic aspects of regeneration.

A final word on structures. Getting the structure right is no guarantee of success; actually people are much more important than structures in that respect. Getting the structure wrong, however, can seriously impede or delay success so this process of consultation is very important.

Obviously we face major risks and challenges in this project. I just want to highlight two. First, there is a vast array of stakeholders and interested parties in the Olympic project. In order to be sure that we take people with us we will need, first and foremost, the clear and compre-



Tom Russell is Group Director of the Olympic Legacy Directorate, London Development Authority. He has

overall responsibility for maximising the physical, social and economic benefits of the London 2012 Olympic and Paralympic Games. His recent roles include Chief Executive of New East Manchester Urban Regeneration Company and Deputy Chief Executive of Manchester City Council.

hensive strategic plan that I have already talked about. People will need to understand what we are trying to do, will need to support us in doing that, and will need to contribute to the project.

Second, we will also need a genuine engagement with the community and with a range of institutions. In parallel with the planning process we have a programme to engage communities in the East End and across London, running throughout summer 2008. We want to learn what people think the Olympics can do for them, and understand what they aspire to. In the jargon we tend to use, we sometimes talk about the 'legacy client'. Well, the true legacy clients for the Olympics are the people living in the East End of London: we will act as their interim voice.

Just how great a legacy there will be is down to all of us privileged to be working on this historic project. www.legacy-now.co.uk

Creating Water City in East London Andrew Mawson

ore than 10 years ago, a small group wrote what may have been the first document to propose the Olympics as a catalyst to transform a neglected quarter of London for the benefit of the local population and London as a whole: they called it 'Water City'. And if we are to create such a lasting legacy, first we have to get the small things right.

Two community projects in Bromleyby-Bow demonstrate what can be achieved. When I arrived in east London as a clergyman, long before Canary Wharf was built, I found 12 elderly church members, dilapidated buildings and £400 in the bank. A group of local families were running a small nursery from one of their homes. They wanted to expand the nursery, so we formed a partnership and built the first integrated nursery of its kind in the UK.

It was planned at the time to rebuild the interior of the church for 40 people rather than 200 and use the space gained for a nursery. This would have a mixed intake catering for the children of doctors, teachers and people like me who can afford to pay the going rate for the service, together with children from the area whose parents do not have the money to pay.

That was the idea 24 years ago, but an expert from Social Services told us that such a project was impossible because it would break scores of rules and regulations. The team did not give up, and thanks to the actions of the director of social services, who overruled opposition from his staff, the go-ahead was given. And now the church site has been transformed into an integrated childcare service, sharing ownership among local groups.

Bromley-by-Bow nursery has now



Lord Mawson OBE is founder and President of the Bromley-by-Bow Centre in East London and cofounder and President of Community Action Network, a national charity supporting 850 social entrepreneurs. He has been a member of the Prime Minister's Delivery Unit and was a founding member of Poplar Harca, a £300 million housing company in East London, and of Leaside Regeneration Ltd which runs a £100 million regeneration programme in the Lea Valley.

evolved into a social business called Bow Childcare, which operates in Newham Tower Hamlets and Hackney.

A project to establish the first integrated health centre in Britain also met with resistance and this time it was intervention by the then Minister of State for Health, Dr Brian Mawhinney, that got the project on the road. The health centre was then the springboard for a multi-million pound social enterprise, the Bromley-by-Bow Centre. These two examples show how local communities can gain from imaginative projects if the planning processes do not stifle invention.

Now, with the Olympics here in the Lea Valley in 2012, East Londonders have a once-in-a-lifetime opportunity to build a Water City, a new metropolitan district for London. To make that dream a reality we all need first to recognise that the Olympic

project is not just about people or place, it is about people and place.

Second, the legacy we are talking about is not the Olympic venues alone: it is a development opportunity running from Hackney Marshes right down to the Thames.

Third, there is now a real need for leadership. We need someone to drive this legacy for East London in the same way that Michael Heseltine drove Canary Wharf and the Docklands.

Fourth, we need central Government, London Government and local Government to start working together, which to date has not been the case. There needs now to be one organisation with the responsibility of running the Lower Lea Valley.

Fifth, we now need to mobilise business entrepreneurs and social entrepreneurs. There is a new way of doing regeneration that is growing and delivering valuable assets and services to local people in east London, but it challenges Government's traditional ways of doing business. This old logic needs to give way to the new.

East London cannot wait on Government, the 40 public sector bodies now operating down the Lower Lea Valley and others to agree. So a new company, called Water City Developments CIC, has been formed: it is a social enterprise, a community interest company, which is designed to invest any profits it makes in the lives of those who live in the Lower Lea Valley.

The Olympics represent a fantastic opportunity. If East London is to make the most of that opportunity we will have to build a new metropolitan district for London that will still be there in 100 years time.

Is it feasible to define a sustainable transport policy? The Foundation for Science and Technology examined the question at a dinner/discussion on 25 June 2008.

The road to integrated policy

irst, I want to look back a couple of centuries at the growth of transport infrastructure. We created turnpikes for stagecoaches in this country, very closely followed by canals and then by railways. We then built trunk roads (which were to some extent major improvements on the turnpikes) and added the motorways. At some point in their history no further investment was made in each component because they had been overtaken by what was regarded as a more modern and different mode of transport. We are now in a situation where we have to reinvest and take some forward in a more integrated way. We are faced with a new set of problems in developing an integrated policy for all of these modes simultaneously.

One of the issues that surrounds all of these investments is the use of energy. One has to remember that there is as much energy moving in petrol tankers as on the grid. To move all transport to electrical power, we would have to enlarge the size of the grid significantly.

Some recent work looked at the lengths of car journeys and their purpose as a function of distance. The biggest single item is commuting (between 10-25 miles) and is therefore likely to produce the most carbon dioxide. From a policy point of view, intervention here could give us the biggest reduction in CO₂ for the smallest adverse impact.

Shopping also accounts for a sizable proportion of car travel. So there are some very interesting social and economic factors to take into account when thinking about Government (and local Government) policy interventions.

I have been working with colleagues to apply basic systems engineering concepts to this issue. When we know what customers actually want, we can go through items like requirement analysis and functional analysis until we end up with an output which is designed to meet those expressed needs.

We are now thinking about transport systems on a scale that has not been done in the UK recently, and we are also beginning to look at them in a multimodal way because today's travelling experience combines several modes on one journey.

Take the example of aviation: there are many sub-systems that make an



Professor Brian Collins FIET is Chief Scientific Adviser at the Department for Transport and also at the Department for

Business, Enterprise and Regulatory Reform (BERR). He is Professor of Information Systems at the Defence College of Management and Technology, Cranfield University.

aircraft fly, but it cannot fly safely unless everything in the air transport system works. It is dependent on global positioning and displays - and increasingly has to integrate with the ground transportation system or, in some parts of the world, the maritime transport system. So you end up with something quite complex.

There is a large academic discipline called 'soft systems analysis' that was started by Professor Checkland at Lancaster University many years ago. He created the idea of 'a rich picture' which shows the interactions between the various elements of a system - it looks rather like a 'mind map'. These are the sorts of maps that one needs to draw in order to provide a picture of the sort of systems

and 'systems of systems' we need to understand. We should not be frightened that this diagram might take half the size of a conference room.

Brian Collins

And that is the scale on which, I believe, we need to analyse the transport problem – but in order to do that we need data. Fortunately, transport systems produce a huge amount of data; we are datarich, but not so rich in analysis tools.

I am proposing that we have an analysis map, drawn around environment and the economy and society - the three value sets to which we need to deliver value. Then we need a 'challenges matrix'. These are the sorts of questions which the public and the professionals expect us to be able to answer with a sustainable transport policy. One is 'minimise the impact of transport on heritage, landscape and communities', which obviously concerns the natural environment. Another is 'support productivity by ensuring a competitive transport industry'.

We need to explore these new techniques: soft systems; systems dynamics; the use of synthetic environments for experimentation (we are already starting that with the Highways Agency); new ways of articulating problems; and eventually the development of a synthesised architecture for transport infrastructure.

Now, I have deliberately not said



Systems and 'systems of systems'

sustainable transport

'integrated transport provision'; I think we have to do integrated analysis, but the provision can be delegated in a way which is proportionate to the scale of the transport being delivered – some of which is national, some of which is very local. We need integrated data-gathering which is not only technical but also social and we cannot neglect the fact that transport has a huge impact (and dependence) on energy, water, housing, special planning and other economic and social development. This is the road along which we have to go to get to integrated policy, but we have to do lots of other integration first.

The full presentations of speakers can be found online at www.foundation.org.uk

21st century high speed rail

s it possible to have a sustainable transport system? The answer of course is 'yes'. For by 'sustainable' we mean one which allows us to live within environmental limits, promotes a strong, healthy and just society, ensures a strong economy, is decided upon using principles and practices of good governance, and uses sound science responsibly to get there.

In transport, there is a great deal of interconnection: it is tightly interlocked in systems, within and between modes, and whatever we do has consequences. If we do not understand the system archetypes in which we are operating, then we will get consequences which are at best unforeseen, and more likely are the opposite of what we want. If we have a system that is in an undesirable state (for example traffic congestion) and we simply take some measure to relieve it (like park and ride) the system will likely relax to some other undesirable state (like congestion in a different place).

The Channel Tunnel rail link is the only main line railway to have been built in Britain in more than 100 years! Elsewhere on our rail lines we are at a speed that we achieved about 30 years ago. We now need to think about rail infrastructure for the 21st century. Despite huge increases in rail fares for rail travellers, rail passenger traffic is the highest it



Dr Bernie Bulkin is Commissioner for Climate Change, Energy, Transport at the UK Sustainable Development

Commission. He is a member of the BERR Energy Board, serves on the boards of AEA Technology plc, Chemrec AB, and Accelergy Corporation and directs the New Hall Centre for the Environment, Cambridge where he is a Professorial Fellow. He is a venture partner with VantagePoint, the California cleantech venture capital firm.

has ever been.

Today, high speed rail (HSR) means speeds of around 350 km/h – and getting faster. Studies in Spain showed that if people can get from city centre to city centre in $2\frac{1}{2}$ hours or less they will switch from plane to train. That is possible throughout Great Britain. Spain is building 10,000km of new high speed rail. This is well advanced with several key lines now open, including the link between Barcelona and Madrid – and the journey takes 2 $\frac{1}{2}$ hours.

Bernie Bulkin

The goal in Spain is the elimination of all internal flights. We could achieve this much more easily, and it is a worthwhile goal. However, HSR must not just be hub-and-spoke with London at the centre. There must be better connections between other cities too.

We need to think, longer term, about there being just a few airports that are used for long haul flights. Connection to these will be by high speed rail links rather than by flights from regional airports.

Two points about the environment. First, it is often said that high speed trains are much less environmentally friendly than today's trains, emitting much more CO_2 per passenger kilometre. These data come from the TGV trains the French use. Today the Shinkansen in Japan achieves power consumption one-sixth that of air travel. So we need to be careful about the data we cite, a point that was not taken into account in the last Rail White Paper.

Second, this is just one more example of why we need to move, in parallel, to decarbonising our electricity system completely. We must completely electrify the railways, and we must have generation which is low carbon or carbon free for the railway to operate on. Incidentally, trains can be hybrids too, and already use (or are equipped with) regenerative braking.

Adapting to consumer demand

e are seeing record passenger miles on a much smaller network. The network is around 50 per cent of the size it was in the Second World War, yet we are seeing passenger kilometres at their highest ever peace time levels. We are seeing punctuality at 90 per cent nationally. We are beginning to see these levels of punctuality in the suburban railway too. Three out of four trains arrive at Waterloo within 1 second of their booked time. We have the most modern fleet in Europe now.

We have also seen 50 per cent growth in the last 10 years. The real issue for the railways, the sustainability issue, is: how are we going to cope if this carries on? Even if we start ordering new trains now and putting in new infrastructure, we are going to be overtaken before this is delivered. Sustainability is about providing, very quickly, additional capacity, specifically in the rush hours where the real growth is happening.

There are a number of things going on behind the scenes too. Recycling waste – taking people's waste off trains,

Ian Dobbs

sorting it out and reselling it – is one small example. We actually make a profit at Wimbledon Train Crew Depot from trading waste. We have some unusual fuel mixes which we are trying as well to see if we can get better efficiency and keep performance at the level we need.

Electrification

Electrification is becoming an increasingly important issue in the industry and one which is becoming politically popular (as well as something that transport professionals have been talking about for years).

sustainable transport

There are lots of other things in the background such as regenerative braking and training drivers to drive more efficiently.

What is different about public transport today? Service standards are improving and we know that road congestion is helping us. Having said that, one of the things that certainly happened in recent times – a lot to do with the oil price and the cost of motoring – is that the value for money perception has changed quite significantly. We are actually beginning to see some very significant changes in people's modal choices due to the fact that motoring is now considerably more expensive.

In April 2008 we rang over 4,000 people in the Cambridge and Southwest Trains operating areas, selected at random, to ask their views on a number of issues. Some 64 per cent believed that the environment was an urgent issue. While we were not totally surprised by that, we

were surprised that 47 per cent said they used their car less. And 19 per cent said they used the train more.

'Take the train'

If you look now at the top 200 companies in this country, nearly all have carbonreduction policies and nearly every one of those policies includes, in the Top Ten actions, 'take the train more often'. We are seeing big switches within Government departments and within private companies from road to rail.

Capacity is critical. We do a lot of talking about it, we have not produced much yet. It is urgent, as I have said. We are leaving people behind at Clapham Junction every morning: it takes two or three trains at Clapham at 8 o'clock to get onto a service for Waterloo. We need to take note of that.

People like cleaner, greener public transport. They like to be told that it is



Ian Dobbs is Chief Executive, Stagecoach Rail, and Chairman of, South West Trains, East Midlands Trains and co-

chair of Virgin Rail Group. Between 1988 and 1993 Ian steered the Great Eastern division through several major reorganisations, significant work practice reforms and a major capital works upgrade. He was headhunted by the Victorian Government in Australia where he reformed the Victorian Public Transport Corporation reducing the state subsidy by over \$250 million a year.

cleaner and greener as well, so we are missing a big opportunity. The mode of choice is changing. Behaviours are changing. We ignore all of that at our peril.

Sustainable aviation

am Secretary General for British Air Transport Association, but I work very closely with other sectors of UK aviation - the airports, aerospace manufacturers and the air traffic control company, NATS. In 2005 we put together a strategy called Sustainable Aviation. The strategy covers the environmental, social and economic impacts of the industry, but we do not apologise for focussing on the environmental impacts; those are the big issues at the moment.

We know that we are a small contributor to global climate change – but we also know that our emissions are growing so climate change is one of the main issues in our strategy. While growth in demand exceeds our improving fuel efficiency, our net emissions will increase. So in Sustainable Aviation our climate change goal is to play our part in a global framework to stabilise greenhouse gas concentrations and avoid dangerous climate change.

Underlying that goal we have a number of commitments covering our technology, our operations and the way we will become more fuel-efficient. We believe the right market mechanism to drive this process is the 'cap and trade' system, which is behind the European approach to climate change. We obviously also need to support the further research that is needed on climate change in general in our industry, we need to continue to inform our passengers about climate change and we need to offer offset options if they wish to take them.



Roger Wiltshire is Secretary General of the British Air Transport Association (BATA), a post he has held since 2000. He had a 30-year career in operational and planning roles at British Airways before that. BATA is the trade association for

UK-registered airlines, including traditional scheduled, no-frills, charter and freight carriers.

We have a good record on efficiency in our technology and operations. Fuel efficiency has improved by some 50 per cent over the past 30 years. The UK aerospace industry has also signed up to the ACARE targets - European-based, challenging targets for the industry to produce more fuel-efficient, more NOx-efficient and quieter aeroplanes by 2020. The ACARE targets include a further 50 per cent improvement in fuel efficiency and an 80 per cent reduction in NOx emissions for new aircraft in 2020 compared with the aircraft available in 2000.

There are also local impacts and the strategy focuses on noise and air quality. We have a good track record for reducing noise levels by making aircraft quieter; however noise will continue to be an issue. Even though climate change is at the top of the political agenda, noise is at the top of the local agenda. We work closely with

Roger Wiltshire

the airports and air traffic control to make sure we deliver the best operational practices around airports and we also want quieter aircraft. ACARE has set a target of halving noise from aircraft by 2020.

Air quality is relatively new on the scene, but it is concerned with EU limits on the levels of pollutants in the atmosphere; very much a regulated issue. We make a contribution to pollution, but road transport around airports has the major impact. The recent Heathrow study developed an advanced modelling of air quality in this area and this has demonstrated that we can achieve a growth in flights within the EU air quality limits that take effect in 2010.

On emissions trading, our preferred economic mechanism, we are about to see a final agreement in Europe covering all arriving and departing flights, with a start data of 2012. This will ensure that any growth in aviation emissions since 2005 generates an equal reduction in emissions in other sectors, paid for by the airlines. And we are in a better position than 12 months ago in regard to a global scheme. I think we will see big changes in US policy over the next 12 months: industry there realises that cap and trade is on its way. It is now a matter of how these changes happen, when they happen and how the various regions and companies around the world can work within a truly global structure.

National aviation sustainability strategy: www. sustainableaviation.co.uk

Each year, the Foundation for Science and Technology gives an award each year to a person who has applied science and technology for the benefit of society. The 2007 award was made to Dr Scott Steedman FREng

Lessons for London from the New Orleans flood

urricane Katrina passed to the east of New Orleans on 29 August 2005 and struck the Gulf Coast near Biloxi, causing widespread devastation throughout the area. The direct economic cost of the disaster was reported to be \$21 billion in the central metropolitan area of New Orleans alone, with an additional \$7 billion of damage to public structures and infrastructure. Wind speeds had fallen before the hurricane made landfall, but the surge of water that struck the coast was among the largest ever recorded in the Gulf. Following the disaster in New Orleans, it is worth asking whether a similar disaster could occur in London, which also depends on a long and complex system of levees, flood gates and the Thames Barrier for flood protection from the sea.

Studying the levees

In the immediate aftermath of Hurricane Katrina, the Federal Government established an Interagency Performance Evaluation Taskforce (IPET) to 'find the facts' behind the inundation of the city. My role was to lead, with Dr Michael Sharp of the US Army Engineer Research and Development Center (ERDC), one of the IPET tasks, supporting the Geotechnical Structure Performance Analysis. Our task was to study the levees - to gather and analyse the evidence and to learn the lessons for the future.

One of the principal tools that we used to research the levee performance was a very large geotechnical centrifuge, part of a special facility in Vicksburg, Mississippi. This had been commissioned some 10 years ago to study large scale field problems in civil engineering using physical models. This centrifuge laboratory was based on a concept that Professor Andrew Schofield FREng FRS and I had transferred to the US Army Corps of Engineers (USAE) during the early 1990s, and was based on the design and operation of a similar facility at Cambridge University.

The Army Centrifuge is capable of carrying a huge payload of up to eight tonnes to 150 gravities, or two tonnes to 350 gravities. This vast capacity allowed us to construct scale models of typical levee



Dr Scott Steedman FREng FICE is a Vice President of The Royal Academy of Engineering, a President-elect of the Institution of Civil Engineers and Director of Group Strategy at High-Point Rendel.

geometries using real soil and water in relatively large model containers. Subject to high acceleration in the centrifuge, these models experienced the same stress conditions as occurred in the field when the flood waters rose. The onset of failure can then be captured in a highly realistic and visual manner.

Substantial challenge

The challenge for the US Army in the aftermath of the disaster was substantial. Of the 284 miles of Federal levees and floodwalls surrounding the city and 71 major pumping stations, 169 miles of levee and 34 pumping stations were damaged by the storm. Very little instrumental data could be recovered from wind or wave gauges as they were almost completely destroyed, but the collection of witness statements, surveys of high tide marks and other physical investigations were quickly set in motion to gather information. From this base, the IPET task teams worked to develop an overall picture of the disaster.

It was by no means the first time that parts of New Orleans had been flooded, but the flooding following Katrina was certainly the worst. In the past 60 years alone, hurricanes flooded New Orleans in 1947, 1956 and 1965 (Hurricane Betsy). A major report by the USAE in 1964 contained their assessment of the critical approach tracks for a future hurricane to affect the city. One of the worst case trajectories that they identified in the 1964 report, passing to the east of the city, was very similar to the actual path taken by Hurricane Katrina, as it tracked northScott Steedman

wards during the early morning of 29 August 2005.

Strong winds hit the city and the heavy rain, over 300 mm in parts, together with the rising waters led to the massive inundation observed over tens of square kilometres of residential and commercial areas. The IPET investigation found that there were 50 breaches in total in the levee system. Four (possibly five) of these, associated with failures in the foundations of the levees, occurred prior to the water reaching the top or crest of the flood wall. The rest occurred as a result of water cascading over the top, called 'overtopping', causing scour, erosion and loss of crest.

One of the facts the IPET sought information about was why so many breaches occurred, given that the height of the sea surge in the centre of the city was roughly the same as the design height of the protection system in the Inner Harbor Navigation Canal and less than the design height on the 17th Street and London Avenue canals.

The investigation

The investigation first concentrated on the breaches that occurred prior to overtopping, when the water level had still not reached the crest. All of these cases had flood walls constructed through the old levee section, a technique used to raise the height of the protection without having to widen the levee itself.

The levees were built originally from local clay, built up in layers with a slope on either side. The oldest parts of the levees in the centre of the city date back to the original construction of the outfall canals, over 100 years ago, when pumps were installed to drain the swampy land between the old centre of the city and Lake Pontchartrain to the north. These old levees had very soft foundations, comprising a top layer immediately below the ground surface of a mixture of peat and clay known as 'swampy marsh' and a lower layer of either soft clay or sand. Below this was more clay and sand, extending to great depth - there is no natural rock anywhere in the Mississippi delta. Borings confirmed that the levee overlay clay at the location of the 17th

Lord Lloyd of Kilgerran Award

Street breach, whereas the levee overlay sand at the locations of both the London Avenue breaches.

Our centrifuge models showed that the rising water in the canal could push the floodwall landwards enough to create a water-filled gap down the front of the wall, effectively cutting the levee in half. In the case of the London Avenue breaches, the IPET study concluded that the leaning movement of the flood wall allowed the water from the canal to reach the underlying sand layer, greatly increasing the water pressures in the foundation and effectively 'floating' away the landward half of the levee.

The IPET study also concluded that all the other levee breaches, many of them several hundreds of metres in length, commenced with overtopping, causing scour and erosion on the landward side of the levee, ultimately leading to loss of support and breaching. Wherever water flow was more concentrated, such as around the end of a section of wall, perhaps part of a pump station or flood gate, local scour was also found to be severe.

Not sufficient

However, these mechanisms alone do not explain the number of breaches and the scale of the inundation, particularly in the centre of the city. IPET found that water levels there were typically 3-4 metres above sea level but there was little wave action and the design levels of the protection system were comparable to, or higher than, the height of the surge. Within months of starting the investigation, the IPET geodetic survey team discovered that large parts of the levee system were in fact lower than was originally thought, and by a considerable margin.

Two explanations for this were put forward by the IPET team. All the official benchmarks in the area were re-surveyed to check their elevation against historic records. Their first finding was that many of these were not at their anticipated elevation, largely due to subsidence within the soft clays beneath large areas of the city. Secondly, IPET found that the reference elevations of benchmarks used in the design of some floodwalls and levees were not always the correct reference elevations appropriate to that particular time period. Instead, for some projects, older out-of-date reference elevations had been used that were appropriate to a previous era. This meant that in some cases, although floodwalls were constructed to the elevation shown on the drawings, their actual elevation 'as-built' was below



Flood damage near the levee breach at London Avenue South (Scott Steedman)

that required.

The IPET investigation found that Hurricane Katrina would have caused widespread flooding even if the levees had held, but the vulnerability of the system, which IPET concluded was "a system in name only", contributed greatly to the scale of the disaster.

And London?

Is it possible that a similar disaster could happen in London? Recent levee failures in the Netherlands have illustrated how older systems are not necessarily safer systems. London is protected by a long and complex system of levees, flood gates and the famous Thames Barrier.

The Environment Agency has the primary responsibility in the Thames Estuary for the flood defences and is engaged in a major capital programme to carry out refurbishment or replacement of the flood protection system and maintenance of the Thames Barrier. Times have changed since 1953, when a sea surge overwhelmed coastal defences and damaged levees. Although stretches of the levee system are founded on peat, as in New Orleans, flood walls of the type used to ill-effect in New Orleans are not found in the Thames Estuary. The Environment Agency is confident that we in the UK have learned from the past and that our sea defences are to a much higher standard today than they were in 1953.

That said, there remains a significant flood risk in London. Computer simula-

tions by re-insurer Guy Carpenter shows that the more likely scenario for flooding in London is riverine, not sea flooding and that this is concentrated in west London. In fact, if the primary defences hold, and particularly the closure of the Thames Barrier is timely, then computer models suggest that the extent of flooding in London would be small (and predominantly on the south bank). Guy Carpenter's modelling found that the closure of the Thames Barrier against a large sea surge will cause a reflected wave to travel back downstream, potentially overtopping secondary defences and flooding rural areas to the east of the city.

Awareness of the risk, and knowledge of the consequences, is vital in containing any such disaster and there is no excuse now for decision makers not to have access to a detailed understanding of what is likely to happen under every conceivable scenario. The mechanisms of flood defence failures are well understood and unlike flash flood, the effects of sea surge are more straightforward to simulate in computer or physical models. Both techniques have huge value in informing investment decisions and in flood risk management. From the evidence to date, London is not exposed to the extent that New Orleans was in 2005. However, the consequences of any flooding in London would be so serious that we cannot afford any complacency - there were many lessons from Hurricane Katrina and we may not yet have understood them all.

The Foundation is sad to report that Sir Hugh Laddie, a long-serving member of the Council, died in November. His contributions, always expressed with good humour, will be greatly missed.

The Foundation is grateful to the following companies, departments, research bodies and charities for their support for the dinner/discussion programme.

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The Foundation for Science and Technology 10 Carlton House Terrace London SW1Y 5AH

Telephone: 020 7321 2220 Fax: 020 7321 2221 e-mail: fstjournal@foundation.org.uk

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