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THE FOUNDATION FOR SCIENCE AND TECHNOLOGY

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US confuses Kyoto talks

The Foundation's dinner/discussion on 31 January 2001 (see pp. 9–13) was timed to precede a special (or "emergency") meeting of the "Conference of the Parties" of the UN Framework Convention on Climate Change, duly held at Bonn from 16 to 28 July.

The expectation was that the meeting would complete negotiations on the Kyoto Protocol, by which developed countries (as defined in the protocol) would assume specific obligations to reduce the emission of greenhouse gases. This was business left unfinished by the earlier meeting ("COP-6") at The Hague (13–24 November 2000). The dinner/discussion meeting followed by a few days the inauguration of George W. Bush as President of the United States.

US dissent

On 14 March, President Bush announced that the restraints required of the United States by the Kyoto Protocol would not be in the economic interests of the United States, especially at a time of energy shortages (such as those in California early in the year). At the same time, he declared that he would not send the protocol to the US Senate for ratification unless it were amended to require restraints in the emission of greenhouse gases from developing as well as developed countries. Instead, the US administration said that it would seek other means than physical restraints for dealing with the threat of climate change.

Although the United States signed the Kyoto Protocol in November 2000, ratification would require a two-thirds majority in the US Senate, which last year voted for a resolution repudiating the Kyoto Protocol unless developing countries were also restrained. The protocol would be legally binding only if developed countries responsible for 55 per cent of their collective emissions had ratified (see Michael Grubb, page 10).

Reaction to the US move was swift and outspoken. In the UK, the British Environment minister Mr Michael Meacher (see page 9) said, "This is not just an environmental issue, but is an issue of transatlantic global foreign policy". The Environment Commissioner of the EU, Ms Margot Wallstroem, said, "this is about international relationships, trade and economics".

Problems for Bonn

The meeting arranged at Bonn for 16 July 2001 duly took place, as reported by Michael Grubb on page 13. It reached political agreement on the outstanding technical and political issues arising from the protocol, which is to be given legal form at "COP-7", arranged at Marakesch, Morocco, in late October this year. Despite the US repudiation of the protocol, representatives of Canada, the European Union, Japan and Russia are reported to have stated at Bonn that their governments would aim to ratify the protocol next year, in time for the "Earth Summit" to be held in Johannesburg in September 2002.

On the face of things, that would account for the 55 per cent of developed-country emissions required to give the protocol legal force even without US adherence. But promises to "aim to ratify" may not be converted into action.

IPCC assessment

Meanwhile, the "third assessment" by the Intergovernmental Panel on Climate Change (IPCC), Climate Change 2001, was published in July 2001 (CUP, Cambridge; 3 volumes, £104.85). Headlines were captured by the prediction in the report that the average temperature at the end of the century may be as much as 5.8 °C greater than in 1990, but that is based on a scenario for the future emission of greenhouse gases that assumes the continuation of economic growth at present rates and the stabilisation of world population by mid-century.

The first of the three volumes (the scientific basis) is the report of "Working Group I" of IPCC, and differs from its two predecessors by including more searching attempts to assess the accuracy, or at least the consistency, of the computer models on which its climate projections are based. In one experiment in which several computer models were used to predict the temperature at the end of this century (on the assumption of continued rapid economic growth), the predicted increase of temperature in 2100 ranged from 1 °C to more than 5 °C.

The report acknowledges that this scatter may represent systemic bias in some models, the difficulty of setting the initial conditions for the long-term integrations the models carry out or the simplifications required to make climate modelling manageable. Two of these, cited in the report, are coarse scale on which the surface of the Earth is represented in the models (which explains why the regional pattern of climate change is not yet accurately predicted) and the neglect of real clouds in the models.

Summaries for Policymakers (SPM) and Technical Summaries (TS) for the three voumes of the " *IPCC Third Assessment Report — Climate Change 2001*" can be downloaded from IPCC's home page (www.ipcc.ch).

Dear Sir...

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Useful climate links

Global Environment Facility (GEF)	http://www.gefweb.org/
Linkages by International Institute for Sustainable Development (IISD)	http://www.iisd.ca/
IPCC Data Distribution Centre	http://www.ipcc-nggip.iges.or.jp/
IPCC National Greenhouse Gas Inventories Programme	http://www.ipcc-nggip.iges.or.jp/
IPCC Working Group I	http://www.meto.gov.uk/sec5/CR_div/ipcc/wg1/
IPCC Working Group II	http://www.usgcrp.gov/ipcc/
IPCC Working Group III	http://www.rivm.nl/env/int/ipcc/
United Nations Convention to Combat Desertification	http://www.unccd.int/main.php
United Nations Environment Programme, Geneva (UNEP) & Nairobi	http://www.unep.ch/ & http://www.unep.org/
United Nations Framework Convention on Climate Change (UNFCCC)	http://www.unfccc.de/
World Meteorological Organization (WMO)	http://www.wmo.ch
CO2 Science Magazine (weekly review of the latest research)	http://www.co2science.org/

Solly Zuckerman: fountainhead of post-war science advice

by The Rt Hon The Lord Peyton of Yeovil

The Role of the Chief Scientific Adviser

At a meeting held at the Royal Society on Tuesday 26 June 2001, Lord Peyton of Yeovil talked about the role of Sir Solly Zuckerman in establishing the post of Chief Scientific Adviser to the British Government. Professor Sir William Stewart described his experiences in the post in the early 1990s in relation to the development of government/science relationships. And the current incumbent, Professor David King, outlined his role and his priorities. Extracts from a note of a workshop and the general discussion that followed, taken by Sir Geoffrey Chipperfield, accompany the text.

Lord Peyton was MP for Yeovil from 1951 to 1983, and served as parliamentary secretary to the Minister of Power, as Minister of Transport and Minister of Transport Industries. He was elevated to the House of Lords in 1983. He is author of the biography "*Solly Zuckerman*" (ISBN 071956283X, John Murray, London) published earlier this year.

Solly Zuckerman possessed a rare panoply of talent, a powerful mind, a storehouse of a memory, phenomenal energy and, when he cared to use it, huge charm. Without that, he would never have made the long journey from unknown Jewish immigrant to Chief Scientific Adviser (CSA), a peerage and membership of the Order of Merit.

He also had a distaste for the boundaries and partitions that we in this country tend to cherish. To him it was wrong that, in education and in government, science should be railed off from the humanities and its own disciplines arbitrarily separated. In education, it was important that students should know what was going on next door; that in research, the lines between the scientific, the technical and the administrative should not be so prominent as to inhibit a feeling of unity in the team he led. It was the breadth of his own science and the ease with which he moved between disciplines, careers and countries, and from war to peace, that gave his advice its unique value.

He was born in Cape Town in 1904; his father was a not very successful furniture and hardware merchant, his mother an overpowering taskmaster. His siblings, three sisters and a brother, were not of his stature. Aware that his family could not help and might hinder him, in 1926 he left both them and his country without any sign of regret. While his mind was focused on England, where, he wrote, "there were great things waiting to be savoured", he still retained the imprint of time spent, often alone, in the veldt of Cape Province, studying and becoming fascinated by the creatures living there. A degree in zoology, a paper on the development of the skull of the baboon and a hundred gold sovereigns were the principal items in his baggage.

Skill in judging people enabled Solly to measure not only their ability but also what they could do for him. Sir Grafton Elliot Smith, Head of University College Medical School, and Julian Huxley, Secretary of the Zoological Society of London, together gave him a splendid start. Huxley obtained for him appointment as the Society's Prosector [the London Zoo's in-house pathologist] and later introduced him to the wider world of science.

By the time that war broke out in 1939, Solly held a Research Fellowship in anatomy at Oxford. His first tasks were heaping sandbags around the windows of laboratories and, as a qualified doctor, pushing undergraduates through their army medical examinations. "Make sure they all pass, unless they have flat feet" were his instructions.

Chance

There never was in Solly's life even the vestige of a plan. His life is the outcome of the interplay of his own qualities with chance. Without some outline of events, the question, how on earth did he come to wield the influence he did, would be unanswered. Because he had some monkeys, he was invited by J. D. Bernal to join him on a study of blast, of which surprisingly little was known. A detailed examination of the effects of a bomb dropped on Banbury station meant that he knew something that others did not. A survey by the so-called Oxford Extra-Mural Unit, set up and managed by him, of a hundred separate bombing incidents and his report on them established him as an expert. His inquiry, at the behest of Lord Cherwell, into the effects of German bombing of Birmingham and Hull did not enable him to endorse the latter's strongly held view that Bomber Command's strategy of attacking Germany's towns and cities could on its own bring the war to an end. That report further strengthened his reputation as someone with exceptional knowledge of the effects of bombing.

That led to his being sent, early in 1943, to the Middle East to examine the bombing strategy of the Desert Air Force. In Algiers in March he met Air Chief Marshal Tedder, then commanding Allied Air Forces in the Mediterranean. It was the beginning of a momentous partnership. Solly remained with Tedder in Sicily and Italy, advising on the choice of bombing targets. He learned how important were rail communications to embattled armies and how vulnerable they were to air attack.

With that in mind, Solly insisted, in his advice prior to Overlord [the Allied plan for the invasion of Europe in 1944] that success required the paralysis of the rail network in northern France. Without that, Germany would be able to reinforce against a landing far more quickly than the Allies, dependent on sea communications and without port facilities, could support it. After weeks of intense argument, Solly's

advice prevailed. The subsequent activities of the Strategic Air Forces reduced rail traffic to a trickle. In the event, Overlord was a close-run thing; without Solly's advocacy of his bombing policy, the outcome might well have been different.

The return of peace faced Solly with a dilemma. Although he wanted to go back to academic life and the chair of anatomy at Birmingham was offered to him, his wartime experience had given him a taste for being near to the centre of activity. In the early post-war years a legion of committees, busy measuring Britain's decline and searching for ways of lessening the pain, offered obvious openings for people with enquiring minds. The generosity of the university in allowing him to divide his time between Birmingham and Whitehall freed him to embark upon what turned out to be a fourteen-year apprenticeship in the ways of governments — he called it "a stimulating tutorial". Without it, he would never have been able — or invited – to cross the gulf between academic scientist and top-level Civil Servant.

Appointed as CSA to the Ministry of Defence in 1960, he was faced immediately with the problems of supplying the services and the spiralling costs of military R & D. He also encountered the field of nuclear weapons for the first time. He reflected on the devastation of Hiroshima and Nagasaki by the first two atomic bombs and the headlong rush to produce weapons of vastly increased destructive power and to add, as he thought, pointlessly to their numbers. He saw the need to end the testing of weapons, both in the atmosphere and underground. He recognised the perils of proliferation. He considered NATO's strategy, defined by the Supreme Commander in terms; "if we are attacked, we shall respond with everything we have". He learned from "war games" that he organised something of the casualties and destruction that would follow a megaton explosion over a major city.

Nuclear strategy

Such thoughts led him to conclude that the use of nuclear weapons in war would involve catastrophic consequences for the human race; that there would be no winners. That a single warhead could, with rocket propulsion, be delivered to any target on Earth, and that there could be no defence. The use of tactical nuclear weapons on the battlefield would make no sense; not only would escalation surely follow, but they would at once knock out the sensitive communications on which commanders relied. Such was the message — a "shock-piece", Mountbatten called it — that Solly delivered to NATO's annual conference in 1961. It marked the beginning of a more thoughtful approach.

preliminary points

David King and Sir William Stewart attended a workshop before the dinner/discussion at which they discussed with an experienced group the problems facing the Chief Scientific Adviser (CSA). The discussion focused on four topics:

Transparency. This is key to developing public confidence in science. The Food Standards Agency has shown how it can be done. But there are limits, security being one. Ministers are unlikely to free with information disadvantageous to them. And civil servants, aware of ministers' political concerns, are cautious. Their advice to ministers will remain confidential (the impending Freedom of Information Act notwithstanding).

Scientists in Government. Outsourcing and the privatisation of government laboratories has caused many scientists to leave public service. The prime tasks now include accessing the best scientific advice, wherever it is to be found, and interpreting objectively that advice to ministers and to the public. The CSA must ensure that advice presented to ministers is not biased to suit policy objectives.

Departmentalisation. Individual ministers have always had different and conflicting objectives and priorities. This can be good (creative tension) and bad (failure to pass information, unwillingness to co-operate). The Cabinet Office and the CSA have a crucial role in seeing that, where problems covered several departments, the bad effects were minimised and genuine co-operation took place. It is also important to recognise policy gaps where no department was taking a lead.

Articulating the need for science. The CSA needs to ensure that government, industry and academia work together to increase the supply and quality of scientists; the recognition of their value to society; and public understanding of scientific methodology. But the danger in being a "cheer-leader" for science is to appear arrogant, and to undervalue non-scientific values strongly held by the public.

Relations between advisers and those whom they advise tend with time to become brittle. Solly's relations with Denis Healey, as Secretary of State for Defence, did indeed suffer. His dual role as CSA to the ministry and, with a lower profile, adviser to the Prime Minister, was bound in the long run to cause difficulties. His consequent removal to the Cabinet Office, as CSA to the Government, had the sound of promotion. It took him into a more rare atmosphere, in which problems, such as those concerning the environment, were less well defined and more open to question. Seen therefore as less urgent, they were not accorded the priority they deserved and which the support of a major department might have secured.

In the early 1960s, Solly suggested that if the recently established University of East Anglia wished to do something really new in science, it should create a School of Environmental Sciences. In forty years the School has made great progress; it has realised and gone beyond Solly's original vision. It faces now the task of bringing to non-scientists some understanding of what has been learned and an awareness of the complex problems that lie ahead.

Not long before they both died, Solly's daughter, Stella, wrote that her father had been "wrong in his insularity… if he had bothered to put his views across more simply and more directly to a much wider and more general audience, the world would have been a richer place for it". Isidor Rabi, sometime Head of Physics at Columbia, whom Solly admired as much as any other in his life, thought on similar lines. "Whereas", he said, "the scientist can listen with pleasure to the philosopher, the historian or the literary man… this channel of communication is often a one way street."

Solly's story gives rise to many questions. Here are three:

- Does the place accorded to science in education and in government adequately reflect its contribution to human progress?
- Should a Government Scientist be an adviser or an expert?
- Are Government scientists sufficiently aware of the "political realities" and of the narrow horizons within which politicians are increasingly confined — or, if you prefer it phrased this way, "to which politicians habitually retreat for shelter?" ❐

Protecting the science base and fighting unexpected fires

by Sir William Stewart, FRS, PRSE

Sir William Stewart served as a Chief Scientific Adviser to the government from 1990 to 1995. During his tenure the post was moved from the Cabinet Office to the Department of Trade and Industry. Prior to becoming the CSA, Sir William was Chief Executive of the Agriculture and Food Research Council from 1988 to 1990. He is now President of the Royal Society of Edinburgh.

When I came to the Cabinet Office in 1990, the times were less troubled scientifically if not politically than in Lord Zuckerman's heyday. I decided that the most important need was to seek a good rapport with the Prime Minister and yet to be my own man. I worked with two Prime Ministers, Margaret Thatcher and John Major, and with two Chancellors of the Duchy of Lancaster, William Waldegrave and John Hunt.

So what, in my time, was the role of the Chief Scientific Adviser (CSA)? There are five main functions. First, the CSA is a guardian of the science base, in which role the Director General of the Research Councils is also hugely important. Second, the CSA must strengthen science and technology across government. Third, there are innumerable issues of the moment to be dealt with. Fourth is the task of coordinating transdepartmental activities and representation, notably overseas. Finally, the CSA must develop, address and bring to the Prime Minister's attention broad strategic issues of importance to the nation.

How to protect basic science? At the apex of government, that is not an easy task. To my mind, there are two lines to take. One is to defend basic science as a foundation of our economic future; John Major accepted that. The other is to defend outstanding science irrespective of discipline or subject-area as part of our culture and our heritage, by which Mrs (now Lady) Thatcher was attracted.

The second role is to seek to strengthen science and technology input across Government. We had some success. The setting up of the Office of Science and Technology was an important development. Giving responsibility for science to a Cabinet Minister, the Chancellor of the Duchy of Lancaster, was a huge step forward.

Dealing with the innumerable issues of the moment is a bewildering and often distracting task. In my time, there were urgent issues such as salmonella in eggs, Ariane rockets blowing up on lift-off, funding for the Large Hadron Collider being built at Geneva, innumerable EU research council matters, official press-releases that had caused problems, ministerial indiscretions at Party Conferences (we lost a junior minister that way), difficult Parliamentary Questions and fusses caused by the pressure group Save British Science (usually helpful). A CSA needs what I suppose would nowadays be called a rapid response capability.

The role of the CSA in departmental coordination and in representation is a less tangible responsibility. Representation was easy, I found. I joined the Prime Minister on visits abroad to Japan, the Middle East and South Africa. When we met the Emperor and the Prime Minister of Japan, I was accorded a place of some prominence. When the Prime Minister went off to talk politics, I had dialogues with the scientific leaders to encourage scientific and industrial collaboration. But when such meetings took place in the UK, the CSA was definitely below the salt.

Transdepartmental coordination was much more difficult, and for several reasons. First, the Prime Minister is invariably busy and ministers like to tell him good things themselves; they call in the CSA only when bad things come along, such as foot and mouth. Second, departmental ministers have their own priorities and, importantly, many of them are driven by personal ambition. (Are there not always lots of former or future Prime Ministers about?) Third, officials rightly support their ministers. And then departments want to contain their own problems, keep a hat on them; the more people who know, the more likely are leaks. All that, I think, is perfectly understandable, it's human nature.

In my time, government departments were compartmentalised and that, I believe, persists. Today, there is much talk of open government. I think that it is a myth, that it just won't come about.

Here's an example to show that they are still at it. I recently chaired a group on mobile phones and health; the report was published in May 2000. It was a good report, I think; it was well received and perceived by the public to be independent. Our remit was to consider all aspects of mobile phones and health. We had observers from the Department of Health, and from the Department of Trade and Industry and the secretariat was from the National Radiological Protection Board. At every meeting, I asked everyone if they had any issues that they felt should be

raised. Yet not a single official mentioned the imminent introduction of TETRAC by the Home Office and the involvement of the Ministry of Defence with that project, although my committee recommended on health grounds that the radio-frequencies employed by TETRAC should not be used. Did officials know and keep quiet? Or was it a lack of joined-up government? I don't know.

That leads me to the last and, I believe, the most important role of the CSA: the need to address broad strategic issues of importance to the nation: scanning the horizon, not tinkering at the edges. I believe that, when I was CSA, we did address some of these issues. One result was, for example, the setting up of OST, another was the decision to publish a White Paper on Science, Engineering and Technology — the first ever. There was also the decision to engage in a technology foresight exercise, "Progress through Partnership", emphasising the need to couple academia and industry. These, I felt, were the kinds of issues with which the CSA should be engaged.

To conclude, I will make a few general points and give an example off an important issue that needs attention.

My first general point is that what causes crises for governments is the unexpected, when they are caught off guard. BSE is an example. I first heard of BSE when I was Secretary of the Agricultural and Food Research Council; Lord Selborne was its Chairman, and we were not told what was going on. When the question was raised at an council meeting, MAFF observers told us that BSE was an animal health issue, that MAFF had responsibility for animal health and that it was under control. There were even suggestions that at Weybridge they might get a Nobel Prize for their discovery of the disease. The rest is history, is it not? Lord Justice Phillips's report is available, there will be no more stuffing hamburgers down little daughter's throats.

Second, what causes problems for governments is unpreparedness. Here we go again, perhaps with foot and mouth disease. Actions that worked in the 1960s have been simply reapplied without appreciating that motorways now criss-cross Britain and that global transport is the norm. I remember speaking to the head of a very large supermarket chain who said, "I don't care where in the world I get my food from, so long as it can be loaded quickly on to a plane at the other end and delivered quickly in the UK". And then there is the vaccination controversy: I will note only that the Department of Health does a pretty good job in using vaccines to control human disease.

discussion

Man/womanpower problems. In the general discussion concern that was expressed about the number and quality of good scientists (not only in government service, but also in the population). Certain obvious problems, such as the small number of women in senior scientific posts, need to be addressed urgently. But what can be done to provide incentives and an adequate career structure in government for able scientists?

Moreover, how can we persuade scientists, who do not intend to have a career in government, but would be more valuable in national life if they understood how government worked, to spend some time inside government learning about it? Professor King made it clear that he considers all these points as falling within the scope of his post.

It is essential that the talents of the female half of the workforce are better utilised and recognised. The problem goes back to attitudes in schools (and Professor King sees science education as a priority); time might partly rectify the imbalance, but pressure nees to be kept up.

The excitement of working on large and difficult problems should encourage able scientists to enter government service; against that, however, is the fact that scientists come out of universities wanting to work in the centre of their discipline, whereas the essence of many of the most difficult issues faced by government overlaps, or ia at the edge of, discrete disciplines. Providing a satisfying career in the absence of major laboratories is difficult; more flexible arrangements for moving in and out of government work might be needed.

My third point is that we are in a new era of scientific advice. The advice now required is increasingly in the biological arena and, because of the general complexity of biological systems, it is much more difficult to be certain. In future, more emphasis will rightly be put on a precautionary approach as in our mobile 'phones report.

My last point is about the big issues on the horizon. What shall we be looking at in five, ten or more years? Different people have different opinions, of course, and I have thought more than twice before deciding to mention what I am going to mention. But what about biological weapons? Foot and mouth has shown how an infectious disease can sweep through a population. If foot and mouth were a human disease, culling would not be an option — or would it be?

In 1918, Spanish 'flu killed 20 million people in six months, more than the whole of World War II. Microbes cause problems, yet SmithKline Beecham, before it amalgamated with Glaxo, shut down its microbiological research base in the UK, transferring it to the United States. Roche is now doing the same. Where does that leave us? This is an issue we are not supposed to talk about. The Royal Society report on measures for controlling the threat from biological weapons said "the threat… must be taken seriously, but it is equally important not to cause undue alarm by exaggerating it". How, one might reasonably ask, could it be exaggerated?

Cynically, one might hope that the foot and mouth outbreak has brought the benefit of putting the Ministry of Defence on alert. But we know from the published literature that biological weapons exist, that over two dozen potential agents are known and that Iraq has manufactured some of them. It is easier to produce biological weapons than to access nuclear or laser technologies. And while the offensive use of biological weapons is forbidden, we also know that the United States is expanding its defensive capability. Are we, in the UK, naive enough to believe that the advances in genetic manipulation will be limited by rogue states to civil applications?

That is a question we should be thinking about. Let us hope we shall not be looking back regretfully in 10 years and asking, "did we adequately prepare ourselves?" It is 12 years since BSE came on the horizon, yet where are we today? These are the kinds of issues that the Chief Scientific Adviser will have to mull over and grapple with in seeking to make a difference. I wish Professor King, my successor-but-one, every success in a really interesting job. ❐

The Chief Scientific Adviser's role

by Professor David King ScD FRS

Professor King is the Chief Scientific Adviser at the Office of Science and Technology in the Department of Trade and Industry.

He is head of the Department of Chemistry at Cambridge University and Master of Downing College.

The role of the CSA has developed over time. Its base now is the Office of Science and Technology (OST), with its 170 staff. A major responsibility is to support the UK's science and engineering base, which is essentially run by the Director General of the Research Councils, John Taylor. There are separate sections concerned with science in government, the Link Scheme, Foresight and international relations. I will deal briefly with the science and engineering base. This is, of course, an essential function, but we must be clear why we offer this support, chiefly through the research councils. Wealth creation through research appeals to governments. The contribution of science and engineering to our culture is why most of us are scientists. But at present health and the environment are very high on the list as well.

The science budget is now approaching £2 billion a year and is set to grow over the next few years at 7 per cent a year in real terms; if that continued, the science budget would double in 10 years. Would that be a welcome development? My answer would be "yes": the science budget has been pared down for 20 years and it is time it grew again. But past restraints have not been entirely negative in their effects. They have produced an extremely efficient machine and above all, there has been an important cultural change.

The government is prepared to fund a 7 per cent increase because it regards the science base as a worthwhile investment. One sign that that is so is the cultural change I mentioned, particularly the strong links with industry that have developed in the past 20 years. Once we had ivory towers; now, at almost every university in the country, we have science parks that are generating intense excitement as well as wealth.

The UK has many strengths in science. There is, for example, my own field in the physical chemical sciences. But at the top of most people's lists would be molecular biology, which was effectively invented in this country and in which there has been a massive investment over the years. That is now beginning to pay returns in the form of the nascent biotechnology industry.

Of course, that industry is not problem-free. For example, genetically engineered foodstuffs and animals raise real ethical questions that must be answered. My position is that we should accept the notion of a proper debate involving all the stakeholders in society. As scientists, we develop enormous enthusiasm for our research. We also like to think we are objective. The truth is that we are objective in the manner in which we do research, but we are not objective in the way we sell our research to other people. That is where the dangers lie.

We need proper discussions with all people concerned, including consumers of the products of new technologies, foodstuffs such as GMOs, for example. Consumers must be recognised as having a legitimate voice. If the consumer says, "Why should I eat this genetically modified potato when I have the alternative of a potato that I have eaten and my forefathers have eaten for years and which is clearly safe? Why should I take an unknown risk by eating this potato that you wish on me?" That is a very good question. Until we have good answers to such questions, we have to proceed with the precautionary principle in mind.

Molecular biology is one strong area of UK research, but there are many more and we shall develop others. What we are now seeing is the transformation of some of these areas into new technologies and industries. That inevitably generates new problems. Because of the investments in the underpinning research, of course, governments are keen to see these nascent industries flourish. But that is possible only in an environment that looks critically at their products.

I turn now to the key issues facing the CSA. Many of those which I have faced in recent months are not very different from those Solly Zuckerman raised many years ago. They include matters such as the need for new energy resources, climate change through the use of fossil fuels, the environment and transport. Each of these issues

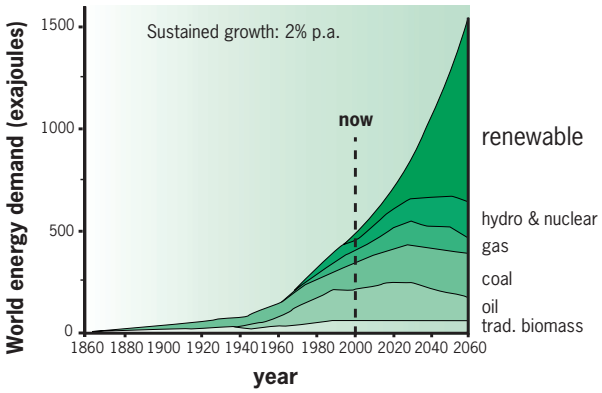


Fig 1 **Predictions for energy supply assuming annual economic growth of 2%.**

cuts across government departments; the CSA has the task of seeing that the gaps between departments are bridged.

Energy is a good illustration. The Department of Trade and Industry (DTI) has prime responsibility for dealing with the energy industries, but energy is also an environmental issue, while transport and energy are also linked.

We are now very keen to develop energy-supply scenarios. In a simple but fairly realistic way, Figure 1 is a graph of world energy demand based on assumed economic growth of 2 per cent a year between now and 2060. You may quibble with the details, especially in the extrapolation beyond the present (which takes no account of concerns about climate change). The contributions of coal, oil and gas are based simply on known supplies. What the graph means is that if we keep to the projected growth of energy demand worldwide, then the relative contributions of fossil fuels will begin to diminish. At the same time, the big green area labelled "renewables" is going to have to come into play. I stress that this conclusion is not based on climate change, which has to be factored in on top.

I would like briefly to deal with the question Lord Peyton asked at the end of his talk about the handling of international issues. The inter-governmental panel on climate change (IPCC) has developed into a substantial and influential body. It is driven by scientists concerned to do good science, but also by the understanding that they are dealing with an issue of worldwide importance. It has been cautious in its statements, which has meant that governments believe what it is saying. Its message is that the increase in global surface temperature, recent and projected, is essentially driven by fossil fuel consumption. IPCC seems one model for a mechanism for dealing with other problems with international dimensions.

One immediate lesson from IPCC's work so far is that we have to work hard on alternative sources of energy. But we also need many more details of the likely course of climate change. At present, projections of global temperature or sea-level carry very large error-bars. We need to inform governments more accurately about the course of climate change, which will require much more effort. If we were able more accurately to predict the secondary effects of global warming — the frequency or severity of storms, for example — the predictions would command greater confidence and governments would be better able to respond. That will also require more research.

I conclude with some direct observations on the role of the CSA. I was bequeathed by my predecessor, Bob May, with two sets of guidelines on science advice addressed to government departments and advisory committees respectively. In due course, I shall have to see that their recommendations are implemented, which is easier said than done. The key principles include the early identification of issues, "horizon scanning" as it is now called. Of all the precepts in "Guidelines 2000", this is the most difficult. The needs to be both reasonable and all-encompassing pull in different directions. We shall have to reach broadly into the academic community for good advice.

The guidelines also require that advice should be published. I believe that transparency is essential if we are to regain the trust of the public in science. The code of practice for scientific advisory committees has been issued in draft form, we have had a discussion about it and publication of the final form is planned for the autumn. I believe that we already have advisory committees that are following this code quite closely. A good example is the Food Standards Agency, chaired by Sir John Krebs, which ice-breaking in openness and transparency.

I conclude with the international dimension. The UK has an important role in international science and technology policy, notably through the EU Framework Programmes. The Sixth Framework Programme, which will emerge fairly soon, has had a tremendous input from this country. But it is also important that we should strengthen links with major scientific partners around the world. In that connection, I am delighted to be able to report that we will be almost doubling the number of scientific cultural attachés around the world. Why is that important? The chief reason is our own self-interest; links with scientific partners serve our scientific, commercial and political purposes. But science has always been strong on international co-operation.

To return home, the CSA is responsible to the Prime Minister and the Cabinet for the quality of scientific advice in government. Quality control is going to be a major part of my activity over the next couple of years. Bill Stewart is right in drawing attention to the complexity of the problems arising in the biological sciences, but I also believe that science can cope with complexity and can minimise some of the difficulties arising. Yet the fact remains that we need better science advice across the whole of government. It my intention to see that that happens. ❐

discussion

Social science and advocacy. In general discussion, the CSA's role in relation to the social sciences was raised, where the scope for bad science and politically slanted theories, statistics and research "conclusions" is even greater than in the physical sciences. What thought is being given to emerging problems such as the ageing work force, and the highly 'politically incorrect' issue of the relationship between differential birth rates and the intellectual ability of the workforce?

Professor King argues that the social sciences — and the humanities — are within his sphere of interest. Many of the issues in the Energy Review will touch on social and economic issues and research, where needed, needs to be rigorous, with the conclusions from it presented objectively. It may be easier to do this from the Cabinet Office, raising the question of whether the OST should be part of DTI.

What of the role of the CSA in the wider public debate on science? If he or she is not to be the "cheer-leader" for science, who can be? How can the misleading arguments of such bodies as the animal liberationists and pressure groups be countered except by vigorous assertions by the CSA of the primacy of scientific methodology? Who else could dispute the widely held view that any scientist who has been employed by industry or government (and knowing the subject) is untrustworthy, and that the only valid scientific input comes from the independent scientist — perhaps knowing nothing about the subject? Perhaps an advocate role sits uneasily with the gatekeeper role, and the two should be split.

Perhaps the answer lies in seeing that as many senior scientists as possible not only know how to present scientific issues, and argue about them with those who did not share their preconceptions, but feel it their duty to do so.

⇨ **A detailed summary of the discussion is available on www.foundation.org.uk**

Governments and climate change

by The Rt Hon Michael Meacher MP

Climate change — mitigation and adaptation

The global response to climate change was debated on Wednesday 31 January 2001. The Government perspective was outlined by the environment minister Michael Meacher, Professor Michael Grubb, of the Centre for Environment Policy and Technology of Imperial College summarised the science of the Kyoto protocol and its offshoots, and Mr Nick Otter, technology and external affairs director at ALSTOM Power, gave a view from industry. The discussion that followed is summarised by Sir Geoffrey Chipperfield.

Michael Meacher is Minister for the Environment, Department of the Environment, Transport and the Regions (DETR).

The evidence for global warming is becoming overwhelming, and it is clear that climate change is the greatest environmental challenge of our time. The Intergovernmental Panel for Climate Change (IPCC) recently reported that, on current trends, the average global temperature may rise by up to 6 °C over the course of this century. The reduction in average global temperatures at the last ice age was about 5 °C, so an increase in 6 °C is momentous.

The scientific community has made valuable contributions to tackling other environmental problems. The parallels with ozone depletion are striking. That brought the realisation that emissions from human activities not only affect local air quality but also pristine environments as distant as the South Pole. As Joe Farman, the British Antarctic Survey scientist who discovered the extent of the Antarctic ozone hole, has put it, "for 15 years, you put the wrong thing into the atmosphere and you end up with something that takes 100 years to put right".

We have now been adding carbon dioxide to the atmosphere for close on two centuries. It will take many more centuries before the full effects of that work through. It is difficult to think of a precedent to equal climate change in global significance. It is not too apocalyptic to say that, if we allow current trends to continue, we shall threaten the survival of the human race.

The threat of climate change necessitates a global response. That is why the IPCC is so essential. It is a unique institution. No other area of public policy has been supported by a scientific body with so many experts from so many countries over a comparable period of time. As a result of their work, few would now dispute the inevitability of some human-induced climate change. The questions we now face are, how much, how fast? Where will be most vulnerable? Just how much climate change can we cope with?

We may not yet have a full understanding of environmental thresholds and the possibility of irreversible damage, or of the effects of carbon cycle feedback or of the release of methane hydrates. But we do know that deep and sustained cuts in emissions will be needed if we are to avoid dangerous climate change and, of course, meet the ultimate aim of the Global Change Convention. The Kyoto Protocol is about reductions of only 5 per cent, but IPCC has suggested that cuts of 60–70 per cent will be needed to stabilise CO_2. Similarly, in the UK, the Royal Commission on Environmental Pollution recently advocated cuts of 60 per cent by 2050.

To achieve global cuts at this level might require developed countries to meet even more stringent reduction targets, perhaps of more than 90 per cent. Stabilisation at 550 parts per million (p.p.m.) of CO_2, about twice pre-industrial levels, would still incur a further temperature rise of 2 °C and commit us to further significant climate change. Clearly, there needs to be a fundamental transformation of the way we use and generate energy, and it is difficult to appreciate the significance of that for society.

Action essential

Despite the uncertainties, we know enough about the risks to realise that we can no longer postpone significant action. To do nothing is simply not an option, not even for the United States. The UK government has demonstrated its commitment to cutting emissions, but unilateral action will never be enough. We are committed to securing effective international action on climate change, and to the early entry into force of the Kyoto Protocol. Despite the failure of COP6 [the sixth "Conference of the Parties to the Climate Convention", held at The Hague in November 2000], we did in fact make progress on a number of key issues and, when the talks resume later this year, we will continue to press for a deal to maintain the integrity of the protocol, to ensure real action to reduce emissions and to pave the way for its entry into force, hopefully in 2002. The Kyoto Protocol is only the first step but it is an essential step. Part of its significance is as a signal of intent by the developed countries to the developing countries, the very places where future action will be essential.

What are we doing in the United Kingdom? Last November we published our climate change programme, which signals the importance of moving onto a lower carbon economic path and sets out some initial measures by the Government. These include policies to stimulate the development of and investment in renewable forms of energy; mechanisms such as the climate change levy, emissions trading and the carbon trust to stimulate investment in low carbon technologies; invest-

ment of £180 billion over 10 years to modernise our transport system in a way that makes mobility more environmentally sustainable; and plans to remove barriers to the introduction of new technologies in the market place. April 2001 will see the introduction of the climate change levy, the launch of the carbon trust, the establishment of the Kyoto mechanism office and the start of some emissions trading. In this we are leading the world, providing for a domestic system of emissions trading as a test run for international efforts in that direction.

Work is also continuing on the green fuels challenge the Chancellor announced last November: that scheme aims to stimulate industry to make practical proposals for alternative fuels and technologies. We also need research to develop and introduce new technologies and to revolutionise the way in which we generate and use energy and to make the switch to the low-carbon economy that will be essential for us to meet the continuing challenge of climate change. I am convinced that making an early start in this area, being a prime mover, will mean new business opportunities for the UK; the environment and the future of the economy are locked together.

Science and technology are likely to be powerful tools for breaking the link between energy consumption and economic growth. But people and their aspirations will be central to the solution. The causes of climate change are deeply rooted in both economic and social behaviour and we need to engender a sea-change in people's attitudes so that all take individual responsibility for their use of natural resources. Perhaps, in the long term, there may even be individual carbon quotas; we should not dismiss that concept out of hand.

Real cuts

We need to develop an environment where people have the opportunity to make genuinely sustainable choices. We need to develop better ways of putting a price on resources that reflect their true environmental cost. We need to educate people better so that they can make a more informed choice.

Making real cuts in emissions is the only way that we will be able to avoid significant damage globally. I am not against carbon sequestration, but we cannot primarily rely on that. The inertia of the climate system means that we will see the effects of past and present emissions for centuries to come. We need to develop a package of responses that include both mitigation and adaptation. The Government has begun to build adaptation into its policies, for example on water resources and sea defences, but there is more that we can and should do to prepare ourselves to cope with the extreme weather events of the future and the climate change that we can expect over the next decades. We need to improve our prediction and assessment of the impact at a scale that allows adaptation to be targeted effectively and we need to revisit the ways in which we make decisions, particularly, I think, on long-term infrastructure investment. The recent floods have been a wake-up call to the urgency of action to reduce vulnerability.

To conclude, the climate change problem is like no other encountered by the human race. It is no mean challenge to negotiate an agreement that is compatible with our development, sustainability and equity goals while ensuring environmental integrity. We have the potential to establish a paradigm for addressing the other global environmental issues that will almost certainly arise. Failure to meet the challenge will have incalculable consequences for future generations. For their sake, let us ensure that history does not find us wanting. ❑

Prospects for the Kyoto Protocol

by Professor Michael Grubb

Michael Grubb is Professor of Climate Change and Energy Policy at Imperial College, London and was previously Visiting Professor at the International Academy of Environment in Geneva.

I will speak about the international negotiation that collapsed so spectacularly at The Hague [in November] and discuss the prospects for action on climate change. I begin with a thumbnail sketch of the key international instrument – the Kyoto protocol signed at the end of 1997. That is the first offspring of the parent framework-Convention on Climate Change. The protocol defines, for each of the industrialised countries, limits on emissions, which in itself raises questions about how they are defined, monitored and enforced and about how flexibility is introduced.

Commitments are defined for an initial period of five years, centred on 2010, with more periods expected to follow. Limits are defined for a basket of greenhouse gases, but carbon dioxide accounts for about 80 per cent of emissions from the industrialised countries. There is some allowance for offsetting sinks against emissions. The collective commitment by the industrialised countries amounts to a reduction of 5 per cent below 1990 levels in the first period. The protocol includes many other provisions – for example, in relation to developing countries, there are provisions for technology transfer and for a fund for adaptation.

The European Union is committed to an 8 per cent reduction below 1990 levels, which was subsequently redistributed among the member states; an intrinsic part of that arrangement was that some of the poorer member states would be allowed to increase their emissions, offset by greater reductions elsewhere, particularly in Germany and the United Kingdom.

What is most striking statistically is the enormous disparity between the

discussion

What price Kyoto without US participation?

On accession to Kyoto, although it was theoretically possible to do so without US participation, it would clearly be difficult to get unity with all other industrialised countries. It would be easier to do so if there were good prospects of being able to reach agreement with the USA over sequestration and trading. A possible way forward would be to try to distinguish between "good" and "bad" sequestration: i.e. those measures which would lead to a genuine reduction in fossil fuel use and those which simply stored carbon.

There was some doubt about the strength of the influences that it had been suggested would play on the USA if Kyoto came into force without it. A worry was that, if industries in Europe or elsewhere, had to incur costs, or suffer regulation, that US industries did not, the latter would have a clear advantage in the market place. Much depended on the length of the gap between EU and US accession, and the perception of the rest of the world on the willingness of the USA to sign up eventually. But one should not underestimate the anxiety of developing nations (for example, China) about global warming – they were more likely than many to suffer from rising sea levels.

Nuclear power. Several contributors felt strongly that, without it, there would be no possibility of meeting the longer term targets of 60–70 per cent reduction. Public concerns about safety and about dealing with nuclear waste were genuine, but could be dealt with by firm political leadership. More difficult was the problem of producing nuclear power at competitive prices; the solution to this might well be ensuring that CO_2 producing fuels paid a price for the environmental damage they caused.

Waste. Waste in the use and production of energy was clearly seen as an important issue to tackle. The existing electricity network, with long-distance transmission lines, was inefficient; more effort should be put into encouraging and installing embedded generation systems. But waste in use could be tackled even more quickly. Mr Meacher had said that everyone should contribute to reducing CO_2 emissions; this meant changes of style and energy use in the home and elsewhere. It was doubtful if present measures were as effective as they might be.

Waste in energy use and production. Although some speakers were concerned over the uncertainties that still lay over the projections and, in particular, the wide spread of opinion about possible increased surface temperature, others considered the scientific evidence solid, and the need to act urgently as proven. There was no single measure which could resolve the issue; both regulatory and economic measures were needed. Greater use of renewables, vigorous action on waste, active promotion of alternative sources of energy to fossil fuels were vital.

⇨ A detailed summary of the discussion is available on www.foundation.org.uk

highest per capita emitters, essentially the countries of North America and Australia, and the very low per capita emissions in the developing (yet high-population) countries. When the growth of "economies in transition" is projected to anything like the level in industrialised countries, the projected global growth in emissions is quite frightening.

The Kyoto Protocol essentially defines as a first objective that the higher *per capita* emitters must get their emissions under control as the basis, in subsequent periods, for bringing in developing countries. Progress towards that goal is, shall we say, very mixed. The United Kingdom is arguably the only country of the OECD firmly on course to meet its target, but there is a prospect that Germany will do so as well. So, the action of the two largest emitters in the European Union, partly offset by action in other member states, means that the Union could plausibly get within shouting distance of its Kyoto target. Any deficit might be met by calling in aid the various flexibilities of the protocol: reductions of other gases, provisions for joint implementation investments in Eastern Europe, emissions-trading and the clean development mechanism.

As for the United States, figures from the US Department of Energy for carbon dioxide emissions show that, in 2000, US emissions were about 13 per cent above 1990 levels and that they are projected to increase by almost 30 per cent above 1990 levels by 2010 — enormously divergent from the Kyoto targets. There are reasons to believe that those projections are exaggerated; in part, they are driven by population growth, for example. But there is also an enormous inertia in the US energy system and in its political system — perhaps even more so since the new Republican administration took office. There is no prospect that the United States will get anywhere close to its Kyoto target for domestic CO_2 emissions.

That was the fundamental problem at The Hague negotiations. Obviously, the EU feels that the USA, as a higher *per capita* emitter, is not an efficient user of energy and should do much more domestically; the Union sought constraints on the Kyoto flexibilities to ensure that. The Clinton Administration, on the other hand, while strongly in favour of Kyoto, wanted something that the USA might ratify and implement; the administration's judgement was that that there is a limit to how much they could deliver at home, so that they wanted a generous interpretation of the Kyoto clauses on sinks (activities that absorb carbon).

That disagreement, substantively and perceptually, brought the Hague conference to collapse. In a nutshell, the USA wanted to claim credits for substantial sinks on US soils, some of which are probably associated with existing activities. The European Union, by contrast, saw that as a sign of the USA reneging on its Kyoto target. (There were doubts on the EU-side about the permanence of carbon sinks, whereas the US-side regarded them as positive contributions to the quality of agricultural soil management.) In other words, there was a dialogue of the deaf.

We need now to ensure that the Kyoto regime, on which so much effort has been expended, comes into force, and rapidly. We also need to ensure that the system moves forward in a way that will allow the USA to join in, if

and when conditions are politically appropriate.

The Kyoto Protocol will enter into force when at least 55 countries have ratified, and when those countries cover 55 per cent of industrial-country CO_2 emissions. The United States accounts for more than a third of CO_2 emissions, the European Union for about one-quarter, and Russia for about 18 per cent. Thus, without the United States, it would require a coalition of the European Union, Russia, Japan and other states to bring Kyoto into force. The obvious target date is the Rio+10 summit in South Africa in the middle of 2002.

There are two ways of perceiving such a move. One is to regard it as intransigence, the rest of the world saying that it is going ahead anyway, whatever the Unites States may think or do. Alternatively, it could be regarded as a constructive move to set the international machinery in motion, while engaging somewhat sympathetically with the United States' difficulties over the Kyoto target and looking for avenues that would make it feasible for the United States to join. Moving forward would help to generate experience and confidence in the business community and in technological innovation and would demonstrate that the problem is not as profoundly difficult as some in the United States believe it to be. If the business community were persuaded that this is the direction in which the world is moving, perhaps the multinational companies themselves might begin to lobby for US involvement in the global system.

If, therefore, the European Union is serious about exerting leadership on this issue, it should be willing to ratify Kyoto and bring it into force by 2002, if necessary in advance of US ratification. As the UK programme demonstrates, there is substantial scope for "no regret" actions: for example, the removal of subsidies that only make the problem worse, and of barriers that inhibit industries and other consumers from being as economically efficient as they could be.

There is a potential "double dividend", as economists call it, from taxing polluting activities while reducing taxes on capital, savings, labour and so forth. It is important also to recognise that actions intended to reduce greenhouse gas emissions can have associated benefits, as for example reductions in other forms of pollution caused by road transport. There is a substantial potential for technological innovation. And if it is recognised that the world is steadily becoming more and more globalised, that our economies are linked with those of the developing countries through investment, trade, and so forth, then those innovations will diffuse and will increase the willingness of developing countries to join in subsequent Kyoto periods.

In conclusion, the Kyoto protocol is dangerously stalled, but the negotiations will be resumed. It is essential that we should recognise some of the problems the United States genuinely faces, to think more laterally about the sinks issue, possibly including links with biomass energy production, and to demonstrate European willingness to put its action and its ratification where its mouth has been for many years. That will encourage industry to accept the challenge in an effective and constructive way and will bring the United States on-board. That will ultimately lead to global involvement in tackling this problem. ❐

Opportunities for industry

by Mr Nick Otter

Nick Otter is Director of Technology and External Affairs at ALSTOM Power, one of the world's largest power generation and service providers.

It is my pleasure to bring an industrial perspective to the real challenges we are talking about. ALSTOM Power is major equipment manufacturer supplying the technologies that will be used to ameliorate climate change and we are grappling with how we devise our strategy for what appears to be a very uncertain future. The environment is certainly becoming a huge driver and the equipment suppliers are positioning themselves in order to take advantage of the business opportunities that exist. I also act as an adviser to the European Commission, looking at energy strategies up to 2050 and beyond. Engaging industry in that process is critical.

So what are the major issues facing my business? There is the demand for technological innovation and its dissemination to developing countries, against the background in which energy markets are going through substantial change: deregulation, privatisation, legislation, and the move from national to a global perspective. The onus is clearly on the suppliers like us to meet the challenges we are talking about.

We are also, as a business, heavy users

> … the big companies are ultimately most driven when there is some wealth to be created — luckily you can both create wealth and contribute to environmental improvement

The Kyoto negotiations: an update from Bonn **update**

It has been a remarkable six months since the FST meeting on the climate change negotiations. Just a couple weeks after President Bush's inauguration, the Secretary of State Colin Powell asked for the resumed COP6-negotiation to be deferred until July, to give the new Administration more time to prepare. In early March, the EPA Administrator reassured other countries that the US was conducted a review that 'did not represent a backing away from Kyoto'; a week later, President Bush released a letter stating precisely the opposite: that the Administration flatly rejected the Protocol.

In the confusion that followed, many people — most of all, those in the United States — expected the global negotiating process to collapse, and the United States stated initially that it would propose an alternate approach. Yet this promise melted away, and the European Union restated its support for the Kyoto process. The Bush Administration Cabinet Review contained nothing to suggest a serious approach to tackling climate change, or was developing any alternate approach in development; and the European Union secured a promise that the United States would not interfere with the ongoing process.

Thus, countries went to the resumed negotiating session in Bonn with the task of finalising the rules for implementing Kyoto, and the United States standing aside. To the surprise of many they succeeded where the Hague conference had failed. Highlights included agreement on:

Principles and rules for the accounting of carbon sinks, including allowed credits for carbon absorbed by managed forests on a country-by-country basis, which in aggregate (excluding the Unites States) equate to about 3% of annual emissions)

Three new funds established to support developing country engagement in the climate change process and their adaptation to the impacts of climate change

The main principles for operating the flexible mechanisms, including that there will be no quantified restrictions on their but that countries will 'refrain' from generating emission credits from new nuclear power projects Compliance procedures are reaffirmed as legally binding in international law, with automatic penalties in terms of subsequent allowances

These and many other points were agreed in a political declaration. The task of turning these main points of agreement into legal text in all the United Nations languages is now passed on to COP7, opening in late October. In principle, the agreement could still be undone in the 'fine print'; or if the US could find and seriously tried to promote some alternative grand design, but this seems unlikely. Barring major surprises, the Kyoto Protocol, injured and missing one key actor, will be secured and is likely then to go forward to ratification and entry into force. If that is achieved, the next big task will be: how to reintegrate the United Sates.

Michael Grubb, September 2001

of fossil fuel: one of the key issues is how we achieve near-zero or zero emissions from fossil fuel. That reliance can be seen as a threat to our business, but it is also a huge opportunity, if we can develop the right technologies, at the right price, our customers will buy them. Of course, legislation has an impact there: governments can "encourage" our customers to take up the newer technologies.

So how do the suppliers of power generation equipment try to anticipate the impact of the global climate change on our technology route-mapping and our strategy? What kinds of technologies are we going to require in the future? How will that affect our market? The marketplace could change significantly if there were to be a large number of countries that had CO_2 tax, for example. We keep a watching brief on all the environmental, political and market developments. We also try to ensure that we have the right technologies in place, for the future.

Of course, there is no single winning technology; and there is a whole range of issues to be addressed, but a critical part of our longer-term planning is to try to identify key modules that will go into a whole range of different types of power plant that are much more effective in their use of the fuel. We are seeking to increase the efficiency of fossil fuel plant and to develop renewable and hybrid systems. Renewables, however, will only ever be part of the solution.

As for the spread of the new technologies, the barriers are often not technological but financial or political. The impact of the Bush Administration on our US competitors, for example, is bound to be significant. Many of the required technologies are too expensive, and changes in the economic and tax framework are needed to encourage use of new projects.

So, what is required? COP6 was a failure, but it wasn't a total failure. With the difficulties between Europe and the United States, the time-frame may stretch a little, but it is clear that certain countries and certain initiatives will go ahead. The European Union is talking about emissions-trading in 2005, while there are already special schemes to encourage take-up of particular technologies. Our big customers, the likes of BP and Shell, now want us to help them solve their problems, to demonstrate the effectiveness of the new technologies, and to identify those that will work for them. But we are still at the pre-competitive stage in a lot of these technologies. We still have to show that they work.

The climate change issue is a huge driver in our development of technology, but the real driver will be legislation. The big companies in the sector are ultimately most driven when there is some wealth to be created. Luckily, you can do both: create wealth and contribute to environmental improvement. ❐

How to dare to dream

The innovative catamaran *Team Philips* was abandoned in mid-Atlantic on Sunday 10 December 2000, the end of a dream. Pete Goss MBE, the project founder, spoke at a Foundation meeting earlier this year about the lessons and achievements of the project, and the technology that it pioneered.

Our aim with *Team Philips* was to build a British entry to win an ocean-going race simply known as "The Race". The compelling attraction was that there are no rules at all — just a course, starting in Barcelona, rattling round the world and back to Marseilles. That gave us complete freedom with the design —the chance to dare to dream.

That was our concept. It was five years' work before the boat was in the water. We started from scratch, a team of four working in a shed. At the beginning we set ourselves a number of clear cornerstones on which we would not compromise. In the early days, we turned down the offer of money from a tobacco company because it didn't fit with our project values of excellence.

It was a real team effort and responsibility was the key word; it was down to everybody in the team to put their hands up and say what they needed to do a fantastic job and then we undertook to do everything we could to provide it. So that was one of the cornerstones. The other one was that we said that we would always embrace a good idea and incorporate it into the boat. We wanted to iron out the wrinkles before they became too big to overcome. We didn't have a massive budget but we had an innovative team, we had imagination.

I always felt that this project was nothing to do with sailing — it was about innovation, technology, challenge and adventure. We were using technology completely new to the boat-building industry, and recruited people from the aerospace and Formula One industries.

We became victims of our own enthusiasm. If we couldn't find what we wanted we would create it ourselves. We had to build our own composite facility in Totnes to mould and 'cook' the hull. And although the manufacturers of sailcloth told us that they had material that would do what we wanted, our test rig showed the material was not up to the job. That caused a year-long development programme in the United States to develop the sailcloth to be able to make the sails. There were many such obstacles to overcome.

An important part of *Team Philips* was the fact that we wanted an open project. We wanted to take sailing to a wider audience, and we ran an education programme — we wanted to make engineering sexy.

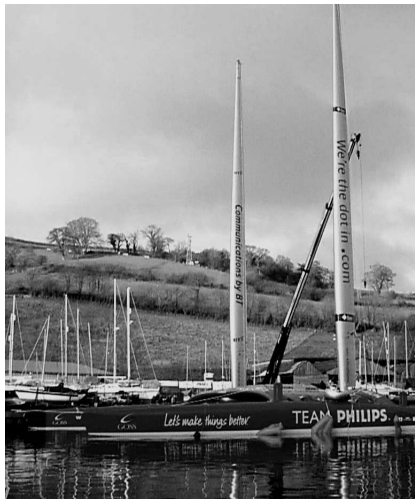
One of the windows into the project was the visitor centre in Totnes. More than 1.2 million people passed through that visitor centre and we have had 79 million hits on the website, 76% of from outside the UK. Public interest was immense. We had 40,000 people at the launch and you could be a personal sponsor and put your name on the hull for £25. We had 9,000 names on the hull, so the boat really took on an identity of its own. If a few of the youngsters who sent us e-mails and wrote us letters go on to be creative engineers we will have achieved one of our goals.

She was a big boat, 120 feet long and 70 feet wide. You could park 80 cars between the hulls. At the outset, we compared a rough design of *Team Philips* with that of a traditional catamaran of similar size. In a normal catamaran, there is a single mast stepped in the middle of a beam between the hulls, which presents several problems. One is that, under sail, there is a downward force of about 115 tonnes at the centre of the beam, which requires a huge amount of infrastructure. But in this business, weight is the enemy; all of it has to be pushed around the world. So we split the mast into two, each free-standing in one of the hulls.

Another crucial element of the design is the wave-piercing technology. You can think of *Team Philips* as sitting on two razor blades — the hulls are only 4 feet wide. Given that the average wave travels between 21 and 22 knots and we anticipated speeds of 40 knots, we would be cutting through the waves quite aggressively even when we were going with them; indeed, we expected the bows to go as much as 12 feet under water.

This may seem strange given the outcome of the project. But a key element in the design was the need for redundancy and reliability. So we had two rigs, so that we could shut one down and repair it while still racing with the other. We wanted the boat to be brutally simple. "If something's not there to go wrong, it won't go wrong." We had a boat that required only six people to sail, against sixteen on a traditional boat — an overall saving of five tonnes of weight at a stroke.

We also wanted control. In a traditional boat, if the wind increases when you are running with it, you need to reduce



High hopes: Team Philips with masts newly erected. Photo: Rick Tomlinson.

sail, but you cannot come up into the wind because the beam resistance increases and the boat capsizes. But you cannot pull the sail down because, as you ease the halyard, the sail goes slack and it gets caught around the rigging.

We had rigs that were free-standing and mounted on bearings; they just weathercock round to the wind. To get power from the sails in the right direction, you then simply pull on the sheet to pull the rig round and offer it to the wind. On *Team Philips*, we had one sheet for each sail that went to the accommodation pod in the middle of the boat. So the whole thing was controlled by two winches. Our insurance against being over-powered was a fire axe with which we could cut the rope.

We wanted our journey to be safe, so we put the crew in an accommodation pod right up in the air, with eye-level 17 feet above the water.

Did she work? Yes she was fantastic. She didn't let us down. Unfortunately, we got caught in a freak storm. She took us through hurricane-force conditions and because the concept of the boat worked, we lived to tell the tale. Sadly we did have damage to a secondary part of the structure and I decided to abandon the boat in the interests of crew safety.

That is how I like to remember *Team Philips*. It was about daring to dream, it was audacious, it was technology, it was adventure, it was a free spirit, it worked and we would dearly love to build another one. ❑

Scientists of Europe unite!

Professor Claude Allègre, an influential figure in French science policy, delivered the Seventh Zuckerman Lecture at the Royal Society in June 2000. Here he summarises the main themes.

Building Europe has been an extraordinary achievement. Slowly and with much difficulty, some political union has been accomplished. We have a common market, common agricultural policy and common currency — which one day the UK will join. I want to persuade you that we now need a common policy on research.

I am committed to the European project, but there will be little political progress in the next few years as Europe faces the problems of expansion. So why not, instead, build a Europe of knowledge, of culture, of universities and research? If we had a truly integrated European scientific enterprise, would not a politically integrated Europe eventually emerge naturally?

Do we really need a European research policy? Yes, because our technology lags far behind the United States. True, in basic research, Europe as a whole is competitive. But almost all the innovations of the modern world were developed in the United States. Many innovations conceived in Europe were returned here only after being taken up by American companies.

So our common policy on research must make Europe stronger in innovation transfer. As things are, each country in Europe is too small to exploit even its own research. And although every European country has some very good scientists, none has expertise in everything at the highest level.

You may think this approach is elitist; I make no apologies for that. What matters now to a country's reputation in science is that there should be a first class team of top scientists and young people with the potential to succeed them. Scientists who are not the best on a world scale nowadays count for little.

In United Kingdom there is a view that the nation's science is very good because of the discovery of the structure of DNA and of what followed. I disagree. UK science is good because this is the only country in Europe able to concentrate resources in a few places. Elsewhere, we operate democratically — spreading resources uniformly. Unfortunately, in science the pioneers are always few in number and thus a minority. Voting on science matters is democratic, but not a guarantee of quality.

France is one example. When we evaluate individual scientists, we give the task to the people in charge of awarding research grants, with the result that science self-replicates. It is now essential for the quality of people's expertise to be determined on a European level, with the further benefit that decisions would then not be clouded by factional or regional considerations.

Another argument for a European policy is the need for expensive equipment. European countries, per capita, spend about 25 per cent more than the United States on such items, not all of which are use all the time. Yet we can build such machines very well if we work together, and CERN at Geneva is the shining example. There has been progress here. With the British, Germans and Italians, France has set up a group to plan these big machines. Instead of having a lobby in each country, we now have a lobby on an European scale.

What is the present situation? The European Union, through Brussels, distributes to science 6 per cent of the total spent by member states individually. That is not much. The budget could be increased without increasing the overall budget as agricultural subsidies gradually reduce.

Then the European Union must become a more effective co-ordinator of research. As things are, there seems to be no co-ordination. Ministers meet each other three or four times a year in Brussels, but they do not have regular discussions on the directions being taken by the different European agencies.

There is related difficulty. At present, Europe's budget competes with individual national budgets. For example, when the BSE crisis broke out, the British, French, Germans and Dutch all developed their own programmes — and Brussels set up a research programme too. What a waste!

Instead European money should be focused on a limited number of objectives. First of these should be the exchange of researchers and students across Europe. We need to organise European meetings and networks that will enable every small business to know exactly what is happening.

The co-ordination of national science budgets can best be done if the directors of the science agencies meet together regularly. We must also organise cross-expertise as we have done in mainland Europe for many years. Now, in France, almost half the members of the National Council of Science are non-French nationals, for instance.

This is what I mean by co-ordination: let the people on the ground tell each other what is going on. From those discussions will spring many joint projects. One example is the synchroton we are building with the UK. In the past, we built a successful high-flux neutron reactor in Grenoble with Germany. All this can be done by multilateral co-operation, letting the people share ideas at meetings, and letting them take initiatives without bureaucratic interference.

My last point is perhaps the most important. Today science is developing much faster than ever before, presenting governments with difficult decisions which they are ill-prepared to make, but have to make quickly. Problems in the life sciences abound. There are important debates about embryo research, about the human genome and patents for pharmaceuticals.

Governments dealing with these problems are under pressure from the media and the public, making rational judgement very difficult. So we have to build a body of professional people who have links with the scientific community and who are themselves respected by the community.

In my view, this body of expertise can only be European. It cannot be national because we do not have the resources and it would not have the credibility. A true European body of this kind would even have the authority to contradict the politicians if necessary.

I conclude where I began, by saying that if we build a truly integrated European scientific enterprise, many other problems would melt away. Of course, we must involve all of the people in Europe in what we are about. We do after all, share common values, one of which is a belief in knowledge and in science. That is the goal we must work towards.

And now is the right time to do it. ❐

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Professor John Clark, Head of Molecular Biology, Roslin Institute, Edinburgh
Professor Robin Gill, Michael Ramsey Professor of Modern Theology, University of Kent at Canterbury
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Professor Rod Smith FREng, ScD, Head, Department of Mechanical Engineering, Imperial College of Science, Technology and Medicine
Lord Bradshaw, House of Lords
Mr David Leeder, Marketing Director and Member, National Express and The Commission for Integrated Transport
Department of the Environment, Transport & the Regions, National Express and Railtrack

29 November, 2000
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Dr John Patterson, Member, Materials Foresight Panel
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Sir John Krebs FRS, Chairman, Food Standards Agency
Mr Geoff Spriegel, Technical Director, Sainsbury's
Professor Hugh Pennington FRSE FRCPath, University of Aberdeen
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13 December, 2000
Future Science Priorities
The Lord Winston, House of Lords

31 January, 2001
Climate Change – Mitigation and Adaptation
The Rt Hon Michael Meacher, Minister for the Environment, Department of the Environment, Transport and the Regions
Professor Michael Grubb, Centre for Environment Policy and Technology, Imperial College
Mr Nick Otter, Director, Technology and External Affairs, ALSTOM Power
Department of the Environment, Transport and the Regions, Department of Trade and Industry and Tyndall Centre for Climate Change Research

14 February, 2001
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Mr Pete Goss MBE, Chairman, Goss Challenges
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Professor Jonathan Gershuny, Director, Institute for Social and Economic Research, University of Essex
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The Lord Sainsbury of Turville, Minister for Science and Innovation, DTI
Professor Alan Windle FRS, Executive Director, Cambridge MIT Instutute, University of Cambridge
Mr Ric Parker, Rolls-Royce plc
The Office of Science and Technology, DTI

14 March, 2001
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Dr John Taylor OBE FRS FREng, Director General of Research Councils, Office of Science and Technology, Department of Trade and Industry
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Dr Liam Donaldson FMedSci, Chief Medical Officer, Department of Health
Professor David King FRS, Chief Scientific Adviser, Office of Science and Technology, DTI
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Professor Paul Elliott FMedSci, Professor of Epidemiology and Public Health, Imperial College of Science, Technology and Medicine
Professor Rob Pickard, Director General, British Nutrition Foundation
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30 May, 2001
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The Lord Oxburgh, House of Lords Science and Technology Committee
The Baroness O'Neill of Bengarve CBE FBA, Newnham College
Dr Peter Goodfellow, GSK
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Professor Brian Heap FRS, The Royal Society
Professor Dominique Dormont, CEA (Fontenay), France
Professor Roy Anderson FRS, Imperial College
The Department of Health, The Embassy of France and Ministry of Agriculture, Fisheries and Food

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