



## RECORD OF SEMINAR: NEW NUCLEAR TECHNOLOGIES II

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On 23 September 2009 the Policy Foresight Programme held a meeting to follow that held on 13 March 2009 on New Nuclear Technologies. Sir Crispin Tickell chaired the event. The main speakers were Lady Judge Chair of the UK Atomic Energy Authority, Professor Chris Llewellyn-Smith Chair of ITER and the Consultative Committee for Euratom on Fusion, Mr Mark Higson, Chief Executive Office for Nuclear Development at the Department for Energy & Climate Change (DECC), Professor Ian Fells Chair of the New and Renewable Energy Centre, Dr James Martin of the 21st Century School at Oxford University, Professor Steven Cowley Director of UK Atomic Energy Authority at Culham Laboratory, and Professor Chris Grovenor Professor of Materials of the Materials Department, Oxford University.

A full list of the participants can be found at the end of this note.

**Lady Judge** gave the opening talk. She said that problems of nuclear energy were at the height all energy and climate change issues. She illustrated this with a list of 'P's.

**'P' for Politics:** would government encourage nuclear?

**'P' for Planning,** and all issues related to local concerns (Not In My Back Years): very often locals who were used to living along side nuclear power stations saw their worth as source of local employment and enhanced local facilities. Therefore it made sense to put new power stations on the sites of old ones.

**'P' for Price:** nuclear power stations were very expensive projects, upwards of 4.5 billion Euros.

**'P' for People:** there was a growing shortage of skilled people to develop and man the stations as nothing had been built for over twenty years in this country. The knowledge base was growing dimmer as the generations passed.

**'P' for Permits:** getting a permit to build a station was a tangled European web, and was quite an obstacle.

**'P' for Public Relations:** people's memories were long and most still remembered the Chernobyl and Three Mile Island accidents. A programme of positive education for the public and media was essential.

**'P' for Proliferation:** again, the media were very negative and less well informed about new technologies than they should be. A range of new nuclear technologies all but eliminated the possibilities of proliferation, but these were given low priority by the media.

Lady Judge could not think of a 'P' for Waste: but disposal of waste still remained a major stumbling block in the public's eye. 10% of all waste was from civil nuclear development. Deep geological storage methods were now being developed. The Yucca Mountain Project which some believed to be suitable for entombing radioactive waste for the hundreds of thousands of years judged necessary still faced scepticism. But things were changing. Increasingly it was being recognized that to meet our carbon emissions reduction targets, nuclear power would have to be included in the range of new energy technologies. It followed that we needed a new generation of people with the required skills.

Points made in discussion:

- Other countries had continued their nuclear research and development. France delivered 80% of its energy from nuclear power. Finland along with other Scandinavian countries and even Germany had far reaching programmes which included nuclear power in the delivery of energy.
- Having to store waste for hundreds of thousands of years was ridiculous. No where in history had there been such a precedent. Keeping nuclear waste safe for 1000 years was ample margin. As new waste disposal technology grew, the waste could be treated accordingly.
- The waste problem was a thing of the past. It was the media through bad press coverage that prolonged this argument.
- As long ago as the 1970s, we had realized that if we wanted energy security we needed to be free from dependence on foreign, in particular Arab oil and gas.
- The huge bottleneck in manufacturing turbines and the delays therein were responsible for ever escalating prices.
- Someone added another 'P' for Parts: Japan almost had a monopoly on technology and delivery.

**Mark Higson** from the Department of Energy and Climate Change talked about the Government's role in present energy policy, and its relationship with nuclear power. He started by adding another 'P', this time for Procurement. At present, government policy was not to procure new nuclear power stations. There was a clash of ideas within the government over the role of market forces and the degree of government involvement. But government was reaching a tipping point and old certainties were now being called into question. He recalled the arguments to and fro since the end of the war about the role of government and markets in determining energy policy. Since 2007 we had a commitment, agreed by the EC Council, to a target of 20% for renewables. Whether this meant energy in general or that for electricity had not been understood at the time. New recently identified objectives of *Security, Affordability and Sustainability* for energy, now over shadow previous thinking. Energy security was about keeping the lights on, and providing enough capacity by diverse and self sufficient policies. We did not want to be reliant on foreign supplies. Affordability was now being aligned to 'new' true costs taking into account ideas on cross subsidies and fuel poverty. Sustainability was now seen in the light of being able to maintain energy indefinitely with the costs to future generations being calculated with new criteria. He drew attention to Ed Miliband's speech on the subject of December 2008.

Points made in discussion:

- The price of a finished plant grew and grew because the Licensing and Certification process was a seriously delaying problem. At the moment all licensing was under EU regulation which delayed building and therefore pushed up the price of the plant. Each Licence and Certificate should be issued in the country of the build. It should be about the local position. There was a great need for a simpler process.
- The problem of over bidding for a building project was a deliberate tactic. Running over budget was expected. A study on what made projects go well or badly was needed
- The process of designing as-you-go also added to costs. The role of perverse subsidies needed to be taken into account.
- We should look at energy policy as a whole before considering the nuclear option.
- At the moment the government gave insurance because private or commercial companies were not willing to do it. It was the case of a small risk against something large.

**Professor Chris Llewellyn-Smith** argued for the inclusion of nuclear energy in the government's energy package. Otherwise, he could not see how future energy demands could be met. Global use of energy was huge - something equivalent to 24 one hundred watt bulbs burning per person on the planet continuously. However, usage was unevenly distributed. At the moment, one third of the world's population lacked electricity. We had

to allow for the increasing demand from developing countries. It was estimated that only twenty five years or so away from now, an increase of 45% in energy would be needed by the world's growing population. At the moment 80% of all energy was produced by burning fossil fuels. We knew these were drying up. Estimates varied but as an average guess, oil would be exhausted in 50 years, gas a little longer, and coal in about 200 years. There were many ways of trying to eke out these fossil supplies, but by anyone's guess by the second half of this century energy supplies as we know them today, would be under serious stress.

We already knew that we had to change our source of energy to limit carbon emissions and to meet our promised emissions targets, and the only foreseeable way of doing so at the present time was to utilize the nuclear option. A mix of nuclear and solar would be a viable option to meet future energy demands. The need to reduce total energy demand world wide was a real and urgent issue but government policy on energy efficiency was not visible. So much more could be being done on this front.

At the Gleneagles Summit in 2006, a summary on how to save energy had been drawn up, but with very little practical result. As usual, there was a lot of talk and no action. Other European countries ran their energy policy better than Britain. In Britain, the same problems and limitations of the last thirty years persisted. On nuclear issues these included: safety, waste, proliferation, and access to uranium sources. It was not being taken into account that the new generation of reactors were much more attractive, with fewer components, better safety, less waste and more resistant to proliferation. The safety aspect of waste had been adequately addressed for the time being. Research into reducing the waste which needed long term disposal was being undertaken. The Yucca Mountain Project could store 100,000 tonnes, but by the end of the century 20 Yucca mountains would be needed. The biggest problem on proliferation was perception and this could be addressed by limiting availability of enrichment technology, and by burning of contaminating fissile products. All this was the subject of research.

Access to resources of uranium and costs of extraction were still major issues. Estimates of resources of uranium, as a function of price, i.e cost of extraction being less than energy content, differed widely from country to country. What was needed was the right level of research and development investment now. The whole nuclear issue was chronically underfunded. There were still many issues to be resolved but research would help enormously to evaluate new technologies, the different fuel cycle options (amongst them uranium/plutonium fast breeders), thorium and fusion in all its aspects. Recycling was another area in need of research funding. The problems remained more political than technical. Then there were still the old constraints on expansion of the industry because of the chronic planning permission problems which delayed things for years at a time, this led to huge over budget costs.

Points made in discussion:

- The quantities available of uranium and other metallic minerals was very uncertain. Reports varied enormously.
- Obtaining international certification for a nuclear power plan remained a bad joke. The aviation industry had found ways to satisfy international safety rules. The nuclear industry should do likewise.

**Professor Ian Fells** spoke on security of energy supplies. He asked everyone to think what it would be like if the lights went out. He ran through the 'brownouts', or, blackouts as we know them, which the world had recently experienced: in particular, the 2003 blackouts in the United States, Britain, Italy and Scandinavia, the 2006 blackout in Auckland, and the continuing rolling blackouts in South Africa. All these had huge economic implications. Worse even than those was perhaps the anarchy that so quickly followed. All kinds of services came to a sudden halt, with house lights out, supermarkets closed, traffic lights ceasing, mobile phones stopped, petrol pumps dead, and threats of a sewage overflow. People started to steal food and police had to be mustered to stop rioting and looting in the streets. All this could come to pass within a few hours just because there was a break in energy supply. These blackouts were in the main due to creaking infrastructure, and lack of investment in energy systems.

What if then, a terrorist group decided to wreak havoc on purpose, and start to tamper with our energy supplies to meet their demands? Or what if our foreign suppliers of energy flexed their muscles and decided to hold us to ransom for whatever reason? Our civilization would all too soon begin to look very shaky. As a net importer of power from Norway, Russia, Qatar, Algeria and Iran, Britain lay well within the extremely vulnerable category, especially as our own generating capacity was falling off whilst our demand for energy rose. By 2020 it had been

estimated that Europe would have to replace 450GW of generating capacity. Put this against the more global problem of greater demand for energy from such countries as China and India and the problem became grave.

It was worrying, therefore, that although the government was now looking more favorably towards nuclear power to fill the gaps, it was still wedded to the view in the White Paper of 2003 of the need to focus on wind power, awarding huge subsidies to off shore wind farms to come to fruition by 2020. Even so this option had already been shored up with coal and now nuclear to meet demand. The Government now openly predicted that by 2017 there were going to be shortfalls and ensuing blackouts.

So how can the situation be alleviated? It was now agreed that nuclear power would play a crucial role. It would not only cut our greenhouse gas emissions but the new Generation 4 reactors used uranium 60 times more efficiently than today's reactors and there seemed no immediate problems with supplies of uranium. It took about ten years to get a station up and running, 45 months to construct it, the rest was down to problems over planning and certification. Just six nuclear reactors in Britain could protect us from foreign dependency. Looking further ahead thorium reactors were being developed in India and elsewhere. There were distinct advantages to this technology, but it was nothing like as well developed as uranium reactors. Pebble Bed reactors were under development in South Africa and China, and beyond that fusion power would probably come on line around 2040. Whatever nuclear option we developed it would have to be supported by other renewable energy sources. For instance the Severn Barrage scheme might at last become another economically viable tidal option. So a mix of new technologies would emerge. Britain should strengthen its connection with the EU grid network and help build cooperation throughout Europe. A secure and robust energy supply was essential, but the prospect of energy gaps in the future should be matter of deep concern to us all.

Points made in discussion:

- Getting a common EU energy policy could be a nightmare. Imagine getting France to agree with Austria. Euro licensing of reactors was a complex political problem.
- Gathering solar energy from a variety of prime sites was an engineering problem which had yet to be solved.
- The government was much concerned about proliferation and the need to avoid technologies which might facilitate it. Negotiations over and with Iran were a good illustration of current problems and dangers.

**Dr James Martin** said it was time for a new paradigm. The brightest people on the planet didn't seem to be able to put the whole picture together. China was still investing in dirty coal technology. Here in Britain we still did not have a clear distillation of the Government's strategic role. For years it had relied on market forces. This was no longer a viable strategy. There were many new technologies that would enable us to meet our carbon emission targets but the British government still seemed in a muddle. Elsewhere, energy choices were crucial if emission targets were to be met. With projected increases in demand from China and India more coherence and cooperation between countries was essential. The world needed to apply itself seriously to new technologies, for instance further development of solar power. In its present form it was crude compared to what it could be, if, for instance lenses were used to enhance performance and deserts were properly utilized. A mix of new renewable technologies should be used to accommodate small and large requirements.

Nuclear energy was the only clear and obvious option to fill the energy shortfall which was expected to hit in about 30 years' time. New generation reactors were being developed all over the planet. These had huge advantages over the old reactors. India was working on a thorium reactor, from which bombs could not be built. The nature and understanding of physics was changing exponentially for future generation reactors. All options were at least 10 years off production and some were not due to come on line for 40 years, but all would eventually contribute to a new generation of energy production. With the growing energy crisis and the likely impacts of climate change, the role of nuclear power was essential.

There were seven fission fusion technologies and all needed investment. This was a decision for the governments concerned, but also remained a global political one. At present, things were going in the wrong direction. Among the problems were continuing dependence on coal, excessive expectations of wind power, and failure to work out appropriate means of developing nuclear energy. Over all, this was the shadow of proliferation of nuclear materials and their possible misuse by such non-state actors as terrorists as well as governments. It was now all too easy to build atomic bombs. The possibilities of high tech warfare were alarming, with the advantage going

to those who struck first. However, war between high tech nations could not be allowed to happen. It would end civilization. Dr Martin went on to look at some of the technologies under development. In particular, pebble bed technology, and current work on it in China, South Africa and the United States.

Points made in discussion:

- Nuclear development was traditionally military based. It had been developed in secrecy and much of it during the cold war. In France, where the priority had since been for civil use, there was little secrecy. You could drive up to twenty meters of the perimeter fence, whereas in the United States everything was shrouded in security. Countries chose nuclear development with definite criteria in mind: some for energy power some for weapons.

**Professor Steven Cowley** spoke on fusion technology. The first question always asked about fusion was when would it be available? The answer had become a joke, because the answer was 'It's thirty years away. It always was, it always will be'. As the Director of the UK's Atomic Energy Authority's Culham Laboratory, whence Britain's fusion programme was run, he saw it as his job to dispel this age old joke. Much headway had been made over the last few decades. We now knew how to produce energy from jet plasma. The problem was how to control and sustain this energy effectively and indefinitely. To produce fusion reactions, the fuel gas was heated to temperatures in excess of 100 million degrees C, several times hotter than the sun. At these temperatures the gas became a plasma. Deuterium and tritium fused together at this high temperature to form helium and high energy neutrons. These high energy neutrons were then used to heat a blanket material surrounding the plasma. Deuterium and tritium were both heavy forms of hydrogen and as such extracted from water. Lithium was generated from a reaction with deuterium. In effect these two materials were inexhaustible.

Fusion was a long term technology, as much a benefit for social as for technological reasons. We needed a clean, safe and environmentally friendly source of power. It had no long-lived radioactive waste, it was an inherently safe reaction process, with no atmospheric pollution, and one kilogram of fusion fuel would produce the same amount of energy as 10,000,000 kilograms of fossil fuel. The future of fusion lay with the International Tokamak Experimental Reactor (ITER), an internationally funded reactor, which was being developed in Cadarache in the south of France. Culham was providing technical support and materials research for the development of ITER. Here was an important example of international technology transfer which should be paramount in our efforts to reduce greenhouse gas emissions while meeting rising energy demand.

**Professor Chris Grovenor** spoke about the supply of raw materials. The first thing to understand about materials was their enormous cost and in turn the enormous cost of building a reactor. It was made in small bits to keep the costs down and then welded together. But only very few companies had the kind of technologies needed to weld and bend these special materials. In this country, we had Sheffield Forgemasters who were good and went back to the old ship-building days, but Japan had a virtual monopoly on welding nowadays. Out of the possible five companies worldwide, only two could make the key forgings to the necessary specifications. This made for a long time lag in building a turbine. At the end of the process you got a turbine which looked as if it had been made by a hammer. Key components came from very far away. A worldwide effort was necessary to source and tool up a company with nuclear components. Once sourced, the most effective way of using them was to extend the life of an existing reactor. If you could extend the life of a reactor by 10 years it became cost effective in most instances. Nuclear steels were of such a rarefied specification and still relatively little understood, that if, for any reason, it got a crack in it, it was still difficult to understand how or why it happened. Individual defects made atoms move around. Materials research into prototype materials in which you could have confidence needed much further funding. Materials companies needed a long lead in time to develop their wares.

## Discussion/summing up

**Sir Crispin Tickell** briefly summed up what he thought had been a most interesting but inevitably inconclusive debate. It was now generally agreed that energy issues, and in particular nuclear issues, could not be subject to market forces alone. It was a question of how to fit market forces into a framework of the public interest, and that could only be determined by governments. The Nigel Lawson approach of the 1980s had been replaced by the Ed Miliband approach of 2009.

The questions we now had to ask ourselves were:

- how to fit nuclear policy into energy policy as a whole. That raised a host of other issues, including climate

change, the sustainability of our society as a and energy security both for Britain and for Europe as a whole

- how to devote the necessary resources to research, education and training of a new generation in the technologies discussed during the meeting
- last how to take good account of the Ps identified by Lady Judge at the beginning of the meeting: in short P for Price, P for People, P for Permits, P for Public Relations, and P for Proliferation. To this list should be added the vital question of disposal of wastes.

## **Biographical Notes of those present at this meeting**

### **Sir Crispin Tickell GCMG KCVO**

#### **Director of Policy Foresight Programme**

Sir Crispin Tickell was a career diplomat, which included being Permanent Secretary of the Overseas Development Administration (now department for International Development DFID), and Permanent Representative to the United Nations in New York. He has since been Warden of Green College Oxford, and Chairman of the Government Panel on Sustainable Development, with service on two Government Task Forces, one on Urban Regeneration, and the other on Potentially Hazardous Near Earth Objects. He was Chancellor of the University of Kent for ten years, a recent Senior Visiting Fellow at Harvard, and Global Environmental Advisor to the Arizona State University. He has a wide range of interests, from the environment to palaeohistory

### **Dr James Martin**

Dr James Martin provided both the vision and support required to establish the James Martin 21st Century School in 2005. He remains keenly engaged with the School's ambitions, and in March 2009 launched a new fundraising campaign for the School with a pledge of \$50 million in matched funding.

### **Dr Ian Goldin**

September 2006. Goldin was Vice President of the World Bank (2003-2006) and prior to that the Bank's Director of Development Policy (2001-2003). He served on the Bank's senior management team, and was directly responsible for its relationship with the UK and all other European, North American and developed countries. Goldin led the Bank's collaboration with the United Nations and other partners. As Director of Development Policy, Goldin played a pivotal role in the research and strategy agenda of the Bank.

### **Professor Sir Chris Llewellyn Smith FRS**

Chris Llewellyn Smith is a theoretical physicist. He Chairs the Council of ITER and the Consultative Committee for Euratom on Fusion, and is President of the Council of SESAME (Synchrotron-light for Experimental Science and its Applications in the Middle East), a Vice President of the Royal Society and a Visiting Professor in Oxford Physics. He was Director of UKAEA Culham (2003-2008), with responsibility for the UK's fusion programme, Provost and President of University College London (1999 - 2002), Director General of CERN (1994 - 1998, when the LHC was approved and started), and Chairman of Oxford Physics (1987 - 1992). He has written and spoken widely on science funding, international scientific collaboration and energy issues. His scientific contributions and leadership have been recognised by awards and honours in seven countries on three continents.

### **Lady Judge**

Lady Judge is Chairman of the UK Atomic Energy Authority and of the School of Oriental & African Studies. She is Deputy Chairman of Forte Energy NL and a non-executive director of Massey Energy, NV Bekaert SA and Magna International. She is Co-Chair of the UK/US Task Force for Corporate Governance and a Member of the Trilateral Commission, among others. Previously Barbara was appointed as Commissioner of the United States Securities & Exchange Commission. She has spoken extensively on the subjects of corporate governance and international accounting standards, and the decommissioning of nuclear power plants and the need for their continued construction

### **Mark Higson**

#### **Chief Executive, Office for Nuclear Development, Department of Energy and Climate Change**

Mark Higson is a professional administrator whose career has focused on competition and utility regulation, privatisation and the financing of state-owned enterprises. Prior to taking on the nuclear portfolio in September

2006, Mark was deputy CEO at the Shareholder Executive, the organisation responsible for discharging the shareholder role for Government owned businesses, with specific responsibility for Royal Mail, BNFL and UKAEA. He has worked as a regulator in Ofgas (now Ofgem); on a number of privatisations in the electricity and gas sectors; and, for a period, in investment banking at Kleinwort Benson.

### **Nick Low**

Nick Low leads the Foreign and Commonwealth Office team developing policy to reinforce the nuclear non-proliferation regime, in particular the Treaty on the Non-Proliferation of Nuclear Weapons, multilateral approaches to the nuclear fuel cycle and the International Atomic Energy Agency. He has previously worked in South America (Santiago de Chile and Brasília) and the Maghreb (Rabat and Algiers) covering a wide range of political, aid, economic, commercial and counter-terrorist work. Educated at Christ's College Cambridge, Bedford College London and a graduate of the Police Staff College Bramshill, Nick spent ten years policing inner London in a variety of uniform and CID roles before joining the FCO in 1993.

### **Professor Ian Fells CBE FRSE FREng**

#### **Principal Founder chairman of the New and Renewable Energy Centre (NaREC) Blyth 2003 to Sept 2005**

Ian Fells was educated at Trinity College Cambridge where he gained a PhD in reaction kinetics. He also spent time in the army on national service as chief wireless officer British Troops in Austria. After lecturing at Sheffield University he was appointed Reader in Fuel Science at The University of Durham in 1962. He has been Professor of Energy Conversion at The University of Newcastle since 1975 and has published some 250 papers on topics as varied as the chemical physics of combustion, fuel cells, rocket combustion, energy economics, environmental protection, energy conversion systems, and energy policy. He was elected fellow of The Royal Academy of Engineering in 1979, was president of The Institute of Energy for 1978/79 and was elected fellow of The Royal Society of Edinburgh in 1996. He was awarded a CBE in June 2000. He has made over 500 television and radio programmes and believes in improving the public understanding of science via the media. He also believes this to be a responsibility of all scientists and engineers. Ian Fells was a science advisor to The World Energy Council (1987 to 1998), has been special adviser to The House of Lords Select Committee on The European Community dealing with energy and the environment and the House of Commons select committee for Trade & Industry & Environment. He has been Energy Adviser to the EC and European Parliament and has advised a number of foreign governments on energy policy. In 1993 he was awarded the Michael Faraday medal and prize by the Royal Society. His recreations are listed in Who's Who as sailing, cross country skiing and "energy conver

### **Professor Steven C. Cowley**

Professor Steven Cowley became Director of the United Kingdom Atomic Energy Authority's Culham Laboratory in September 2008. He received his BA from Oxford University and his PhD. from Princeton University. Professor Cowley's post-doctoral work was at Culham laboratory and he returned to Princeton in 1987. He joined the faculty at the University of California Los Angeles in 1993 rising to the rank of Full Professor in 2000. From 2001 to 2003 he lead the plasma physics group at Imperial College London. He remains a part time professor at Imperial College. From 2004 to 2008 he was the Director of the Center for Multi-scale Plasma Dynamics at UCLA. His main research interests are: the theory of fusion plasmas, the origin of magnetic fields in the universe, the theory of plasma turbulence and explosive behaviour in both laboratory and astrophysical plasmas. He has published over 120 papers and articles. Professor Cowley co-chaired the US National Academy's decadal assessment of, and outlook for plasma science: Plasma Science: Advancing Knowledge in the National Interest (National Academy Press 2007). He is a Fellow of the American Physical Society and the Institute of Physics.

### **Professor Hamid Aït Abderrahim**

Prof. Dr. Hamid Aït Abderrahim is director of the Advanced Nuclear Systems at SCK CEN, the Belgian Nuclear Research Centre. He is professor of reactor physics at the "Université Catholique de Louvain" (UCL) at the mechanical engineering department of the "Ecole Polytechnique de Louvain (EPL)". Since 1998, he is the director of the MYRRHA project, an accelerator driven system coupling a sub-critical Pb-Bi cooled reactor and a high power proton accelerator through a spallation target. He is partner or coordinator of various projects of the European Commission framework programme related to advanced nuclear systems or to partitioning and transmutation of high level nuclear waste management. He is presently the chairman of the Strategic Research Agenda (SRA) working group of the European Sustainable Nuclear Energy Technology Platform (SNETP, [www.snetp.eu](http://www.snetp.eu)) initiated in September 2007.

### **Ian Hore-Lacy B.Sc.(hons), M.Sc.**

Ian Hore-Lacy is Director for Public Communications with the World Nuclear Association, an international trade

association based in London. His function is primarily focused on public information on nuclear power via the Web. He is author of *Nuclear Electricity*, the eighth edition of which has been published by Elsevier and World Nuclear University as *Nuclear Energy in the 21st Century*. His particular interests range from the technical to the ethical and theological aspects of mineral resources and their use, especially nuclear power. He has written several books on mining, environmental, economic and related issues, the latest being *Responsible Dominion - a Christian approach to Sustainable Development*, published in 2006 by Regent College Press.

### **Dr. Jerome R. Ravetz**

Dr. Jerome R. Ravetz is a leading authority on the social and methodological problems of contemporary science. With Silvio Funtowicz he created the NUSAP notational system for assessing the uncertainty and quality of scientific information, and also the concept of Post-Normal Science, relevant when 'facts are uncertain, values in dispute, stakes high and decisions urgent'. His earlier seminal work *Scientific Knowledge and its Social Problems* (Oxford U.P. 1971, Transaction 1996) now has a smaller sequel, *The No-Nonsense Guide to Science* (New Internationalist 2006). His other publications include a collection of essays, *The Merger of Knowledge with Power* (Mansell 1990).

### **Mark Lynas**

Mark Lynas has worked for nearly a decade as a specialist on climate change, and is author of three books on the subject – 'High Tide: News from a warming world' (2004), 'Carbon Calculator' (2007) and 'Six Degrees: Our future on a hotter planet' (2007). *High Tide* was longlisted for the Samuel Johnson Award for Non-Fiction, and short-listed for the Guardian First Book Award. It became a best-seller in Sweden. *Six Degrees* was long-listed for the Orwell Prize in 2008, and won the prestigious Royal Society Prize for Science Books in the same year. *Six Degrees* is published in the US by National Geographic, which has also made a television documentary based on the book and broadcast on the National Geographic channel internationally. Lynas was selected as a National Geographic 'Emerging Explorer' in 2006, and was placed at no.7 in the Independent's Green List 2007. He writes for various newspapers and magazines, recently including the Guardian and the Independent, and is a frequent contributor to the New Statesman.

### **Professor David Cope**

#### **Director, Parliamentary Office of Science and Technology, Houses of Parliament**

David Cope is a graduate of Cambridge University and the London School of Economics. He is a Life Member of Clare Hall, Cambridge University's international postgraduate college. His academic career began with an innovative 'interdisciplinary' lectureship at Nottingham University, teaching in departments ranging from Engineering to Theology, in particular, the first university courses in 'Futures Studies' in the UK. Here he developed a strong interest in energy policy. In 1981, he joined the International Energy Agency as environmental team leader. In 1986, he returned to the UK and to Cambridge as the Executive Director of the UK Centre for Economic and Environmental Development, a charitable research institute. An early piece of work there involved him being the independent non-industry member of the official committee that examined the implications of the 1986 Chernobyl incident for the UK. In 1997, he became Professor of Energy and Resource Economics at Doshisha University in Kyoto; Japan's second oldest private university. Plans for an extended stay in Japan were however, revised when he was offered his current position as Director of the Parliamentary Office of Science and Technology (POST) at the Houses of Parliament. David is a trustee of the Canada-UK Colloquia, the Great Britain Sasakawa Foundation and the International Polar Foundation, UK. He is an Academician of the Academy of Social Sciences and a Fellow of the Energy Institute and the Royal Geographical Society.

### **Oliver Morton**

Oliver Morton is a writer and editor who concentrates on scientific and technological change and their effects. He has written for, among others, the New York Times, the New Yorker, the Financial Times, Wired, Science, Nature and The Economist. He is currently on a sabbatical between jobs at Nature, where he was Chief News and Features Editor, and The Economist, where he will be Energy and Environment Editor. His most recent book is *Eating the Sun: How Plants Power the Planet*. He is currently working on a book about geoeengineering to be published in late 2010.

### **Chris Goodall**

Chris Goodall is a writer and commentator on energy and climate change and has written three recent books on the subject. He tries rigorously to quantify the costs and benefits of emissions reductions. He writes for the Guardian Environment Network at [www.carboncommentary.com](http://www.carboncommentary.com) Most recently, he compiled the Guardian's material on ways in which individuals could reliably reduce their emissions by 10% for the 10:10 campaign.

Earlier this year Mark Lynas and he wrote in the Independent that the severity of the climate problem meant that environmentalists should rethink their opposition to nuclear power. He has an MBA from Harvard Business School, and he briefly taught economics at Harvard University.'

### **Mike Ullman**

Entrepreneur & industrialist; affiliate professor of Entrepreneurship INSEAD, 1987-2005.

### **Dr James Marrow**

Dr James Marrow is Director of the Materials Performance Centre (MPC) at the University of Manchester. This is an interdisciplinary centre for training and research in nuclear materials science and engineering, addressing issues across decommissioning, aging plant management, new build and Generation IV reactors. The MPC works closely with academia and key nuclear stakeholders in the UK, Europe, and further afield. Dr Marrow is a material scientist, with interests in degradation mechanisms of nuclear materials such as stress corrosion, fatigue and brittle fracture. He studied at Cambridge, Oxford and Birmingham, and leads a wide-ranging research program at Manchester.

### **Dr Chris Grovenor**

Chris Grovenor is Professor of Materials and currently Head of the Oxford Materials Department. He has an MA and D.Phil. from Oxford and worked for IBM for a time in the 1980s before returning to Oxford first as a Royal Society Warren Research Fellow and then as a Lecturer. His research interests are broadly in the development of analytical techniques for the study of materials structure and chemistry, and the application of these techniques to developing a better understanding of key problems in engineering materials. The systems on which he has worked include semiconducting materials, superconductors and most recently the metallic alloys that form the critical components of nuclear plant. He has published more than 200 papers in these areas, is on the editorial board of 2 major journals in functional materials and acts as an external member of the technical assessment panels of the science foundations of 3 EU countries.

### **Susan Lee**

#### **Programme Manager, Policy Foresight Programme, part of the 21st Century School, University of Oxford**

Susan Lee has been Sir Crispin Tickell's Personal Secretary since 1997. She was also secretary to the Green College Centre for Environmental Policy and Understanding at Green College Oxford, before becoming the Programme Manager of the Policy Foresight Programme at the James Martin 21st Century School, University of Oxford. She continues to be Sir Crispin's Personal Secretary.

*Report produced by Susan Lee, October 2009*