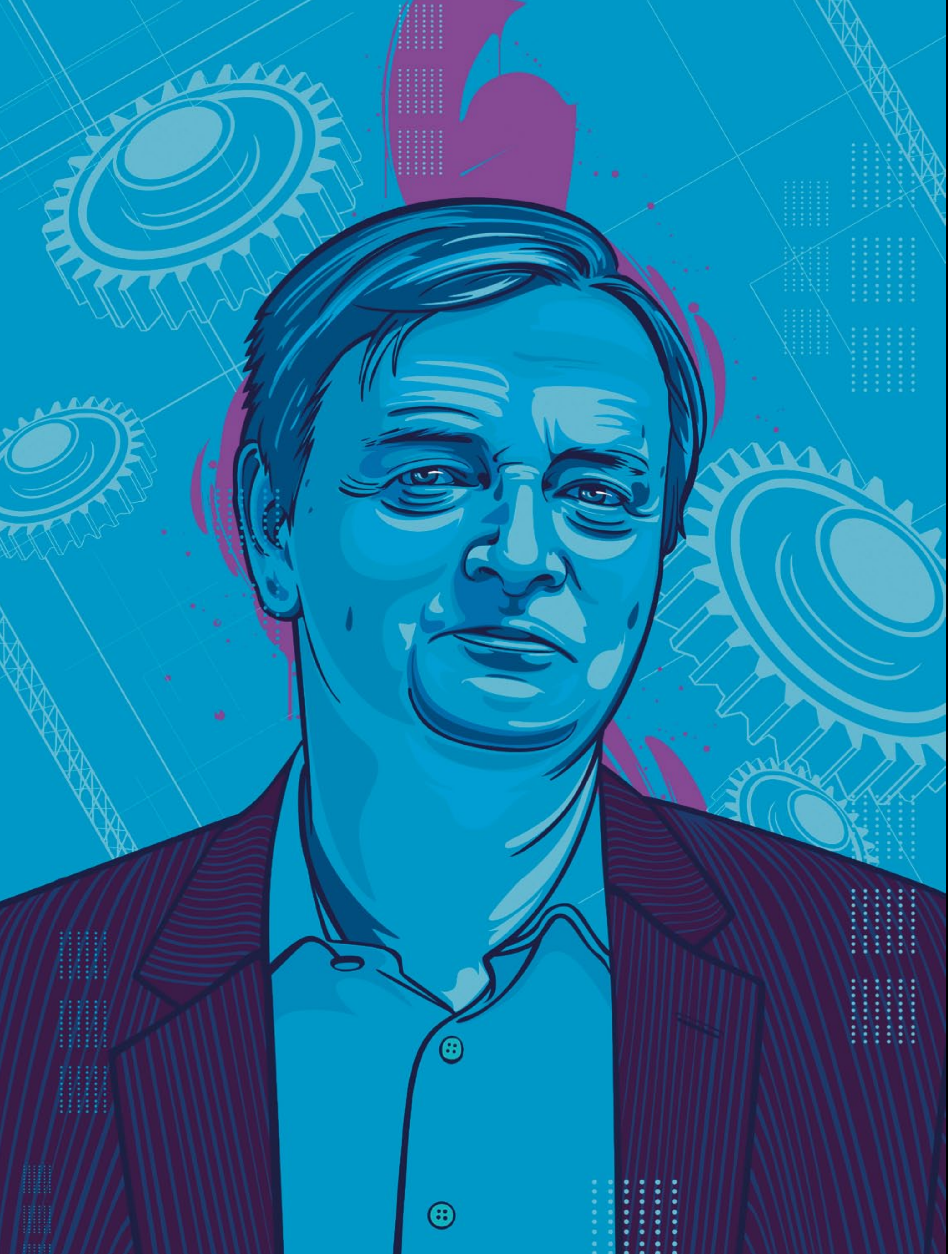

GETTING THINGS DONE

AN INSIDE VIEW ON THE ROLE OF ENGINEERING IN GOVERNMENT

As a House of Commons select committee considers how government uses engineering advice and expertise, systems engineer David Fisk reflects on his experiences in strengthening relations between government and engineering to show why this relationship matters, how it has evolved, and how Imperial alumni might strengthen it.

BY DAVID FISK

'Engineering' to most people means getting things done. Technology – 'the knowledge of things' – plays its part, but engineering is more than 'things'. Stripped to its essentials, to engineer an outcome takes someone to be persuaded to make something, and others to want to use it when it is made. If that something has never been made before, then it follows that there are judgments to be made and risks to be taken. Governments are also supposed to be about getting things done. So what should citizens expect from their governments when they need something engineered?

KEEPING UP WITH INDUSTRIALISATION

For several thousand years governments have required access to an engineering capability to arm their nations. But it was not until the nineteenth century that engineering issues began to appear in UK civilian legislation. Industrialisation was taking place at speed and government needed a way of engineering factories to be cleaner and safer, as an alternative to forcing them out of business through prohibitions.

The pragmatic Victorian solution was for parliament to appoint a person with formidable technical knowledge as Chief Inspector to regulate industry. Regulation was designed to encourage incremental improvements in innovation and therefore keep pace with the rate of industrialisation. This approach provided a strong incentive for manufacturers to secure competitive advantage by devising new technologies that exceeded the current standard. The Chief Inspector needed to be alert to false claims, but the incentive system made the job technically plausible.

The Chief Inspector oversaw the industry, but did not need to run it. This approach was certainly effective. It is essentially how vehicle emissions, once the bane of urban life, have been regulated through continued technical improvement to levels where eating at a pavement café in central London is now a pleasure.

FROM SOLUTIONS TO OUTCOMES

By the 1970s, this approach to regulating technology was becoming a little ragged where issues of scaling and complexity were involved. For example, oil refineries presented a bespoke legacy of systems stitched together over decades rather than a discrete technical solution to a single problem. The energy performance of the interconnected systems of a modern commercial building or hospital was far too complex to be regulated by the simple rules that applied to a domestic house.

Attention thus started to move from specific best practice solutions towards performance targets such as maximum rate of pollutant emis-

Illustration by VINCENT RHAFAEL ASEO

sions. This permitted different engineering solutions with the same outcome, without the need to identify which one was best. The government's requirement for in-house technical skills moved from the engineering expertise of Chief Inspectors towards specialists in measuring performance. The US was probably the first to push this logic further and set as the target the state of the environment itself. If the environmental standard was met, then surely firms could decide how to achieve it amongst themselves by reconfiguring their technologies and emissions?

THE ECONOMICS OF INNOVATION

This line of reasoning soon led to the birth of air pollutant emissions trading in the early 1990s. But it was also accompanied by something of a paradox: if the environmental standard was a sharp universally agreed level, then the conceptual economic model worked fine; but if the standard were to be a trade-off, the regulatory body would be hard pushed to know the true cost of an innovative measure without the engineering expertise to know 'how the widget works'. Unfortunately, by focusing on outcomes, this knowledge had been lost from inside government agencies. Asking the industry to come up with a number would be like asking a turkey to pick the date of Christmas. This was brought home to me during the negotiation of one EU directive where 'cost per unit' emission differed by at least a factor of 10 between member states for the same technology, even when some of those states were being briefed by different parts of the same company.

The difference in intellectual spaces inhabited by the economics of innovation and the economics of the public sector means that government measures aimed at improving the economy can have a rather poor net effect on the national balance sheet. 'Market-based' regulatory instruments are a case in point: they might offer a theoretical economist some satisfaction, but if the starting point is a poorly structured engineering regulation, the outcome cannot *per se* count as a triumph of public policy.

The lack of direct experience and true understanding of the parameters that govern engineering innovation have often led to the opposite of the intended effect when it comes to public policy. For example, the European Trading Schemes (ETS) for greenhouse gas emissions promised to open the market to innovative solutions for a low carbon economy. But brave new expensive green technologies that relied on high ETS prices have been bankrupted, and smoke stack industries that kept their nerve have survived the crash in market prices for carbon units. Somewhat belatedly, governments are realising that they cannot avoid employing engineering knowledge and judgment after all. But how should they do so in today's complex world so different from that of the Victorian Chief Inspector?

ACADEMICS AS GOVERNMENT ADVISORS

In search of an answer, we might first look to a model that was originally developed to help government better assess technology for military procurement which has always set a particular challenge and requires immense amounts of good judgment. As government is frequently seeking to buy what has never been made before, discovering that it does not work as intended in a real conflict can be disastrous.

The problem of finding a better way to assess military technology became more pressing once the concept of a technology arms race really caught on after the First World War. By the 1950s it had become sufficiently perplexing for the Ministry of Defence (MoD) to institute a new role of Chief Scientific Advisor (CSA). In the MoD this was and remains a senior post recruited from academia, closely linked to the procurement process, and with an internal analytical capability to challenge technical assertions from equipment providers and internal advocates.

The CSA model is now widely replicated across government departments, demonstrating a spread of concern about things technical that spreads far beyond military procurement. I myself performed this role for the then Department of the Environment from 1988. As my colleague, David Edgerton (PhD Social and Economic Studies 1984) described in issue 36 of this publication, Imperial has contributed a full-house of such advisers across different departments, including the current Chief Scientific Advisor to the government, Professor Sir John Beddington.

CSAs have 'access to ministers', meaning that they often join meetings where technical substance underpins the political decision. They are not intended to be a walking Wikipedia, but are well-positioned to draw heavily on external peer networks, such as Fellows of the Royal Society and the Royal Academy of Engineering.

The CSA model forms part of a wider check and balance system to ensure that technical expertise is available to those who need it. But while it seems to work for big issues, it is less good for some of the other levels at which government is engineering things. Some of these never drop into a CSA's inbox at all, or if they do, it is at a stage when the only intervention left is to halt gross errors in official process. So the problem of sourcing good day-to-day engineering judgment remains. Very large problems can start from very small errors.

OTHER OUTSOURCING OF ENGINEERING EXPERTISE

Rethinking how government's engineering competence could be improved cannot be just a matter of going into reverse gear to a golden age. First, the move to focus on specifying outcomes has meant that engineering expertise has long since left central government. The state industries and laboratories have gone to the private sector and with them their engineering knowledge. This makes plausible engineering careers in government a little hard to identify: you will find fewer chartered engineers in most central civil departments than you would in a typical town hall (or indeed the state council of the People's Republic of China).

What has emerged to fill this space has been the engineering consultant. Imperial academics, through Imperial Consultants, have frequently played this role of analysing the engineering implications of policy, under contract to a department. In one sense the new world order is good business for independent consultants: no-one in government would believe industry, even if government were equipped to understand fully what they were saying. The critical point arises when a government department no longer has the internal knowledge to match the consultancy contract it is managing, at which point it fails to understand the limitations of any advice it has commissioned – the 'unknown knowns'.

The imperative to recover engineering competence in modern government is as strong as ever. Regulators like Ofcom are facing formidable technical opponents in the form of the world's monopoly-minded IT industry. Regulators like Ofgem and Ofwat are signing off billions of pounds of novel green infrastructure proposals that will end up on our utility bills, even if the widgets do not work as intended. Only the European Commission, with the collective strength of member states behind it, succeeded in taking on the power of Microsoft to unbundle the internet services from the Windows platform. But even the well-endowed Commission had to rely on a valiant consultant to make the case. The National Audit Office (itself with no internal engineering expertise) meticulously records progress on vast IT engineering procurements, such as the communications system for the Fire Service, that subsequently collapse in disarray, without even appearing to ask why such ambitious projects are being scoped by non-engineers in the first place.

RECENT PROGRESS

The good news is that this problem has not gone unnoticed. In 2009, the UK Commons Select Committee on Science and Technology published the report of its enquiry into how government uses engineering advice and expertise in policy, *Engineering: turning ideas into reality.* I, with other colleagues like Professor Julia King (then Principal of Imperial's Faculty of Engineering), gave oral evidence.

Since then there has been some noticeable progress. In December 2011, and after many months of indecision in Brussels, the President of the Commission appointed the EU's first Chief Scientific Advisor, Professor Anne Glover. Considering that so much of the UK's technical legislation arises from implementing EU directives, it must be with some relief that the UK CSA system has at last a point of contact in Brussels. Nearer to home, the UK's Department for Energy and Climate Change has been the first central department to advertise for a Head of Engineering.

At the time of writing, the Committee on Science and Technology has also launched a short follow-up investigation to its original enquiry. Imperial's Faculty of Engineering has made a submission in which we recognise the top-level improvements that have taken place. We suggest that a wider use of short-term expert secondments, especially from academia, could provide a possible solution to enriching the back-room processes where key detailed decisions get made. UK universities potentially have much to offer.

These concerns may all sound rather geeky in a world of sound-bite politics, but the problem threatens to harm the heart of a participatory democracy. It is hardly plausible to envisage a parliament able to assess engineering issues on its own. It relies on the knowledge of the executive. But if the executive no longer fully understands its engineering, the only certainties are the policy's cost, and that someone will benefit directly from charging for it. The outcome, for which the hapless taxpayer yearned, risks becoming totally indeterminate. This is not just a local British problem. Technical complexity is engulfing the participatory democracy the world over. Institutions like Imperial with its vast cohort of professional engineering alumni could prove an invaluable resource in preventing this from happening.

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STOPPRESS

STRENGTHENING THE VOICE OF SCIENCE AND ENGINEERING IN GOVERNMENT

As we went to press, the House of Lords Science and Technology Committee published its report on the role and functions of departmental CSAs. The report sets out a range of recommendations to strengthen CSAs' access to the expertise, independence and resources they need to do their job effectively by challenging ministers and continuing to play a crucial role in informing government policy.

Turning **ideas** into **reality**

When the House of Commons select committee published its 2009 report of the enquiry into how government uses engineering, it drew on a piece of career advice from Lord Mandelson that would warm the hearts of many of our staff and students: "If you really want to change the world, choose a career in engineering".

At the time, Lord Mandelson was Secretary of State for Business, Enterprise and Regulatory Reform, and his comment encapsulated the spirit of the committee's report, which observed that the recent economic crisis has presented government with a "once-in-a-generation opportunity to restructure the economy by building on the existing substantial strengths of UK engineering".

The report recognised that engineering underpins the work of many government departments and has a major role to play in addressing global challenges such as climate change, food and water supplies, energy sources and economic stability. After reviewing key themes via case studies on nuclear engineering, plastic electronics and geo-engineering, the report went on to make a number of recommendations about the specific role of engineering in government, which were broadly welcomed in the government's subsequent response. These include:

» Government should know what expertise it has in the civil service, and might look towards establishing greater levels in the generalist civil service as well as recruiting more engineering policy specialists, for example, via the science and engineering fast stream;
» The policy process should recognise that engineering and scientific advice have different things to offer, for example by seeking engineering advice earlier in the process of policy formation, and ensuring that government has enough in-house engineering expertise to act as an intelligent customer;
» Government should adopt a practice of developing roadmaps for major engineering programmes, coordinating between them, and providing more strategic support for emerging industries and policy areas such as geoengineering;
» A reorganisation of the high-level advisory structures in government could provide better overall transdepartmental management of engineering policy.