Principles and Practices for Using Scientific Advice in Government Decision Making: International Best Practices

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ABSTRACT

Concern at the role of science in public policy and decision making extends across the global community, including individual national governments, political and trading partners, and NGOs. Such concern has been heightened in recent years by major public controversies concerning the role of science in public decision making, including BSE, tainted blood and a wide array of other environmental and health concerns. The increasing emergence of cross-sectoral issues that are urgent, involve a high level of uncertainty and risk, transcend traditional departmental and disciplinary boundaries and generate widespread public and political concern have further stimulated debate, review, and restructuring of the science-decision making process in many different countries and organisations.

This report characterises the international responses to these changing demands on the science–policy process (Terms of Reference, Appendix I). The investigation and analysis was done in December 1998 and January 1999. The approach adopted was three-fold: Firstly, an extensive review was carried-out of the international literature on the role, and changing demands for science in government decision making, including in particular its role in public policy and management of high profile issues. This literature review also included an examination of the key elements of the different systems of science advising used in different nations and organisations, the best practices identified and approaches to risk assessment and public communications. Secondly, and simultaneous to this review, was a series of detailed investigations and interviews with senior officials in selected countries and NGOs as to their principles, practices and structures concerning the use of science in decision making. These countries were: Norway, Denmark, Australia, New Zealand, the United Kingdom, the European Union and the United States; the two NGOs examined were National Academies and The World Bank. Thirdly, a series of case studies was developed to examine the effective use of different principles for the incorporation of science into decision making and to highlight both the strength and weaknesses of alternative approaches. These case studies comprise the disposal of the Brent Spar (UK); The Tussock Moth infestation (New Zealand), *E.coli* infection (Scotland); transportation policy (UK); and the use of antibiotics in animal feed (EU).

Of those countries examined in this report, all have some vision which includes a desire to position themselves as knowledge-based societies in a global economy. All view the effective use of research, science and technology in government decision making as fundamental to realising this vision and are working to redesign or strengthen their national science systems to this end. The place and use of science in decision making is equally evident in the NGOs as they redefine their missions and responsibilities.

There is evidence both at national levels and within NGOs of an active, on-going debate on how best to strengthen science in decision making, to improve the links between science and public policy, and to do so recognising the rapidly changing context within which this must occur. Globalisation, widespread public education and increased access to information, a decline in respect for traditional authority and increased scepticism about science and technology are everywhere contributing to increased debate, controversy and public concern over science related issues. The use of science in public decision making has become the focus for many of these concerns. In response, different countries and organisations are experimenting with alternative models that reflect their own individual circumstances, needs and cultures.

While there is a global awareness that science and technology underpin almost all aspect of modern life and intrude into aspects of government decision making such as international trade, previously run on other criteria, there is a paradoxical increase in public questioning and even fear of science, its capabilities and use. This is highlighted in public concern regarding governments' ability to make good decision based or sound science.

Public concern extends to the use of science at all levels of government decision making. However, for routine regulatory issues, most governments have effective, non-controversial and diverse mechanisms in place to incorporate new scientific research findings and to meet shifting social objectives (such as heightened concern for the environment). Equally, in all governments, urgent decisions may be required that demand an immediate Ministerial response. In such circumstances it is not always possible to observe 'best practices' for the use of science, but to accept the need to make good, effective decisions within a tight political agenda.

The crux of the matter, and where energies and international 'rethinking' are particularly focused is on that other level of decision making where the time horizons are longer, where the decisions required are complex and involve many different types of expertise, where the risks are high and uncertainty great, and where public (and political) concern is probable. For such issues, the primary concern is often how to best use science to manage uncertainty, how to balance incomplete scientific understanding against any potential risks, and better incorporate social concerns in the policy process.

The British Government has led the way in developing and implementing a set of formal guidelines for the use of science in government decision making. However, other countries and institutions are also rethinking their approaches to the integration of science with decision making, and international codes of best practice are impacting on all countries. In this, the principles based on the Codex Alimentarius Commission provide a useful example.

Underpinning all the debates and re-evaluation of existing practices is a common theme, that of a necessary cultural shift in favour of more openness in the use of science in decision making, both as a means to secure greater public understanding and support, and as a means to improve the quality of decision making through a much wider process of debate and peer (and expert) review. Such a cultural shift is plainly much easier for some nations than others, but it is an almost universal trend.

Increased openness is viewed as one vital means to help untangle and address three other common themes or concerns: uncertainty; ethics; and risk. Each of these concerns is also being addressed in its own right and there is considerable experimentation as to the best approach.

The assessment and management of risk is now an integral part of the decision making process in most countries and organisations. What stands out is the increased awareness of the need to separate-out this exercise from any formal science/technological assessment and to carry out risk assessment recognising this fact. In particular, risk assessment is being accepted as requiring the involvement of a much wider range of participants than scientists, and the balancing of professional experts including scientists, economists, ethicists and others with lay members. Managing uncertainty or 'using our ignorance' requires the inclusion of policy makers and community representatives with scientists in formulating decisions. It also requires an acceptance that there must be a long-term programme of public education which includes promotion of a better understanding of risk and uncertainty.

One of the biggest challenges facing organisations and governments is how to address increased public expectations and meet ethical and social responsibilities in decision making. This challenge is again particularly pronounced where the decisions required concern those increasingly common, chronic problems which transcend traditional disciplinary science boundaries and most frequently involve concerns for public health and social and environmental well-being.

Uncertainty, ethics and risk are being addressed and incorporated differently in individual circumstances and as different cultures require. Independent expert panels, consensus conferences and ethics committees, the greater involvement of foreign experts, and other vehicles to broaden the range of sources of information used and involve greater public debate are all being explored and tested.

In all of this what stands out is the need to examine a range of mechanisms and processes to better incorporate science with decision making. However, whatever the mechanism, whether the development of guidelines for the use of science, or the application of some alternative system of evaluation and assessment for scientific information, such examination must recognise the changing decision making context within which the mechanism or process must fit. Implementation of guidelines and other systems designed to improve the quality of science based decision making often falter through inadequate data, weak enforcement, poor procedures, and failure to recognise the need for social and political acceptability as well as robust scientific and technical standards.

Improving the use of science in government decision making requires a cultural shift, political will, and the need to address science as but one, if vital, component, in a broad, rapidly shifting social context. The effective use of science in decision making is no longer just about managing performance, but also about managing perception. It involves and requires governments and other institutions to re-evaluate their role, and the role of science, in an increasingly integrated, but diverse world.

CHAPTER 1

THE ROLE OF SCIENCE ADVICE IN GOVERNMENT DECISION MAKING

Introduction

The structures of science systems vary enormously, reflecting the distinctive history and culture of those countries concerned. These variations inevitably influence systems of science management, the nature of the relationship between scientists, decision makers and the public, and the role of science advice in public decision making. While this is so, in the face of increasing globalization, political integration (as in the European Union) and the emergence of new trading agreements (such as NAFTA and GATT) and international conventions (for example, the Convention on Climate Change and the Convention on Biodiversity), there are clear moves to build and restructure these relationships, by 'swapping politics for expertise'.

This use of science to legitimise new relationships can be seen as a pragmatic response to changing economic, political and social needs. It is also a recognition of the extent to which science now permeates every aspect of daily life, and the inability of traditional political processes to deal effectively with many of the emerging issues on which decisions are required, without better use and management of scientific expertise. Differences in how scientific expertise is used in different countries may be explained in terms of cultural factors and established relationships between science, economy and society. Cultural and economic factors may also influence attitudes towards risk and uncertainty (Douglas, 1992). However, there is increasing recognition that the problems facing individual countries have common threads, and that the institutional processes being explored at a national level must meet essentially common, international objectives.

Science in Public Decision Making

Everyone benefits from good policy decisions, and in most western societies at least, science is accepted as an important quality dimension in the decision making process. In technologically advanced societies, scientific knowledge has commonly come to enjoy special status, often being directly equated with 'truth'. In the last thirty years this perspective has come to be increasingly challenged, and there is a growing acceptance that scientific and technological expertise as used in decision making is neither necessarily disinterested nor objective. This has reduced the capacity of government officials to maintain hierarchical control through their reliance on scientific evidence to legitimise their beliefs and policies. The general public and politicians have become less confident of the scientific advice they receive. This has lead to on-going demands for mechanisms to integrate different forms of knowledge in the science-policy process, and to extend public involvement in policy debates. Decision makers have improved their efforts to ensure that the scientific evidence used is robust, and its use transparent.

Despite the increasing complexity associated with the use of science and expert advice to solve problems and clarify conflicting interests in public decision making, there remains broad acceptance that science can and should play a key role in the policy forum. The uses of research, science and technology have been variously described. They are perhaps most commonly accepted as having a capacity to support management and decision making, provide new information and understanding, and help define alternatives and balance competing interests. However, the use of science within policy (i.e., within the political process) exposes a range of other purposes to which that knowledge is put: as a source of authority and legitimisation of policies; as a basis to 'rationalise' a policy response; to delay or avoid an unpopular action; to justify unpopular policies; as a scape-goat; to centralise decision making; as a problem solver; as an arbitrator over facts; and to clarify conflicts of interest in the policy process (Boehmer-Christiansen, 1994).

Not surprisingly, public policy is more often than not a highly contested area. Science alone may not provide the solution, and politics, culture or economic reasoning may on occasion make the scientific argument largely irrelevant. Indeed, the debate may revolve around fundamental, unresolvable differences of opinion over the nature of the society in which people want to live. All this raises a series of important questions which must be addressed in order to better handle the use of science in the public policy debate. These include:

What mechanisms and processes should be adopted to ensure the best use of science in public decision making? How can public and political confidence and trust be strengthened in the science-policy process? How can the public policy debate be framed to allow adequate consideration of scientific and other legitimate viewpoints? How should issues of uncertainty and risk be addressed and conveyed to the public? How should ethical concerns be built-into the decision making process? What best practices should be adopted to ensure consistency of approach, both within countries, and across political boundaries? What special approaches may be required to deal with the increasing emergence of those issues which involve many different Ministerial or departmental responsibilities, have a high level of uncertainty, involve public concern over risk, require multi-disciplinary expertise and demand a policy response?

The Decision-Making Environment

Arguably, the transformation of scientific evidence into expertise occurs when it is incorporated into the decision-making process. How this occurs depends on the interface between the science process and the decision-making system (Roqueplo, 1994). International experience as exemplified in the various case studies and examples used in this report illustrate the extent to which the geography and culture of the nation or organisation concerned shape that interface. As noted above, however, globalisation and other forces are putting pressure on national governments to develop more internationally consistent responses to issues of common concern so that there is evidence of some convergence in the approaches adopted in different countries.

The central and increasingly controversial role of science in policy reflects the rapid evolution in scientific understanding, perhaps particularly in the biological sciences. It also reflects the fact that science is moving at a rate which often exceeds the ability and capacity of institutions, governments, or individual citizens to understand its implications or to respond effectively to its impact. The result is a raft of moral, ethical, and policy dilemmas.

Science now underpins almost every aspect of daily life, acts as a major element in international competitiveness, influences human health and the quality of life, and is a driving force in global change. High profile controversies over blood products tainted with the AIDS virus or hepatitis, BSE, and other issues have fuelled public concern and raised political questions over the quality of science advice used in decision making. Part of this context is the emergence of a public with much greater access to information than before, a public sceptical of authority, and a scientific community that has proven less than skilled in conveying to either the public or decision makers the concepts of uncertainty, complexity, hazard and risk.

In effect, whether in Canada or elsewhere, the traditional science and technology priorities of government have been displaced. The high priority given to science for defence and development during World War II and which was maintained well into the 1950s and 1960s (providing not incidentally a strong popular and political basis to maintain and support government science) has shifted in favour of scientific and technology concerns related to:

- Global environmental threats, such as global warming, ozone depletion, biodiversity, and resource depletion.

- Biomedical issues, such as the prevention and cure of AIDS, the prevention of BSE, and genetic engineering.

- Sustainable development, including energy efficiency, alternative agriculture, and sustainable resource use.

- Improved manufacturing technologies, including clean technologies, and reduced resource consumption.

- Information technologies and computers.

These new and emerging issues have not replaced traditional science needs, but have shifted the emphasis and refocussed concern in the decision making process. The new agenda is characterised by problems which are chronic, complex and global. It poses a series of challenges to the science-decision-making system that transcend national interests and demand a response evidenced in the evolution of new mechanisms and processes to better incorporate science within the decision making system.

The Science - Policy Interface

It goes without question that decision makers should have a close, continuing interaction with scientists, and that there should be a relationship of confidence, respect and trust between the two communities. However, both the differences in the culture between scientists and decision-makers, wider management needs and ideological preferences make such a positive relationship difficult to secure. The undermining of the positive model of science as 'truth' and a source of certified, neutral knowledge, uncorrupted by the influence of politics has tended to further isolate the two groups.

The characteristics of the two cultures include:

- A scientific training generally favours specialisation over breadth and cross-disciplinary understanding. Decision makers must offer advice across a wide range of different issues and respond to shifting political agendas.

- Communication between scientists and decision makers requires a common basis of understanding both of the science involved and of the policy objectives. In the translation of the message between the two communities, attempts to simplify risk the generation of superficialities, and misunderstandings.

- Research and science frequently require long time horizons and the testing of data against hypotheses, leading to a conclusion. The decision making process operates within a much more explicit political context, and more commonly has a predetermined goal, and involves risk and compromise.

- Scientists strive for objectivity and 'testability'. They are reluctant to recognise political objectives. The decision maker must work to meet these objectives.

(After, Colyer, 1994)

In practice, research and science are frequently and consciously separated from decision making within the government system. Consequently, whether and how science is incorporated into decision making frequently depends not only on the decision makers' recognition of the need for scientific input, but on the capacity of decision makers to readily obtain the research and science required. Recognition of that need requires 'science literacy', in effect, a sensitivity to the value of science and an appreciation by those officials concerned of its value in decision making (Smith, 1997). This may not exist.

Even where officials do acknowledge the potential contribution of science to quality advice, they may yet be stymied by the time constraints under which they must operate, the format in which the scientific evidence is available, and the constraints under which their advice must be presented.

In these circumstances, some tension between scientists and decision makers must be expected and accepted. Indeed, it may be the price of sound, objective advice (Beckler, 1991). But the effective coupling of the science with the policy process remains crucial to its success.

Typically there are no ground-rules for how science is incorporated with decision making. Nationally and internationally, science systems have evolved in an *ad hoc* fashion, or have been arranged with little specific regard to the use of science for decision making.

Internal Procedures

Most governments and NGOs use a wide range of mechanisms to build science into decision making. Although there are increasing reasons why such institutions are drawing upon outside sources for science advice, more often that advice comes from within the government's own institutional system.

Although the words 'policy' and 'decision making' are used largely interchangeably in this report, it is important to recognise that while, as noted earlier, science can serve a range of different political purposes, government research and science commonly serve three basic functions within the decision-making process:

- To monitor, measure and provide scientific and technical assessments to support national regulatory needs (for example, fishing quotas, health and safety regulations, etc.).

- To help formulate national policies and support international negotiations and trade agreements (for example, GATT negotiations and environmental Conventions).

- To provide scientific and technological advice to Ministers on high-level, complex long-term, national issues (for example, transgenic transplants, BSE, and nuclear power).

In addition, of course, government funded research and support for science includes development of 'public good' knowledge (i.e., basic research). Government also supports science through its purchasing policy, as for example, defence procurements, space programmes and the like. Although publicly (and politically) contentious issues can emerge from any of these areas in which science is used, current demands to improve the use of science in decision making centre largely, if not exclusively, on high-level national issues. However, it is worth noting that while most of those interviewed identified such issues as the focus of concern, they believed them to be generally identifiable and predictable, therefore manageable, while it was the contentious, high profile issues that emerged from 'left field' that were least predictable, and most intransigent.

The United Kingdom is plainly a leader in the development and implementation of guidelines to promote a coherent approach to the use of science across all arms of government. However, the examples of the European Union and New Zealand, and the case studies of *E.coli* (Case Study 1), and the Brent Spar (Case Study 2) in particular, all illustrate the increasing use of generic approaches, guidelines or methodologies to address policy issues which have a sizeable science component.

The reasons for this increasing codification of approaches to the use of science in decision making appear to be fourfold. They are in part a response to a loss of scientific credibility due to some well-publicised policy disasters. Increasing too, costly legal challenges to science-based decision making have undermined the credibility of government decision making processes, and raised political alarm. Guidelines are a means to incorporate the precautionary principle in decision making. They are also seen as a means to improve quality control over the decision making process.

Arguably, it is premature to come to any final decision on the effectiveness of guidelines in the provision of policy advice or in the overall process of decision making. However, British officials certainly see an early positive impact. The guidelines there have raised awareness of the need for careful handling of scientific evidence and improved the consistency of approach across government.

Both in the example of the United Kingdom, and in the other examples presented, the development of guidelines in and of themselves is no assurance that all controversies will be resolved and problems avoided. The guidelines should help minimise the risk of policy disasters. They also offer a means to assure the public that best practices are in place. The guidelines should also be capable of substantiation in a court of law should a challenge to a decision occur, or litigation over the impact of a decision be made. What the examples and case studies highlight, however, is the persistent need to set such guidelines within the wider context in which decisions are made, including their social, political, and ethical dimensions (see, for example, Irwin, 1995; Bovens and 'tHart, 1996).

The problem with guidelines is that too often they may appear trite. This can make them easy to accept, but equally easy to ignore. Thus, their strength or effectiveness rests on their implementation. In the British case, this has resulted in the allocation of responsibility within departments and agencies to implement and monitor their use. It is in the allocation of such responsibility that questions of their precise meaning and implications arose, and at which point their impact began to be fully felt.

This is important. It highlights the need to communicate the very existence of the guidelines and a potential need to train personnel to implement and monitor their implementation. This requires scientists and decision makers to understand the context within which they themselves work.

The perceived failure of guidelines, as is evident in the case of the Brent Spar and *E.coli* (and arguably in the case of BSE, although that is not discussed here) rests largely on their misinterpretation, on the lack of appropriately qualified personnel to implement them, lack of effective monitoring of their implementation, or a failure to recognise the social and political context within which the guidelines apply.

Whether guidelines for the use of science in decision making are adopted (as in the United Kingdom) or whether such practices are introduced as a product of international agreements (as in the case of the Codex Alimentarius) there is substantial evidence (as in Denmark, Norway, and New Zealand) of increasing attempts to strengthen the coordination and leadership of science within government systems. In the United Kingdom, Australia and the United States this is achieved in part through a Chief Scientific Adviser, Chief Scientist, (or Chief Scientific Adviser to the President as is the case of the United States).

Whether the national preference is for a chief scientist or the equivalent may be related to the overall structure of government and national cultural preferences. In the case of the United Kingdom the importance of the position lies mainly in the stature of the individual concerned, their powers of persuasion, and in their direct access to the Prime Minister. The role and title undoubtedly also assure the profile of science within government. This is an important consideration in the on-going debate as to the need for such a position within the devolved national government structure being established in Scotland. In Denmark, the Ministry of Research and Information Technology, established in 1993, was designed specifically to contribute to a more coherent and coordinated advisory structure. The establishment of the Norwegian Research Council also in 1993, is designed to meet a similar leadership and coordinating role. In each case, the need is two fold: to better improve domestic advisory relationships, and to ensure that domestic arrangements are properly integrated within a wider international context.

Outside Advice

Outside advice is characteristically used by governments and other organisations to meet a range of different needs. They most commonly exist to meet narrow technical needs and usually operate in secret and help fulfil specific departmental mandates. Sometimes the use of such expert committees is mandated by law; at other times they have simply proven an effective means to obtain advice of a type or quality not otherwise available.

Outside scientific advice is characteristically used to meet a wide range of different circumstances, such as:

- Where there is a need to access information unavailable in-house.
- Where the issue cuts across a number of different departmental responsibilities.
- Where the decision required is of such high profile or is perceived as likely to be controversial so that independent expertise is viewed as desirable.
- Where there is a need to maintain or increase public confidence.
- Where cutting-edge research/scientific expertise is required.

(After Beckler 1991)

The use of external sources of advice appears to be an increasing characteristic of many governments. It is illustrative that a recent survey of the advisory role of national academies highlighted a major increase in their own recognition of their role and responsibility as independent sources of science advice for public policy (Collins, 1998). The expanded use of independent advice is occurring for all of the reasons listed above, but most particularly because of the increasing need to address issues which cannot be readily addressed with existing in-house arrangements. The key elements in these issues is usually the need for cross-disciplinary science and their implications across several different departmental mandates. Many of these issues are also controversial, and high profile.

As is evident from the national profiles and individual case studies, it is clear that there are a number of vehicles to generate independent science advice to government. Many of these instruments have a long established history, and there is an element of fashion in the extent to which they are used. There is also a significant cultural factor favouring specific mechanisms in individual countries, for example, the role of the National Academy of Science in the United States, the emergence of independent science panels in New Zealand (Case Study 3), and the establishment of ethics committees in Norway and Denmark.

It would be illusory to assume from all this that governments either want independent advice or are prepared to pay for it. There is little evidence that this is so. The increase in use of independent science advice is very much a product of necessity and its acceptance partly dictated by an ideological perspective which favours a plurality of advice in public policy.

As both the examination of the role of national academies, and the use of independent science panels in New Zealand shows, the use of independent advisory bodies is not without problems for governments, nor indeed for those advisers concerned. New Zealand has now designed guidelines regarding the establishment and operation of independent science panels (1998), and addressed the legal responsibilities associated with the acceptance of membership of such panels. A manual of procedural guidelines has been drafted by The Royal Society of Canada, for expert panels (The Royal Society of Canada, 1996). The British Government is exploring the need for similar guidelines. The example of the BSE advisory science committee in the United Kingdom has highlighted the need for greater consistency and rigour in the operation of such institutions and the need to advise members of the legal and ethical responsibilities that accompany acceptance of expert status.

The three imperatives identified as underpinning independent science panels in New Zealand–the need to build in appropriate means of quality assurance, necessary breadth of representation of members, and appropriate authority and responsibility (Smith, 1997)–are important characteristics inherent in all advisory systems (including in-house advice–as evidenced in the UK *Guidelines,* Office of Science and Technology, 1997).

Quality Control

The traditional approach to quality control in science is peer review. This remains an integral and universal component for that research by scientists within a policy context. For small countries in particular, and in this context the examples of Denmark, Norway, and New Zealand are particularly pertinent, the national science community is small. In these circumstances, governments are increasingly exposing their science for policy to scrutiny by scientists from other nations, to avoid accusations of 'cronyism' or bias in the interpretation of data. The involvement of 'external' peer review of science for policy advice is customary in Scandinavia and there is easy communication among the countries of the region. Increasingly, however, such review involves scientists from other European countries as well. This reflects the growing interdependence of Europe as a whole, but also the increasing acceptance of the need for broader review. The physical isolation of New Zealand makes the involvement of non-nationals in panels or as reviewers of policy advice less characteristic, though perhaps increasingly accepted. For example, the scientific information pertaining to *calecivirus* (RCD) in 1997, prior to a formal decision as to its release in New Zealand for rabbit management, was fully reviewed by overseas science experts. British experience with BSE has again highlighted the need for changes in quality control on science advice, and an acceptance of the value of using experts from elsewhere in Europe and North America on important advisory committees.

Whether in the United States, Britain, or elsewhere a crucial component in quality control and in increasing the public (and political) credibility of science advice, rests on the scientific reputation and prestige of the individuals selected to provide advice. The increasingly public, controversial nature of much such advice seems to have reduced the automatic acceptance of this basis in the selection of advisers. The British for example now have a system in place to encourage independent scrutiny of appointments.

A much bigger, more controversial issue is who the experts are (i.e. who should be appointed to panels or other advisory groups) when the scientific information is incomplete and uncertain, and when a wide array of non-science issues such as ethics and social impact must be incorporated into the advice or decision. As specifically identified in a New Zealand context (Smith, 1997), the value of participation by non-science experts in such circumstances rests in some part on their ability to raise questions as much as to provide answers. Narrowly based scientific advice is increasingly proving inadequate as highlighted in the case of the Brent Spar.

Review of the disposal options for the Brent Spar recommended a parallel evaluation of social and political acceptability to any technical assessment/evaluation process (Case Study 2). Professor Pennington, with respect to the *E.coli* outbreak in Scotland, identified the value of including a behavioural scientist on his committee. His reasoning was that while the outbreak had a basis of explanation in science, its occurrence and spread rested on a failure of individuals to implement appropriate hygiene regulations and that future control or prevention of infection rests on appropriate modification of such behaviour—matters well beyond the expertise of natural scientists.

The involvement of non-scientists on science/policy advisory panels is contentious among scientists. Where a non-scientist is included on the advisory group, the scientists involved may effectively exclude their participation in discussion. This was noted in some such efforts in the United Kingdom. However, the risk posed by non-recognition of those ethical, social and political concerns as exemplified by Brent Spar and the *E.coli* infection, and the resultant policy failure is increasingly encouraging the involvement of lay persons, with proper acknowledgment of the need to carefully select such participants.

The argument can be extended still further. Ravetz (1986) has cogently argued the need to involve managers, policy makers and public interest groups. He argues their inclusion primarily as a means to resolve the uncertainty inherent in using science in the face of the complexity and magnitude of many major policy problems.

What Ravetz also points up is the inherent difficulty in determining 'who are the peers' in science for policy, and the particular problems of securing scientific advice in a policy context. This latter point has been persuasively examined in *Mandated Science* (Salter, 1988) which explores the implications of scientific research or advice designed to address a policy goal. In such a context, as he points out, the scientist is not a free agent seeking 'the truth' but establishes a research project or provides advice knowing the policy goal. In other words, the scientist does not choose the project, rather it is defined by the (policy) client. In this context, advice may be required within a time framework that pays little heed to the needs of science, and where the boundaries between science and policy are easily disregarded. Plainly in such circumstances the constraints on the scientist are such that the difficulties of assuring sufficient and appropriate processes of quality control are greatly increased.

The example of National Academies, highlights the need for scientists to recognise both the nature and limitations on their expertise. However, individual circumstances easily cloud the issue. Scientists within government, in particular, may well face particular restraints in their role as public servants that are contrary to their own perception of their role as scientists. Extending peer review to include, for example, managers may smack of political control rather than an acknowledgment of the complex world within which both communities operate. Increased openness in the scientific information and advice used in decision making is commonly viewed as an important step forward to manage these concerns.

Transparency

In a hierarchical society secrecy is readily equated with power. In modern technologically advanced societies, hierarchical management systems are breaking down in the face of changing needs. The 'flat' management structures now increasingly typical in the commercial sector are a direct response to the need for greater flexibility in a rapidly changing global economy. Such shifts are equally a response to much wider social and political changes that make traditional power structures vulnerable in the face of popular demands for greater accountability from the private sector, and all branches of the public service.

Consequently, moves to increase the transparency or openness of the scientific information and advice used in public decision making is at once a response to public demand and a tactical shift by governments, public servants and scientists to increase (or maintain) support for their activities, and recognition of the difficulties faced in using science, particularly in the face of uncertainty. Increased openness may generate short term costs and discomfort as identified in the case of the British science system (*Memorandum* from The Office of Science and Technology, 1998). The public may ask awkward questions, and express considerable concern or displeasure at actions executed in their name, or at the scientific basis for these decisions. Equally, they may become frustrated at the volume of information presented to them and the pressure on their time to comment and 'get involved'. Politicians and public servants may feel vulnerable when their operational processes are tested in the media. Scientists too, despite their protestations that science is built on openness and debate may not find it easy to defend their analyses against sceptical colleagues, or an even more sceptical public.

The extent to which the science for policy process has traditionally been 'transparent' has been shaped by the political and social culture of the country concerned. For example, Norway and Denmark have a long history of a relatively open, participatory democracy. In the United States, the 1970 Freedom of Information Act opened agency records to public surveillance and the 1972 Federal Advisory Committee Act severely restricted the ability to exclude the public from meetings of advisory committees. In the United Kingdom and New Zealand on the other hand, the push for greater openness is more recent and as yet, less well established.

Moves favouring greater openness in the science - decision making process can be explained to some extent in terms of major long-term shifts in social values and an increasing rejection by the public of delegation of authority to a self-appointed elite. However, the spur for action has frequently been a specific incident where government claims for the scientific basis of a policy decision have been undermined by subsequent events.

Greater openness is therefore also in large part a direct response to the failure of secrecy to secure public (and/or political) confidence in science based decision making. In Canada, attacks on the use of science in fisheries' policy (Hutchings, Walters and Haedrich, 1997) and in Britain, on policies with respect to BSE (at least from 1996 on, there have been repeated articles in *Nature* bemoaning the secrecy surrounding the scientific evidence used in the BSE crisis) both centre on this issue. Increasingly, secrecy is viewed as no more than a means to disguise a government's selective use of science advice.

Openness in the science advice for decision making, including access to all relevant data and analysis, is increasingly accepted as necessary, and as the best means to address a series of challenges to science and public policy. These challenges include: public confidence in the decision making process, international concerns as to the quality of data used pertaining to trade and public safety issues, the effective management of uncertainty and risk, and the better incorporation of ethical and social values in the science debate.

Openness is no simple panacea. It is not easily achieved and for some governments and agencies requires a fundamental cultural shift. It also has several different dimensions, including the public availability of data, extended peer review, explicit quality controls, public debate, and increased public accountability of decision makers and policy advisers. What is not incorporated in this agenda is greater openness in the actual process of decision making. The basic premise is simply increased transparency in the scientific advice used. Plainly decision makers may well still not act on such advice, but openness would assure that they could no longer claim to have done so, and their incorporation of other considerations would be more explicit.

All these different dimensions of openness are addressed within the UK Guidelines (Office of Science and Technology, 1997). Access to scientific data used in decision making is already obtainable in many countries under access to information legislation. The cost of access and proprietary rights on data remain a concern and are highlighted in a neo-liberal regime as in New Zealand, where science is increasingly organised within a user-pay system. Extended peer review of scientific information is already being promoted by the process of globalisation and the use of international scientific organisations, such as, for example, the International Council for the Exploration of the Seas (ICES) (see Nordic Union example); and global Conventions, as on climate change (see Case Study 4). In both these instances the capacity to reach a broad scientific consensus minimises political conflict over the scientific data and analyses and focusses argument on the appropriate policy response.

Extended peer review is evident in the use of overseas experts on science panels (as in the UK for BSE, and as is almost routinely observed in Norway and elsewhere in Scandinavia). It provides a powerful means to break any perception of an inner group of science advisers based on national allegiance, and helps assure the confidence of trading partners. More contentious is the use of lay persons on science advisory groups. Work in New Zealand highlighted the potential value of such representation in raising questions and viewing problems from a different perspective (Smith, 1997). Public hearings may provide an alternative mechanism. Lay representation on advisory panels has proven highly successful in the United States, as in the NASA Challenger inquiry. Consensus conferences (as in Scandinavia, the United Kingdom, and New Zealand) provide yet another approach to promote quality control within a more transparent process.

Social Science

For the most part this study focuses on the place of the physical and natural sciences in public decision making. However, the social sciences also play a substantial role in public policy, and this is not limited to such areas as education, social welfare, or penal policy. It is perhaps particularly noteworthy that the recent Ehlers' report in the United States which sets guidelines for a new science policy there, explicitly includes the social sciences within its mandate (1998, p.9). Departments and agencies traditionally associated with the natural and physical sciences also require information and analysis from social scientists. The case studies illustrate this point. Thus, for example, international data on climate warming have been extended using understanding of human behaviour to develop an integrated transportation policy for the United Kingdom (Case Study 4). Management of the Tussock Moth in New Zealand integrated understanding and expertise on perception and behaviour to control the outbreak (Case Study 3). Analysis of previous *E.coli* outbreaks (Case Study 1) highlights the need for the cooperation and understanding of both consumers and food processors to prevent or manage future outbreaks. Such examples have forced increased recognition by decision makers of the importance of the social sciences in public policy.

Newby (1992) extends the argument still further. He presents the need to recognise the limitations of the 'linear model' of translating science into technology as the impetus for social and economic progress, and pushes the case to fully incorporate the social sciences with the physical and natural sciences in the policy process. He argues that an interactive model of the relationship between science, technology, and society requires acceptance of the social sciences as an integral component in understanding how scientific excellence and technological innovation can be used to economic and social well being.

The argument presented by Newby is increasingly accepted by managers and government decision makers, and has resulted in at least two major reports on the place of the social sciences in public decision making (Australian Science, Technology and Engineering Council, 1997; Ministerial Review - New Zealand, 1995). However, the integration of social science with the physical and natural sciences and their incorporation within the decision making process is proving difficult to implement in practice.

In addition to the common challenges posed in the use of science in decision making, there is a substantial cultural gulf between the physical and natural sciences, and the social sciences. To some extent this rests on the different methodologies inherent in the two cultures. Part of the problem is also in the nature of the social sciences which include a number of individual disciplines each with their own body of knowledge and approach, and their consequently lesser tendency to view themselves as part of one 'social science culture' than their counterparts in the other sciences.

The Australian report summarised the barriers to change as:

- inadequate communication between practitioners and researchers across disciplines, and with the general public;

- institutional impediments to trans-disciplinary research;

- the lack of an identified responsibility within government for broad policy making on research in the social sciences and humanities; and

- ineffective use of humanities and social sciences research in policy making.

The New Zealand study echoes these concerns. In a review of science in policy making (Smith, 1998) recorded that every science based department recognised the need to strengthen its capacity to use social science research and better incorporate it in the policy process, but was uncertain how this might best be secured. Work for this study generally confirms this earlier perspective. Most countries acknowledge the role of, and increasing need for, social science input to decision making but find the problem difficult to resolve. The British Foresight exercise highlights the increasing evidence that social and cultural forces will play a dominant role in how science and technology are used. All the Case Studies support this view.

Risk Assessment

Risk assessment is now an integral component in most major policy decisions and this is clearly evidenced in the Case Studies. However, the domination of risk assessment by expert approaches in which science is viewed as the source of objective knowledge and understanding is increasingly proving unsatisfactory. In this, the use of risk analysis in the disposal of the Brent Spar (Case Study 2) provides an apt example. Just as there are moves within science to more consensual approaches which acknowledge scientific uncertainty and the indeterminate nature of knowledge, so too there is a growing awareness that risk assessment must be explicitly separated from the science process. Effective risk assessment requires an open context which legitimises different sources of knowledge, and integrates technical concerns with social and ethical values, political acceptability, and cost effectiveness (see, for example, Case Studies 1, 2, 3, 5). This is not to deny the legitimate need for technical evaluation and assessment, but to emphasise that risk assessment is a much broader concern than any conventional 'science' issue. (Fisk, 1998; Office of Science and Technology, 1998).

In the public eye, risk assessment is commonly presented as a rigorous tool. Politicians too, commonly view the results of a risk assessment as providing an objective measure on which to base a decision. Any resultant public dissatisfaction (as in the case of the Brent Spar) can consequently seriously undermine the credibility of the process. Yet what is included in any risk assessment depends not only on the availability of information and data, but on the perception from which the assessment is made. Thus for example, the identification of BSE as an animal health problem could result on an assessment which highlights the potential risk to animal health but ignores (or plays down) any risk to people. In practice, of course, as scientific understanding increased BSE emerged as a grave risk to human health. In the United Kingdom this shift in risk perception was reflected in change in the composition of the BSE advisory committee in favour of public health rather than animal health experts. Equally, the UK Government's legitimisation of its handling of the BSE crisis by an appeal to science, undermined the legitimacy of technical and scientific competencies, while highlighting the need incorporate an array of other factors in any risk assessment for the development of public policy.

Uncertainty is not a unitary property in some external environment amenable to objective analysis and interpretation in the traditional framework of the natural and physical sciences. It is bounded by important social uncertainties. Risk assessment therefore involves an interactive debate between a number of different stakeholders, including scientists, business leaders, lay persons, technical experts, and policy makers. An effective risk assessment for decision making involves each of these different stakeholders developing a consensus framework which integrates their different perceptions and expectations (see, for example, Powell and Leiss, 1998).

The limitations of a risk assessment process which ignores cost benefit analyses (as for example, in the case of the Tussock Moth in New Zealand (Case Study 3) or ignores social and political risks (as in the case of the Brent Spar, Case Study 2) reinforce the need for a broader perspective. It may also raise concerns that a risk assessment become a somewhat 'fuzzy' process. However, this is again to ignore the uncertainty inherent in science and the limitations on objective quantification of risk. It is also to deny the potential to develop robust risk assessment using the conventional 'burden of proof' arguments established in courts of law.

Management of risk is now an intrinsic part of good business practice. Risk assessment provides a rigorous way of thinking that can contribute substantially to good public decision making. Increasingly there is acceptance that the political, social, economic, legal and physical environments within which the assessment is made must be properly defined as a preliminary step in this process. Establishing this context is an essential precondition for the identification of the risks which must be addressed, analysed, and prioritised. Recent experience as illustrated in this report highlights the increasing recognition of the value of separating the risk assessment exercise from the science, and giving specific responsibility for risk *assessment* to an independent agency, leaving government to *manage* the risk (see, Leiss, 1998). This has again been further prompted by the apparent conflict of interest between departments whose responsibilities could conflict with public health, consumer protection, or environmental conservation.

Science Communications

Although the issue of communications in science extends well beyond risk communications both are linked in the overall debate on the need for greater openness in the science decision making process.

In keeping with the theme developed in this report, it is important to recognise that in a modern technologically advanced society, it is no longer possible to assume that pronouncements from experts will be accepted at face value. Repeated studies identify the need for science communications to be conceived as part of an iterative process between scientists, risk analysts, and the general public (see, for example, Irwin, 1995; and Powell and Leiss, 1998).

Productive communications and productive policy is commonly accepted as dependent on the public's understanding of science. Consequently, internationally, science policy increasingly includes an explicit strategy to increase public understanding of science. This is certainly the case in all the countries reviewed in this report. However, as Doble (1996) points out, surveys suggest that it is not always lack of understanding that constrains the public's thoughtful consideration of science issues, but lack of an appropriate framework that outlines the choices and trade-offs in decision making. This further reinforces the point made in the *Memorandum by the Office of Science and Technology* (1998) that in the area of risk assessment, for example, "bland statements of zero risk or 100% safety are much more likely to undermine the scientific advisory system than to promote confidence in it" (p8). Thus as the UK *Guidelines* require, it is now necessary in communicating with the public to distinguish between scientific advice and value judgements, and to identify and highlight any contentious areas.

Although national policies commonly include a commitment to improve the public's understanding of science, individual scientists interviewed frequently noted the greater need to improve the public's understanding of risk and uncertainty. It was also pointed out that while promoting the improved public understanding of science is a valid professional activity, it is a gross assumption that increased understanding will lead to increased approval of science, anymore than increased understanding of any other activity necessarily leads to improved support for that activity.

Public communication is now accepted as a necessary and integral part of most science based policies. This is not without risks. It may deflect attention from other important issues (as, for example, in Case Study 2, on the Tussock Moth). However, equally an effective communications' strategy is integral to the success of most if not all major policy decisions (for example, see the examples of *E.coli* and British transport policy - Case Studies 1 and 4).

Successful science communications may conflict with a scientist's commercial or governmental contract obligations. It also requires time that many scientists see as a direct debit both in dollars and time against their research budget. It requires a range of attributes and skills, including a capacity to present findings within a meaningful context. There remains a stigma of popularisation within science. And while the communication skills necessary are rarely part of a scientist's education or training, nor are they commonly perceived as contributing to one's promotion prospects (Lowe, 1997).

Structures and Procedures

All the countries examined exhibit a range of different structures or institutions to manage science for decision making. These have evolved over the years, reflecting historical factors, cultural characteristics and chance (see, for example, Golden, 1991; Stocker, 1997). However, as the individual national examples and Case Studies show, there is an increasing commonality of problems to be addressed globally, and under the pressure of international trade agreements and Conventions, increasing convergence in the ways science is used in decision making.

There is no reason to believe that any one country has that ideal structure in place to best manage science for policy, or to address emerging issues. All those countries examined willingly admit their uncertainty as to their capability to properly manage science for decision making. All acknowledge that it is unrealistic to simply transpose one national model into a different national context. The UK *Guidelines* provide a useful framework for evaluating the robustness of existing institutional arrangements and processes and are used as such in the Canadian counterpart to this report (Halliwell and Smith, 1999). It is equally possible to identify two common themes from this current study which all the countries concerned have addressed, or are making efforts to address, whether through new institutional arrangements or improved processes.

Openness: This is a recurrent element in this report. It is crystallised in the UK *Guidelines* which offer a set of procedures to strengthen existing institutional arrangements. In the United Kingdom, as in USA, New Zealand and elsewhere, legislation increasing access to information supports this overall procedural thrust.

Most countries either have or are experimenting with specific institutional arrangements to support this move. Consensual conferences and ethics committees are two particular initiatives, but there is also increasing use of the Internet and conventional publication to increase access to scientific data and analyses used in decision making.

Coordination and Leadership: All countries are promoting processes and increasing efforts, including the establishment of new institutional arrangements to ensure better coordination and leadership of science activities for decision making. Again in the UK, the *Guidelines* have been used to encourage greater coordination through their use as a basis for discussions between the Chief Science Adviser and departmental Chief Scientists. In Norway and Denmark, restructuring and the establishment of the Norwegian Research Council and the Danish Ministry for Research and

Information Technology was designed primarily to promote a better coordinated approach. The restructuring of the science advisory system in the EU and in Australia, the formation of the Prime Minister's Science, Engineering and Innovation Council and modifications to the Coordination Committee on Science and Technology are all designed to similar ends. These institutional changes are all reinforced with stronger processes to meet national goals.

Both issues of openness, and coordination and leadership, highlight the extent to which science and technology now impinge on almost every aspect of daily life, and the extent to which national management of public policy in modern, technologically advanced nations is being driven by common forces of globalisation. Today, more than ever, national priorities invariably cross traditional departmental/management arrangements. It is, for example, difficult to envisage any major, emerging, high profile issue which does not impinge on research and science, nor any such issue which does not at once have implications for public health, education, and environmental well being.

Most, if not all the countries discussed here already have well established, reasonably comprehensive and effective institutional arrangements for the use of science in decision making. New institutional arrangements are therefore most commonly designed to refine existing arrangements and invariably require a parallel strengthening of those processes which shape the operation of these institutions. Research, science and technology have always been part of the social fabric rather than a distinct property of the external environment. It is the very success of science in becoming such a major part of every aspect of daily life that requires such evolutionary measures to strengthen, clarify, and manage the interaction between science and public policies.

Science in a Social Context

The central and increasingly contentious role of science in the modern world is causing a plethora of scientific and public controversies over scientific and technical issues. These issues frequently have far reaching economic, environmental and ethical implications. They increasingly incorporate a global dimension.

Substantial advances in science at an disciplinary level are compounded by a growing realisation that everything is linked to everything else, so that it is increasingly recognised that addressing future challenges requires the use of science in public policy in a much more powerful and rigorous framework than was previously the case.

There is increasing depth of disciplinary knowledge, increasing awareness of the growing interconnectedness of people, technology and natural systems and paradoxically perhaps, increasing awareness of the uncertainty in our understanding of these interconnections. All this is embedded in a context where people are better informed, more sceptical of authority and expertise, and increasingly demanding greater public accountability in public decision making. Against this background, established linear approaches to incorporate science into public decision making are proving inadequate, and new institutions and processes are being tested to meet new needs. These new approaches, as exemplified in this report, are characterised by a more inclusive or consensual partnership between scientists, decision makers, private corporations and lay persons, designed to formulate a response to current problems that is acceptable to all stakeholders.

To address the challenges posed in today's 'risk society' it is necessary to recognise that issues of risk and uncertainty are not separate from the public's concerns around the uses of science. Science is no longer viewed as a higher form of rationality or 'enlightenment' (Irwin, 1995) but an obstacle to the expression of concerns. The challenge facing governments, therefore is how to find new ways of using and managing science within a risk society, that re-legitimises the use of science in decision making. To this extent at least, the apparent increasing evidence of misalignment between science and decision making in public policy is a crisis in the popular understanding of the relationship between people, science and the world in which we live, and the social institutions and conventions we use to manage these relationships.

CHAPTER 2

NATIONAL PERSPECTIVES

The European Union: Scientific Rationality and the Policy Process

The creation of the European Union was characterised by a pragmatic use of science to replace national politics. The very nature of this process has resulted in a drawing on multiple and pluralistic streams of science advice. These sources of expertise include the Commission itself, national expertise, private consultants, and the expertise of lobbyists and others. Each type of expertise, and each source has its own place and role in the decision making process.

The result is by no means an assurance of scientific rationality in decision making or greater transparency in the expression of different points of view. There is not yet any evidence of any truly independent European expertise, the links between European research programmes and European decision making processes remain weak, and there is a lack of overall transparency in the advisory process. Consensus decision making at a European level often involves an amalgam of national consensual positions and an inherent tendency to address issues using science, but 'weighing' that science to incorporate economic and social interests. European environmental policy for example, can be described as "the outcome of bargaining in which political factors play a dominant role, though these factors are usually neglected in analyses and remain hidden under mountains of expert advice built on postulates of rationality that tend to be narrowly economic or technological ... so that European environmental policy is largely piecemeal and formulated by lawyers." (Horlick-Jones 1994, p10).

The Use of Scientific and Technical Expertise

The overall tendency within the European Union remains an internationalisation of policy resting on the creation of common institutions. In this the European Environmental Agency is an example. Through such institutions there is an imposition of normative structures, standards and procedures equally binding on all member states. This can evolve in two ways, either through the initiation of a member state influencing other states and leading to the modification of European norms (as in the lead generated by some environmentally progressive, northern European states) or through the European Union itself taking the initiative. The structure of the European Union undoubtedly allows easier input of expertise (scientific and other) than in many national states, but the political context into which this expertise falls has an enormous capacity to shape its use in debate.

Overall, the use of increasing scientific and technological knowledge in decision making and legislation within the European Union is devolved to expert committees of various types, chaired and serviced by the Commission, and include representatives of each member state. These committees vary in their powers. Hundreds of committees exist. All have traditionally met in secret and until recently none have made public the minutes of their meetings.

The non-democratic nature of these committees has been cause for concern. Arguably the European Parliament and its Standing Committees have lacked the capacity to effectively assess and review the proposals from the expert committees, and greater public transparency in the deliberations of the expert committees would at least allow interest groups and professional associations to alert Parliamentarians to concerns and promote wider debate.

Reform

Some moves to address these concerns are now in place in response to issues raised by the BSE crisis. In 1997, the European Commission announced a substantial reform of its scientific advisory committees. This involves their removal from Commission departments whose interests could conflict with concern for public health and consumer protection.

These reforms are in part a response to criticism of how the Commission handled BSE, and reflect similar concerns expressed in the UK and elsewhere over potential conflicts of interests within Ministries of Agriculture with respect to food production and safety.

The European reform package involves the creation of a new department for scientific advice on health under the Directorate for Consumer Policy (now Consumer Policy and Protection of Consumer Health). It is this Directorate which has produced the draft guidelines discussed below.

The reform of the scientific advisory committees is designed to improve the clarity and openness of the science advisory process. To remedy many of the concerns raised in the previous section, all advisory committees are now brought under a steering committee responsible for developing and implementing standardised rules as to how advisory committees should be established and operated. The steering committee has powers to oversee the advisory committees and the biggest science issues at least, are now discussed first at this level, prior to distribution as required for debate and action within the advisory plan. Details of committee members and minutes of meetings are now publicly available on the Internet.

Guidelines and Principles

In initial attempts to promote European cooperation, science was the motivating and driving force. Now integration is the driving force and science but one of many mechanisms through which this is evidenced.

Stumbling and confusing though the process may have been until recently, there remains a long-term drive to standardise the use of science and develop a coherent, consistent and robust set of guidelines or procedures which could be justified in international law. Such guidelines are viewed as a means to harmonise procedures not only in Europe, but also in a much wider international context. One of the most interesting proposals (although these remain as a draft for discussion) are *Guidelines on the Application of the Precautionary Principle* (unpublished, October 1998).

The guidelines are proposed in response to the increasing concern among consumers to the risks associated with modern methods of production. Their preamble acknowledges the role of the mass media in fuelling this concern and the failure to date of scientific research to be able to fully explain the problem in question. The guidelines are consequently designed to set down those general conditions necessary in the application of the precautionary principle to support decision-makers and lawyers in their work so that there can be no accusations of disguised economic protectionism, while providing a move towards harmonisation of preventative health protection methods.

The pressure for such guidelines is acknowledged to come from the demands of the public for decision makers to accommodate their perceptions and fears and adopt preventative measures to eliminate risk or restrict it to a manageable level. The penal sanctions faced by governments where inaction leads to a public health crisis (e.g., the transfusion of blood tainted by the AIDS virus; BSE) have added further momentum. In particular, they address the need for decisions which must be taken before the necessary scientific data are available, and therefore must rest on the precautionary principle.

The development of the guidelines in the European Union are founded on the legal establishment of the precautionary principle in the field of environmental protection, in Community law, and in International law.

The six proposed guidelines are listed in Appendix III.

The guidelines recognise that the precautionary principle is an approach to risk management, and must address not only present risks, but the risks for future generations. Implementation of this approach should, it is argued, begin when there is some perception by decision makers that there is a major public health risk. This often arises through the concerns of a minority in the scientific community that draws attention to such an emerging problem.

The process should start with an objective and complete risk assessment using all available scientific knowledge. Completion of the risk assessment may provide the basis on which to trigger a decision and in the absence of scientific data decision makers should consult widely with stakeholders. The measures taken should be proportionate to the perceived risk and the cost of likely actions (or inaction) should be assessed in terms of the global cost to society both in the short and long-term. Thus the guidelines incorporate a cost-benefit assessment within their framework. The guidelines also identify the need to establish who is responsible to generate the scientific information to meet knowledge gaps and ensure a revisiting of all assessments as new information becomes available.

Lessons

The distinctive national science-decision making systems that have evolved at a national level remain within the European Community. The needs of science were a powerful, early driving force behind European unity and science remains a key tool to replace politics and national self-interests in the process of political change. As in a nation state, the drivers behind regulatory decisions and policies within the European Union vary from the leadership provided by any one member state to Community concerns and global forces such as global economic integration, trade agreements and environmental Conventions. The pressures to generate guidelines for the use of science within the Community are no different from those elsewhere. They are designed to protect decision makers and politicians and the public alike. Their measure of success will be in the courts and this will put increasing pressure on all nations to evaluate the quality of their science for decision making against legal standards.

Sources

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New Zealand: Enhancing Public Policy through Research and Science

The science system in New Zealand has been fundamentally restructured in line with the broader reform of the New Zealand economy and the public sector which began in 1984. This has seen a major withdrawal of government from a wide range of activities, increased privatisation, and much greater attention to economic efficiency and transparency.

For the system, these reforms resulted in the disbandment of the Department of Scientific and Industrial Research (DSIR) a large multi-disciplinary organisation, as well as of those research activities in some other government departments and agencies. In their place three new organisations were created to perform those functions previously carried-out within departments.

These new organisations are: The Ministry of Research, Science and Technology (MoRST) which has a primary responsibility to provide policy advice to government; The Foundation for Research, Science and Technology (FRST) which administers the Government's large targeted research funds and a small pool of undirected funds; 10 Crown owned Research Institutes which carry-out around three quarters of the public funded research in the country (one of these Institutes has since ceased operations). There is in addition a Health Research Council which administers funds for health research, and The Royal Society of New Zealand which administers funds for 'blue-skies' undirected research. In line with the overall philosophy behind government restructuring in New Zealand, the key feature of these agencies is the clear separation of policy, funding and operational functions.

Science Advice

Only a few of the largest government departments now have significant in-house research capacity. However many departments employ experts and fund scientific research by outside organisations. They carry out a limited amount of original in-house research, but most rely on the synthesis of existing New Zealand and overseas scientific and technological information.

The previous amount of funding used by the DSIR to support public policy and government decision making was not accurately established prior to its disestablishment. The funding approved by Cabinet to carry out some of this activity within MoRST only identified the cost of those direct DSIR head office activities attributed to supporting science for policy advice. No account was taken of the actual costs attributed to the scientists in carrying out their research to support policy advice or of the costs associated with broader underpinning areas of science that supported departmental initiatives.

Arguably, some of the science programmes incorporated into the Public Good Science Fund (PGSF) managed by FRST, such as environment and conservation, were conducted primarily to support public policy. At its establishment, however, FRST chose not to allow the use of the PGSF to support any research identified as operational, departmental responsibilities. To date this has been strictly adhered to, leaving an uncomfortable vacuum in the availability of funds to support research and science needs of direct use in public policy development and evaluation.

In practice many departments use a wide range of mechanisms to ensure the effective use of science and research in their decision making, including departmental scientific advisory committees, in-house research, and contract arrangements with individual scientists and institutions. However, in the wake of recent political concern at the quality of policy advice, there has been an analysis of the quality (and quantity) of research and science used for that purpose. As in other countries there is also a recognised need for mechanisms to address the increasing number of high profile, contentious issues which require input and which transcends traditional departmental mandates. In New Zealand the specific mechanism that has been used is that of the independent expert panel. Both the use of science for policy advice and expert panels are discussed below.

Other mechanisms used to support science for decision making include the Technical Participation Programme (TPP). This Programme supports departments sending independent scientific and technical experts to meetings and international fora of foreign relations, trade or policy significance. New Zealand also uses National Science Strategies (NSS) to coordinate and foster research on key issues of national interest. These do not interfere with existing funding arrangements and provide no funds for research. They are designed to enhance efficiency in a disaggregated, largely contestable science system. They achieve this through enhanced information flows to key decision makers and the provision of advice to Ministers on key topic areas. To qualify as an NSS, a topic must be of significant national importance, be funded through several sources, require coordination, and be of such interest of Ministers as to require regular reports. Those NSS currently in operation include those for Climate Change, Control of Possums and Bovine Tuberculosis, and Sustainable Land Management.

In December 1997, New Zealand also initiated an on-going Foresight Project. The project is focussed on the future and has encouraged community wide involvement in setting future directions for public investment in research, science and technology. To date over a hundred sectors and groups have participated in the Foresight Project and developed foresight strategies for their sectors. These strategies outline a 2010 vision for the particular sector or group in question and indicate the areas to which research, science and technology can contribute. The strategies are now being used to develop advice to the Government about its future investment in research, science and technology. New directions will be phased in during the year 2000.

In the future it is planned to establish 'strategic conversations' between all parties, including Government departments as a means to develop portfolios of research to meet the specific outcomes (at present there are 17) identified for science research funding. This should provide the underpinning and medium-term knowledge needed for public policy.

Science into Policy

Examination of the extent to which decision making by the New Zealand Government in key areas of public policy is supported by effective research, and scientific and technical input involved study of all those papers submitted to two Cabinet Committees during 1997. It included consideration of inputs from research both in the physical and social sciences. The work also involved a series of interviews with senior policy and research staff in the nine government departments concerned, and with other policy experts.

Papers were identified where some science content might reasonably have been expected and these were examined both for evidence of the use of science in the presentation of the paper and the quality of that science. Of the 50% of papers considered which could reasonably have been expected to include some scientific research component, only 28% contained such evidence. The overall conclusion of the analysis was that research and the scientific and technological inputs are significant, if not always predominant contributors to current policy advice to the Government in Cabinet papers. Interviews with officials in general supported this view. Although there was some acceptance that more research input is required, and that the existing research capacity could be better used, many officials questioned the validity of using Cabinet papers as a basis on which to evaluate the scientific component in policy advice. Limitations on paper length, time constraints, Ministerial preferences, and the availability of people and funding were all identified as significant problems. Others included the difficulty of incorporating the findings of physical science into papers that are required to be concise and clear, but where there is no clear scientific consensus. In addition the challenge of the development of a clear, cogent argument using both quantitative and qualitative materials was highlighted as a limitation on the presentation of scientific information.

Research and the scientific and technical content of Cabinet papers may best be viewed as quality components in advice to Government. To this extent, a first step proposed in response to this analysis is to increase acceptance of the need to provide a better audit trail of the sources of information used to support policy advice. This would require more explicit referencing or sourcing of that knowledge included in Cabinet papers. Some changes to the instructions for the preparation of a Cabinet paper and modifications to the format required were also identified as desirable. In effect, there is a need for politicians to recognise and demand the inclusion of scientific evidence in the policy advice they receive.

A more fundamental change to ensure that the scientific basis for policy advice is robust and that research resources are better aligned to meet policy needs is now being implemented. Departments' performance assessments will effectively require them to prepare an annual research and evaluation strategy as part of their annual business plan. This will require the inclusion of provision for research and evaluation (including cross-portfolio, long-term programmes) so that adequate information is available when future policy options are considered and existing and new programmes reviewed. Departments will also be required to demonstrate the use and application of this research and evaluation in the development and review of their policies and programmes.

Expert Panels

The context for the activity of these panels was characterised by unpredictability. The issues on which the panels provided advice were not anticipated in advance. The two most important criteria identified in a subsequent review of their activities were their independence and objectivity.

Three imperatives were identified as necessary in the design and development of future panels.

- The advisory panel should incorporate quality control mechanisms.
- The composition of panel members should reflect the nature of the issue and the breadth of judgement required.
- Clear authority and accountability should be invested in panels.

These imperatives have since been developed to provide a template (or guidelines) for an operational response in any future crisis (Ministry of Research, Science and Technology, 1998, Report 76). The critical attributes identified include:

- *Integration* - To be effective, a science panel should be established as early as possible, and contribute to decision making throughout the duration of the process. Where the science panel enters into the operational programme late, it is likely to be reacting to decisions made elsewhere, rather than participating directly in the decision-making.

- *Independence* - The panel should focus on providing objective scientific advice to the Minister of Research, Science and Technology and the Minister or Ministers with responsibility most closely related to the particular issue. This requires independence from the policy priorities of any individual department, and from any contractual arrangements relating to the operational response.

- *Ministerial Direction and Reporting* - the panel needs to report directly to the responsible Ministers, in order to enhance communication between government and the panel.

- *Credibility* - Scientific credibility of the panel is vital. The panel should comprise recognised experts, appointed, after widespread consultation, by the Ministers, on the advice of the Ministry of Research, Science and Technology.

- *Respect* - Once appointed by Ministers, the science panel must have the respect of the departments with operational responsibility. Full and free access to relevant information is vital for effective functioning of the science panel. The science panel, once appointed, must be seen as integral to the development and implementation of an operational response, and not be treated merely as part of a process or protocol.

- *Commitment* - The panel, and especially the Chair, must recognise a primary commitment to providing advice to Government. Such a commitment will need to over-ride other commitments, as required.

The operation and success of the panels in New Zealand highlighted the value (and the difficulty) in adopting a more open process of science for policy and the value of independent expert advice to address policy issues. The operation of the panels has also raised a series of legal issues which have helped raise awareness among scientists and other experts of their responsibilities and obligations as advisers (Ministry of Research, Science and Technology, 1998, Report 79).

The findings drawn from the experience of these panels (particularly of the Tussock Moth Panel) are now being used to support the operation of the Biosecurity Act. This Act reflects the need for a coordinated approach to the extent of nominating a responsible Minister and giving that Minister coordinating responsibilities.

Also underway are initiatives to establish a generic approach to risk assessment for biosecurity issues that incorporates cost-benefit analysis within the overall framework. An Environmental Risk Management authority has been created. There is also a Biosecurity Council designed to coordinate biosecurity issues across all departments concerned and advise the Minister of Biosecurity through an independent chair.

Lessons

New Zealand is a small country with a science system that is evolving from one characterised by highly centralised government control to a much more pluralistic science-decision making system. This will require a much wider appreciation and understanding of science by all New Zealanders. Achieving this is seen as a key to improving participation in science and technology, optimising the value of science to social and economic goals, and increasing both public and private investment in science.

New approaches to research are being developed to ensure that solutions to problems take account of the concerns of all stakeholders and give increased weight to social concerns. Science promotion and international science links are two further planks in this overall plan.

Ensuring that policy development and decision making, including those aspects that impinge on international matters, are based on sound scientific inputs is an underlying theme. Independent science panels (including the development and implementation of guidelines for future independent panels), and the better articulation of the process whereby science is incorporated in decision making are two initiatives to this end.

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Nordic Union (Denmark and Norway): Participatory Science Systems

Reorientation and Internationalisation

Both Denmark and Norway have restructured their science systems in recent years in response to shifting domestic and global needs and circumstances.

The major shift in arrangements for science advice in Denmark came in 1993, with the establishment of a Ministry for Research and Information Technology. The creation of this new Ministry was designed as part of a wider strategy to more effectively use research and science to meet economic and social goals recognising the increasingly international context within which research and science now take place. A key objective was to improve and secure a coordinated and coherent advisory structure, which addressed cross-disciplinary and strategic needs and better coordinated cross departmental advisory functions. In effect the Ministry performs a powerful coordinating role both across the different arms of the Government, between Ministries, and at Cabinet level. The Deputy Permanent Secretary (Chief Executive of the Ministry) chairs an Interdepartmental Committee with representatives from 10 (of a total of 18) Government departments and supports a Cabinet Research Board which prepares and discusses issues involving questions of science.

The most radical recent change in Norway was the creation of a Research Council in 1993. This new council replaced the previously existing five research councils led by an Executive Board under which operate six research boards: industry and energy; bioproduction and processing; environment and development; medicine and health; culture and society; and science and technology. The Research Council is a national advisory and executive body for research strategy. Its responsibilities therefore also require that it view all disciplinary areas in context, define priorities and ensure balance and cooperation between basic and applied research. The Council is also responsible for such issues as international research cooperation, the recruitment of researchers, the quality and relevance of research, the evaluation of research institutes and the dissemination of research results. The Council also acts as a research policy adviser to the Government. This amalgam of responsibilities places particular importance on the Council as a 'meeting place' which bridges the gap between researchers and research users, and although the Government does not always follow the Council's advice, since its establishment, the Government has attached greater importance to it, and strengthened its role and responsibilities.

As in all Western European countries, the Scandinavian states have a well established science culture, and a strong tradition of participatory democracy, at least by international standards. They also have (or have had until recently) relatively homogeneous populations. As elsewhere their advisory systems involve a range of different mechanisms including expert committees, departmental advisory groups and contracted research. They each share a tradition of cooperation among their different countries which encourages the use of each others scientists in processes of peer review and advisory roles. This is increasingly being extended to a pan-European level. Thus while there are no guidelines in place to promote consistency of practice or exercise quality control across government departments, there are well established processes to 'bench-mark' science inputs to Nordic policy using international experts or international frameworks to peer review scientific information for decision making. The use of the International Council for Exploration of the Seas (ICES) is a case in point with respect to fisheries policy. However, their major contribution to the science for policy debate arguably centres on two distinctive institutions: consensus conferences and ethics committees.

Consensus Conferences

Consensus conferences are designed to provide a forum where panels of 14-16 lay persons can question a group of experts on a high profile, controversial issue, answer a set of questions and generate a consensus statement that will provide decision makers with advice as to how various aspects of that issue might best be handled. They also provide a mechanism for raising public awareness and understanding of science in all its dimensions. Recent conferences on health issues have addressed topics such as cholesterol, breast cancer and stroke treatment. Within Scandinavia these conferences receive widespread media attention, and this is viewed by officials as an integral component of their success. The consensus conference as a model for improved public involvement in controversial areas of science decision making has been used in New Zealand (with biotechnology) and is being explored in the UK with respect to the disposal of nuclear waste.

The philosophy behind the consensus conference is the need to extend the involvement of peer groups by involving citizens reviewing and debating controversial bodies of scientific understanding in areas where policy decisions are required, but where the level of scientific uncertainty remains high. Participants are encouraged to debate the issues with experts who hold diverging view points. Reviews and analyses of the consensus conference by Fixal (1997) and Joss (1998) have suggested that the conferences are a useful facilitating mechanism, but do not obviate the need for a formal technology assessment process (Norway is planning to establish a National Technology Assessment Board). They also highlight that the likelihood of success of such conferences is increased where there is a strong, articulate and aware population.

The studies by both Fixal and Joss recognise the strength of consensus conferences as a means to institutionalise wider public participation in the science-policy process and acknowledge the value of such an approach in developing reports and material which should lead to more informed, better, political decision making. There is some evidence that the results of the conferences do indeed help shape the subsequent decision making process. However, the need for care in such areas as the selection and composition of the groups, and in the formulation of the questions, reinforces the view that the consensus conference is not a panacea. It is however an interesting and potentially powerful tool to better involve citizens in decision making, and an effective means to better articulate social concerns in controversial areas of science.

Although now a well-established mechanism for science within the Nordic countries there is also recognition in these countries of the enormous financial resources, extensive preparatory time and appropriate, skilled personnel required to run a consensus conference. To address this, an attempt is made to select topics for any one country which do not overlap with initiatives in another Nordic state in that same year. Against these pragmatic concerns there is also a perspective that the conferences fail to engage other than the socially concerned, informed and relatively well educated. But for all that, the conferences have achieved a sizeable level of political and popular success, and recognition.

Ethics Committees

Both Denmark and Norway have a strong, national commitment, backed by political will to open-up the debate on ethics and science. Both these countries now have distinctive systems of committees designed to achieve this goal. In both countries these have secured broad public support and interest, and the enthusiastic support of politicians, decision makers and scientists.

The systems which have evolved are particularly distinctive because they go well beyond the more accepted institutionalised debate on medical ethics and bioethics to embrace all science disciplines. In 1988-89, the Norwegian Government proposed the establishment of three national committees for research ethics. This proposal was approved by the parliament in 1990. The three independent, but coordinated committees are: The National Committee for Research in the Social Sciences and the Humanities; The Committee for Research in Science and Technology; and The National Committee for Medical Ethics. These committees are supported by a secretariat of six permanent staff and each committee has its own director who pursues independent research in areas related to research ethics in general and to the specific field of responsibility of the committee concerned. The secretariat stays in touch with national authorities, academic institutions and research centres, is represented in international fora and is building international links.

Their identification as research ethics committees is perhaps misleading. The committees not only deal with issues within the more narrowly defined arena of research ethics, but also address the ethics of science in the widest context. This includes scientific responsibility for large social concerns.

Members of the committees are appointed by the Research Council of Norway. This ensures their political independence and scientific competence. All members are appointed on the basis of their personal qualifications and do not function as representatives of any interest group. In each committee, members are appointed to represent that committee's specific area of responsibility. Each committee also includes lay members and representatives from the fields of ethics and law. There are in addition a series of regional research ethics committees.

These committees are a formal recognition by governments that research and development in all areas of science do not happen in isolation, but interplay with the norms and expectations of the wider society. As such, the committees are viewed (and operate) as independent bodies, reflecting the values of that society, to observe, counsel and inform on issues of ethics in science. They therefore act to raise issues of public concern, provide information and provide advice to national decision makers. That the committees have interpreted their already wide mandates still further is a direct reflection of the extent to which they have come to fill a gap in the science-decision making process. In this they are strongly supported by a political system that is interested in ethics and science and wants wider public debate. (New Zealand is planning to establish a committee shortly, designed along similar lines, but focused solely on biotechnology.)

The mandates of the committees include the following responsibilities: to remain continually informed of current and potential questions of research ethics in the appropriate area; to inform researchers, government officials and the public of current and potential questions with respect to research ethics; and submit reports on matters of principle relating to research ethics. The national committees also function as the coordinating and advisory body for regional ethics committees. The national committees must report on their activities at an open meeting at least once each year and by whatever other means they identify to promote informed public debate.

Lessons:

The Nordic countries have built their own specific institutional mechanisms to address some of the most controversial and high profile issues which are taxing governments in all technologically advanced countries. Denmark and Norway are both small countries and their scientific and other experts are used to 'wearing many different hats' and juggling conflict of interests. This has encouraged officials to consciously seek to involve new people to promote quality control and to broaden the range of sources of advice. This has long involved drawing on experts from other parts of the Nordic Union and from elsewhere in Europe.

These countries have been particularly successful at promoting informed public debate and in recognising the need to formulate policies and decisions which have a science dimension within a social context. This reflects their distinctive culture and history, the existence of a strong commitment to science, and an awareness that science is a tool to secure social objectives. In many ways the response of these countries is very pragmatic and their institutions are carefully tailored to meet concrete needs. This is not to argue that big, controversial issues in science do not exist in these countries, nor to pretend that the policy response is always clearly determined, and all issues clearly defined and easily addressed, but that decision makers can proceed with a greater understanding of public views and concerns, and a greater source of research and information on which to determine their choices.

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United Kingdom: The Scientific Advisory System

In the United Kingdom, each government department is responsible for the provision and use of the scientific advice it needs to fulfil its mandate. This reflects the principle on which British policy for applied research is based, as set out in the 1992 Rothschild Report. This requires a clear customer to commission research from a contractor. Consequently there are as many Ministers responsible as there are client departments. This structure of responsibility for decision making is also premised on the belief that departments are best positioned to determine those systems or processes meet their needs, and that flexibility is required to meet the varying range of needs across government. In practice, all departments use some common sources including expert committees, to advise on particular issues and commission research from scientists in the UK and elsewhere.

While a diversity of sources of science advice is inherent in the British system, there is equally an acceptance that all parts of government should adhere to certain principles and best practices in the provision and use of science advice. There is also an accepted need for a coherent approach across government in those increasingly significant areas such as biotechnology and food safety which raise issues that run across traditional departmental mandates.

To secure this consistency of approach, the UK has an Office of Science and Technology, headed by a Chief Science Adviser. Its role is to ensure that best practices are promulgated, adopted and coordinated effectively throughout the government with no unnecessary overlap between departments.

Guidelines

To promote the sharing of best practices, in 1997, the Office of Science and Technology issued guidelines on *The Use of Scientific Advice in Policy Making*. These guidelines (Appendix II) were developed in consultation with departmental Chief Scientists, the Research Councils, The Royal Society, and the Council for Science and Technology. The guidelines set out principles for departments to apply to the use and presentation of scientific advice in their work.

The key principles set out in the guidelines are:

- *Identifying issues:* Departments should ensure that their procedures allow early identification of issues for which scientific advice or research will be required.

- *Building science into policy:* Policy making should draw on the best available scientific advice, from a sufficiently wide rage of sources (including from overseas), and should also take into account the views of experts in other (not necessarily scientific) disciplines.

- *Presenting policy*: There should be a presumption towards openness in explaining the scientific advice and its interpretation. Departments should aim to make public all the scientific evidence and analysis underlying the policy decisions on the sensitive areas covered by the guidelines. The scientific process thrives on openness, which stimulates greater critical discussion of the scientific basis of policy proposals and raises any conflicting evidence which may have been overlooked.

To ensure effective implementation of these guidelines in 1997 the Cabinet Minister for Science, secured the agreement of her colleagues to the following measures:

- Designation of Minister within each department with special responsibility for ensuring that the department's general procedures are consistent with the guidelines.

- Presentation of an annual report from each department to the Chief Scientific Adviser on the general procedures they have established to satisfy themselves that the guidelines are being taken into account.

- Establishment of regular meetings between the Chief Scientific Adviser and departmental Chief Scientist to discuss emerging issues where the guidelines may be relevant, so that potential problems can be identified and, if necessary, appropriate scientific advice sought. Such discussion will also facilitate the sharing of experience and is now a standard agenda item for regular meetings of the Chief Scientists.

The first evaluation of the impact of these guidelines took place one year after their release (Office of Science and Technology, 1998). There is general acceptance that they are working and making a difference. A new proposed framework for future reports on the implementation of the guidelines is now being discussed to provide a more comprehensive evaluation. The main issues Departments will be required to address are:

- How widely are the Guidelines circulated within the Department?
- What steps have been taken to promote and gauge awareness of the Guidelines amongst policy makers?
- How successfully have the Guidelines been incorporated into departmental procedures?
- How is compliance with the Guidelines monitored within the Department?
- Have the Guidelines had their intended effect?

Already one example of their effectiveness is in their contribution to management of the crisis which arose in Montserrat in 1997. Two reports were commissioned by the Government's Montserrat Action Group—an updated assessment of the status of the volcano and its hazards, and a risk analysis to quantify the health and safety risks for those remaining on the island. Given the resultant scientific uncertainties involved and sensitive health and safety issues, the Chief Scientific Adviser was asked by the Foreign and Commonwealth Office to review and validate the team's work. An *ad hoc* group of those scientists responsible for the assessment and risk analysis, senior officials from various departments and other eminent scientists was established for this purpose, including three members not previously involved in this issue. The result was a short report to the Chief Science Adviser, endorsed by the group, and subsequently used by the Governor of Montserrat in his advice to residents.

The Quality of Science Advice

It is recognised by senior officials that the scientific advice used in policy making must be of the highest quality; that the advice should be drawn from the full range of opinions; and that where debate is required, it should happen before the advice is used rather than after. In those increasing areas where decisions are necessary but where the scientific evidence is as yet inconclusive, the approved approach is to use the most recently available evidence and to ensure continual reassessment of the decision as further evidence emerges. All this is supported by the responsibility given to Departmental Chief Scientists to ensure that those scientists consulted have sufficient breadth of knowledge and that their work is world class. The recent establishment of a new high-level Ministerial Committee (1998) designed to build on the work of the Ministerial Foresight Group is specifically designed to ensure that the Government takes full advantage of the best British scientific expertise to deliver its objectives.

The Guidelines themselves embody a number of principles to ensure that this happens. Scientific advice should be sought from a range of sources both within and outside of government. Those chosen to give advice should not necessarily be of like mind, and it is accepted that those experts consulted may well have to be drawn from other, not necessarily scientific, disciplines. Differences of opinion are viewed as a possible cause for a more thorough debate. In particular, perhaps, any critical views should be clearly flagged.

The success of this approach hinges on the need to have a system in place to ensure that those who provided advice are the best people available. There are a number of cross-departmental initiatives as well as departmental procedures to help secure this.

To ensure those appointed to non-departmental public advisory bodies are appointed on merit, Ministerial appointments to such advisory bodies now fall within the remit of the Commissioner of Public Appointments. This will apply to a number of scientific advisory bodies. In addition there is a proposal under discussion that such advisory boards should adopt plans to establish codes of conduct for their members which set out the high standards of propriety expected and make provision for registering and resolving any conflict of interest.

There is a long standing convention in the UK that decisions on the merits of different scientific strategies and projects carried out as part of scientific research should be separate from the policy function which departments provide to Ministers. This is now being reinforced with a heightened commitment to seek research through competitive tendering. This is matched by an acceptance that it requires that government departments are 'intelligent customers' and in effect can ask the right questions. To do this requires that departments maintain and foster a sufficient in-house research capability. This points up the important role of the Chief Scientific Adviser in coordination across departments during discussion of departmental research activities. This was highlighted in the *Sixth Report of the Science and Technology Committee* (1997-98). In-house research capability is further supported by a range of measures, including an Interdepartmental Liaison Group on Risk Assessment to identify and fund research of cross-departmental interests, and a National Health Service Health Technology Assessment Programme priority setting process including widespread consultation throughout all levels of the health community.

Public Confidence

The high profile, public controversy surrounding the use of science in the management of BSE (Mad Cow Disease) and other similar incidents have undoubtedly dented public confidence in the use of science in public policy. There is an acceptance that the need to maintain public confidence has been neglected and that this must be accepted as an important consideration both in the development and presentation of policies. Increasing and maintaining public confidence in the science used in decision making is seen as fundamentally dependent on the public's belief that the full range of scientific evidence and analysis is considered in an honest and open way. The science Guidelines should help realise these objectives, but there is also an awareness of the scope for further actions. The programme for the public understanding of science, supported by The Royal Society and other professional groups is one initiative that may help contribute to broader public understanding, if not support for science, in the decision making process.

The key issue remains of how to respond to increasing public questioning (indeed suspicion) of authority (including scientific authority) and the extent of information available to the public through the Internet and from other sources which allows a more informed public with a greater capacity to question evidence and decisions. The Internet (which currently supplies many Britons with access to a global knowledge base) is plainly contributing to a more informed public.

This changing context within which scientists and governments now operate cannot adequately be addressed even with the application of the Guidelines. Greater transparency in the presentation of scientific evidence to the public and is expected, in the short run at least, to even raise more questions as to the values inherent in the science and the consistency of procedures across departments. This may, it is believed, require greater efforts to separate out scientific advice (ie knowledge/facts) and value judgements in addressing an issue. In addition, it is argued that much greater attention may be required as to how science advice is obtained so that it is robust when subject to national and international peer review; as immune as possible to recognised sources of bias; and characterises uncertainty where possible by establishing consensus without suppressing the nature and strength of dissenting views.

Building public confidence in the use of science in decision making and perhaps particularly in effective risk assessment and risk communications is viewed as requiring a much improved understanding of the different stakeholders attitudes to science, how these different populations perceive risks and are involved in the risk assessment/decision making process. In an effort to begin to address these concerns, the Minister of Science is planning to use 'big issues' in science to open-up public debate (including debate on ethical issues) and to explore new techniques to better engage the public in the science/policy arena. This is initially planned to involve a public consultation exercise on recent advances in the biological sciences, and a Consensus Conference, run by an independent charity, on nuclear waste disposal.

Access to Information

The UK Government has established a Code of Practice on Access to Information. The current Government is committed to replace this with a Freedom of Information Act. This will apply to science as to other areas of Government activity and reinforce the Science Guideline on the presumption to openness in publication of advice used in policy making. The major difference with the establishment of an Act will be to remove final decisions on the release of information from the Executive to an Independent Information Commissioner, or the courts.

It is expected that the new Information Act will require the release of information pro-actively. This is described in the White Paper:

- "Facts and analysis which the Government considers important in framing major policy proposals and decisions;
- Explanatory material on dealings with the public;
- Reasons for administrative decisions to those affected by them;
- Operational information about how public services are run, how much they cost, targets set, expected standards and results, and complaints procedures."

In practice, departments are already moving to publishing key scientific data and advice used in reaching policy decisions. The Committee on Toxicology, for example, which advises a range of departments on the toxic risks to people of substances has a policy of issuing statements summarising their conclusions together with the key points of evidence that influenced their views on all topics they have considered.

Lessons:

The British case study represents a highly structured, well established science system that is rapidly evolving in response to changing domestic and international needs and experience. What stands out is the underlying cultural shift in favour of more open government and need for greater public involvement in the science-decision making process. It is easy to exaggerate the extent to which such openness is now established. There remains a political culture with a debilitating fixation that all advice to Ministers be kept secret. However, this is changing in the face of political necessity and an increased acceptance that the cost of secrecy outweighs the benefits of openness. The BSE crisis has added weight to this move in Britain, but it is a global trend. There is also a much greater attention and emphasis on the role of social science in science policy, partly stimulated by the UK Foresight exercise which has highlighted the importance of consumerism, regulation, and demographics rather than technology, in driving change. The net result is a much greater weight being given to public communications, a better understanding of public perceptions of science, and an on-going search for new systems to involve the public in debate on contentious issues.

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United States: Science Advice in Government Decision-Making

One of the most distinctive features of the American science-policy system is the proliferation of independent, non-government organisations that provide checks and balances to government. There is an equal variety of advisory bodies within government to address that expanding range of issues on which research, science, and technology impinge. During the past few decades, advisory boards and committees have increased in number. Some of these are high level advisory groups such as the 18 member President's Committee of Advisers on Science and Technology (PCAST) which has addressed a wide range of issues from health to education and fusion research.

Federal government departments and agencies also use a variety of advisory committees focussed on science and technology issues. For instance, the Department of Defence has a Defence Science Board and there are equivalent advisory units for each of the armed services. The National Science Foundation has over fifty advisory committees to assist in the management and selection of scientific directions of various programme areas. The National Institute of Health, and other Departments and agencies such as Agriculture, Energy, Interior, NASA, and the Environmental Protection Agency (EPA) all use a similar variety of advisory committees to provide strategic guidance and advice on science issues.

The range of government functions in the United States supported by formal institutional advisory structures has been categorised by Branscomb (1993):

- Regulatory processes and decisions: statutory advisory committees.
- Technology assessment: socio-technical agendas.
- Resource allocation: peer review and less formal methods.
- Programme management: committees that track specific programmes.
- Conduct of research, the outcomes of which will influence policy.
- Procurement strategies and decisions.
- High-level policy: setting agenda for political decisions.
- Administrative support: programme evaluation, planning.
- Institutional performance: oversight committees for laboratories and agencies.

It is perhaps hardly surprising that with this range and diversity of advisory functions, backed by supporting structures, much of the on-going debate as to the strengths and weaknesses of the science decision making system in the United States centres less on structure than process. This perspective must be qualified by recognition of the demise of the Office of Technology Assessment (OTA) in the 1990s. The demise of this institution has been explained by the clash between the neutrally competent advice offered by this organisation and the political priorities of government (Bimber, 1996). Other factors involved were its value as an easy target for symbolic budget cutting, and its lack of friends within Congress to come to its defence (Coates, 1996). But there were also legitimate concerns about duplication of efforts between the OTA and other research/review groups already accessible to Congress including The Congressional Research Service, The General Accounting Office, and The National Research Council of the National Academy of Sciences. It remains incongruous, however, that while other industrially advanced countries in the 1990s are exploring new means to provide neutral sources of expert advice to decision makers, the United States has eliminated a major source of non-partisan advice in science and technology.

Role of Science in Making Good Policy and Legal Decisions:

The Legislative

The Congress is in the midst of redefining the relationship between the Federal government and the scientific community for the first time since World War II. Representative Vernon Ehlers, the first PhD physicist in Congress, published his report, *Unlocking Our Future: Towards a New National Science Policy* last year (1998). In it he identifies a new function for science in modern society, "helping society make good decisions". Based on this report, Congress has now asked Ehlers to continue his work and generate a more detailed report that would outline specific steps that the Congress should take to implement the recommendations of the first report.

The Ehlers report identifies the potential value of science as a common currency which transcends conflicting cultural values and competing needs at a global level and as providing a basis for wise and informed decisions by individual countries and international organisations in addressing common problems. To this end the report identifies the need for the US State Department to strengthen its contingent of scientific advisers if it is to provide a coordinated, coherent and scientifically informed global approach to its overall mission.

The Ehlers report also highlights the need to ensure that the technical decisions of government bodies are founded on sound science and the need to take steps to better inform the scientific and technical decisions made by regulators, legislators and the courts.

To this end, the report points-up a series of specific concerns and needs:

- To strengthen the legitimacy of technical policy decisions, the report argues that decision makers must have access to sound scientific data and that this requires that there is a sufficient commitment of resources to identify future issues that will require scientific analysis. This in turn is then seen to require an allocation of sufficient funding for research rather than an over-concentration of resources in regulatory agencies.

- To protect the integrity of the science performed in support of decision making the report believes that scientists must be seen as honest brokers with the proper expertise to render advice. As a primary step it is argued that scientists and engineers should be required to divulge their credentials, provide a resume and indicate their funding sources and other affiliations when offering expert advice to decision makers.

- To ensure that the scientific opinions of those experts offering advice is seen as sound, credible, and objective by those who rely on it, the report argues that in all federal government agencies that pursue scientific research, and particularly in those that formulate regulations, standardised peer review procedures should be developed and used.

- Uncertainty is highlighted as fundamental to the science process, particularly in rapidly developing areas of study. That decision makers recognise this is seen as essential, and it is further stated that regulatory decisions made in the context of rapidly changing areas of inquiry should be re-evaluated at appropriate times.

- The Ehlers report also stresses the need to use risk assessment in the regulatory decision making process, and argues that comprehensive risk analysis should be standard practice. Efforts to improve the communication of risk to the general public are also recommended.

- That scientific research now impinges on almost all aspects of life has generated problems within Congress in the need to ensure appropriate advice is fed into a wide range of committees and subcommittees with overlapping mandates. The report stresses the need to better coordinate committee efforts through joint hearings and joint authorisation bills.

The Executive

The Federal Advisory Committee Act (FACA) was passed in 1972 as one of the "openness in government" laws. The FACA governs how the federal government seeks outside advice, and is recognised as having had a profound influence on who participates in government decision making, when they participate, how they participate, and what influence participation has on policy (Long and Beierle, 1999).

There are over 1000 outside groups governed by this Act, advising the federal government. They are overseen by the Committee Management Secretariat of the General Services Administration. Many of these groups are involved in peer review of grant applications, especially in the National Institutes of Health. Others such as the EPA Science Advisory Board provide peer review of the underpinning of the science upon which regulations are based. Increasingly there are many policy-recommending FACA groups with 'stakeholder' participation which include scientists and others.

All technical FACA groups are required to have qualified experts whose views span a spectrum of legitimate technical points of view.

The National Research Council of the National Academy of Sciences also generates many outside, objective reports that evaluate current science and its policy implications. These reports often drive policy decisions. Interestingly, two years ago the National Academy and the National Research Council were sued for not complying with FACA requirements. They argued that as independent, outside groups chartered directly by Congress they were free from such strictures. But in the end, the result has been that the NAS/NRC now operates with much the same openness as FACA committees.

The Judiciary

There is increased awareness that the judicial system increasingly requires access to sound science, and concern over the adversarial setting within which such scientific information is commonly presented. For many years US courts operated under what was termed the Frye Rule which basically said that only generally prevailing scientific opinion was operative in a court of law. With the *Merrill vs. Dalcon Shield* case about 20 years ago, the courts were opened to a much broader range of scientific views being expressed in cases. In March 1999, a Supreme Court ruling seems to have constrained this trend with judges granted the power to screen out what they consider dubious expert testimony (Biskupic, 1999).

In a landmark 1993 decision in a civil case *Daubert vs. Merrill Dow Pharmaceuticals, Inc.* the Supreme Court ruled that federal judges must act as gatekeepers in order to exclude unreliable evidence in the courtroom, raising the possibility that an increasing number of judges will avail themselves of the right to seek independent, qualified scientists to assist them in addressing complex scientific issues.

Fundamental Principles

Several fundamental principles have guided the US government's commitment to investment in science and technology. The political consensus forged by World War II and by the Cold War era which followed has now been replaced by a much stronger commitment to the need for science as a basis to maintain economic strength. In general, investment in science and technology is seen as a means to: sustain and nurture America's scientific system through pursuit of specific agency missions and through stewardship of critical research fields and scientific facilities; strengthen science, math and engineering education, ensure their broad availability, and contribute to preparing the next generation of scientists and engineers; focus on activities that require a Federal presence to attain national goals, including national security, environmental quality, economic growth and prosperity, and human health and well being; and/or promote international cooperation in science and technology.

The inter-agency priority research areas, identified through the National Science and Technology Council (NSTC) process, reflect objectives of maintaining excellence, maximising effectiveness and minimising the costs associated with investments in research and development.

The President's Committee of Advisers on Science and Technology (PCAST) is designed to assist the NSTC in securing private sector involvement in its activities and to advise him on matters involving science and technology.

The PCAST consists of distinguished individuals from industry, education and research institutions and other NGOs. It serves as the highest level private sector advisory group for the President and the NSTC. The formal link between PCAST and the NSTC ensures that national needs remain an overarching guide for NSTC. PCAST provides feedback about Federal programs and actively advises the NSTC about issues in science and technology of national importance. PCAST meets in public session about four times a year.

For several years the Office of Management and Budget and the NSTC have worked closely together and issued broad policy principles and goals to guide individual agencies in preparing their budgets for research and development. For 1999, agencies were instructed to adhere to investment principles for research and development that give priority to Federal research and education programs that: are peer reviewed and selected through a merit based competitive process; are planned and funded jointly through industry, university or State partnerships; are designed to establish and use quantitative and qualitative indicators, as appropriate, to provide realistic and objective measures of progress and performance; are designed to improve interactions with State and local governments to enable technology development; build professional capacity for the workforce; and promote international cooperation in S & T.

Improving the Process

The Federal Advisory Committee Act and the Freedom of Information Act in 1970 increased the transparency of the work of science advisory groups. Despite some initial scepticism it is now generally agreed that these moves have neither stultified debate nor lowered the quality of advice. In a recent independent review of the FACA, some of its notable successes are highlighted including its role in limiting the unbalanced influence of special interests acting through advisory committees on public policy making. A number of 'social goals' with respect to public participation are also noted, including educating the public, bringing public values into government decision making, improving the substantive quality of decisions, increasing trust in government institutions, and reducing conflicts. Countering these achievements is a belief that the procedural requirements of the Act make it difficult for groups outside of government to become advisory committees and gain access to decision making. Ambiguities in the law and its regulations limit the willingness of public agencies to engage the public outside the FACA. Policies of the current administration limit the number of advisory committees that agencies are allowed to establish.

Chubin (1996) noted that in the next 10 to 20 years the State Department may be more vital to research and development in the United States than the National Science Foundation or any of the mission agencies. In effect, science policy will have to 'think bigger' and better identify with national and international issues. Science will need to be better integrated to achieve national goals. This has surfaced again more explicitly and most recently in a report from the National Research Council (1998) with recommendations on how to improve the quality of scientific advice available to foreign policy advisers. This, the most recent report on this issue, comes in response to the Secretary of State's request for outside assistance to shore up the diplomatic corp's sagging expertise in science and technology.

Such moves to broaden the constituency for science policy are part of much wider calls to improve approaches to science policy in the United States recognising the need to increase public trust and understanding, and encourage greater public involvement in the decision making process.

These issues have their parallels in other countries. In the United States much of the debate is framed in terms of the need to better promote a democratic society and the need for an informed public to participate in the debate on the scientific and technological controversies which are on the agenda. But the debate is also underlined by concern that lack of public sympathy will in the long run lead to a decline in public funding for science, increasing tension between public advocacy groups and government agencies over science priorities (as, for example, The National Institutes of Health), and a growing acceptance that any future science based policies should be decided with wider popular participation (and support).

The bottom line in all this is a perceived need to reduce the reliance on an elite, insider approach to decision making, and a growing appreciation of the need for more socially responsive policies backed with much wider public support.

An editorial in *Science* by Sclove (1998) exemplifies the challenge.

> To help frame a year-long effort to develop a post-Cold War US science policy, the House Science Committee on 23 October convened an elite group: the presidents of the National Academies of Science and Engineering, representatives from the Council on Competitiveness, leaders of the Sandia and Lawrence Berkeley National Laboratories, the president of MIT, and so on. Notably absent were any representatives from the many grassroots, worker, and public-interest organisations concerned with science policy. There were no social scholars of science, no proponents of alternative science policies (from within the science community or without), and only a solitary science policy critic.
>
> This event's restricted roster was hardly anomalous. For example, in 1992 and 1993—when Democrats controlled Congress—the House Science Committee organised 30 hearings on a comprehensive National Competitiveness Act. Among 120 invited witnesses, there was not one from an environmental, defence conversion, or labour organisation commenting on a major piece of legislation with ecological, employment, and other social implications. In the Executive Branch, the composition of high-level science advisory panels—such as the President's Committee of Advisers on Science and Technology and the National Science Board—is similarly constricted (p.1283).

There have been complementary calls for greater public involvement in health. An Institute of Medicine report *Scientific Opportunities and Public Needs* (1998) recommended that the National Institutes of Health create a new network of committees that would enable public representatives to communicate more directly with NIH bosses about research priorities. The report argues that each new panel should represent a broad range of public constituencies, and include "disease specific interest groups, ethnic groups, public health advocates, and health care providers". This proposal also includes the recommendation that these panels be backed with a new permanent staff of "public liaison" agents who would solicit information and help citizens understand the NIH. These proposals for a Citizens' Council have been embraced by the NIH. They reflect a specific response to what is an internationally recognised need to better tailor the science-decision making process to incorporate a diversity of views and at the same time strengthen the credibility of the process itself.

Lessons

The richness and diversity of the United States' science-decision making system do not shelter it from the universal challenge of accommodating the different cultures of science and politics in ways which preserve the strengths of both cultures. Nor does it avoid the problems generated by a reliance on a (large) technical elite where the decisions required have a sizeable social and political *component. Despite its pre-eminent global position in science and its economic, military and political strength, the United States is also having to adapt to the realisation that globalisation requires the incorporation of new elements in its science-advisory process. The recent Congressional report identifies a series of principles or guidelines that echo concerns evident in other countries and support the view that increased consistency in the use of scientific advice in decision making is an increasing global concern.*

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Australia: Consultative Pluralism

Change and Adaptation

In February 1997, the Australian Prime Minister initiated a review of science and technology arrangements. The aim was to investigate and report on gaps and overlaps in science and technology in the Commonwealth of Australia, and ways of identifying national science and technology priorities. Professor John Stocker, the Chief Scientist was commissioned to carry out this review, which also included an examination of cross-portfolio science and technology advisory and coordination arrangements. The subsequent report *Priority Matters* (the "Stocker Report") was published in June that same year.

The Stocker Report describes the existing science system in Australia as highly decentralised and pluralistic with less than half of the national government's support for science and technology provided by its own major research agencies and direct funding programmes. These include a large and diverse Commonwealth Scientific and Industrial Research Organisation (CSIRO).

The review concluded that while the current Australian advisory system appeared to include a reasonable set of advisory structures, that some improvements were required in relation to the level and type of interaction between different elements in the system. The improvements recommended included the need to strengthen the interaction between the Chief Scientist and Cabinet-level decision making, improved coordination and increased level of policy research support within government, and improvements to ensure an integrative representation of advice streams to government, and a more effective input of independent advice to the Prime Minister and Cabinet.

The report was requested recognising the all-pervasive role of science and technology in modern societies, and the consequent increased necessity to ensure that access to new knowledge and the methods to apply it are connected as directly as possible, to its users. The recommendations in the report have now been considered by the Australian Cabinet. In December 1997, the Prime Minister announced the formation of a new Prime Minister's Science and Engineering and Innovation Council to replace the former Prime Minister's Science and Engineering Council and the Australian Science and Technology Council. The new Council is to be the Government's principal source of advice on issues in science and technology, relevant aspects of education and training, and the national system of innovation. It is designed to improve the coordination of science advice across different departments and agencies. In March, 1998, the Government made a further series of responses to the review, including steps to improve advisory arrangements within each science-based department, highlighting the role of chief science advisers or their equivalent and the need for effective coordination.

These changes in Australia reflect that country's particular response to recurrent themes evident in most of those countries examined, in particular the need to ensure effective mechanisms to channel advice to the highest levels of government, to ensure access by government to independent advice, to secure improved coordination of science advice across different government departments, and within individual departments and agencies. The Stocker report has been a key catalyst in achieving change to the Australian science system. However, it must also be recognised that the Government wanted to put its own stamp on a science advisory system that it perceived to be largely a creation of the previous labour Government. The Government now has a structure which it owns and with which it is comfortable. It has done similar clear outs of other areas of public administration.

Advisory Arrangements

The current advisory arrangements in Australia to support decision making and guide priority setting are:

The Prime Minister's Science, Engineering and Innovation Council (PMSEIC). This Council is chaired by the Prime Minister. It includes senior ministers involved in science and technology, as well as key representatives of the business and scientific community. The Chief Scientist is its Executive Officer. The terms of reference of the PMSEIC are:

- to advise on important issues in science, technology, engineering and relevant aspects of education and training, including as they relate to economic growth, employment creation, the development of new industries and the sustainable development of new resources;
- to examine the contribution of science, technology and engineering to the innovative capacity and economic and social development of Australia;
- to enhance awareness in the community of the importance of science, technology and engineering for Australia's economic and social development;
- to examine Australia's science and engineering resources and the effectiveness of their organisation and utilisation; and
- to examine Australia's science and engineering infrastructure and the effectiveness with which it achieves the application of science and technology in the economic and social development of Australia.

The non-ministerial members of the Council are constituted as a Standing Committee to oversee and contribute to studies and research aimed at improved understanding of major science, technology, engineering and innovation issues, and has the power to invite other experts to join in its work. The Standing Committee is envisaged as a strong source of independent advice on issues in science and technology and has a capacity to undertake work on its own initiative as well as work requested by the Government. The PMSEIC is a direct response to the need identified in the Stocker Report for improving the advice to government across those different departments and agencies which involve science and technology.

A Chief Scientist provides advice to the Prime Minister and the Minister for Science and Technology on issues affecting science, technology and engineering and on other issues where science and technology are relevant.

The Coordination Committee on Science and Technology (CCST) was designed, at least in part as a mechanism to addresses the need to coordinate major cross departmental and agency issues in science and technology; to allow these departments to share information about their different programmes, policies, problems and future work plans; to ensure coherence and consistency in the implementation of Government policy for science and technology, and to stimulate coordinated responses to science and technology policy related issues. It brings together the heads of agencies and senior representatives of departments with an interest in science and technology and complements the PMSEC, but offers an administrative perspective. The Chief Scientist is a member of this committee, but it is chaired by the relevant Deputy Chief Executive Officer in the Department of Industry, Science and Tourism.

These three components in the science advisory system are designed to function in a coordinated way. The PMSEIC is a high-level discussion forum which allows ministers to discuss issues with leading experts, but includes a capacity for policy research so that government decisions are technically well informed. The Chief Scientist, as noted, acts as Executive Officer of the PMSEIC and is a member of the CCST, providing a further means to encourage a coherent, coordinated approach across government to science issues and better linking of science and technology to Australia's national development goals.

The PMSEIC has been an unexpected success, particularly in getting senior scientists to actually talk directly to the Prime Minister. He takes a great interest in its working, and the science community is taking the opportunity to brief him as a new chance to get science back into the game with a government that is widely perceived to be at best not pro-science, and at worst anti-science in some areas. The issues presented have been high-level and strategic, so the scientists have been forced to think of the national interest and have mostly done so and this is leading to actual changes in science priorities, such as in land research. In practice too, the CCST is taking a more active role as time goes on and is becoming the place where national science brokering occurs since all the big players sit on it. Also the CCST is starting to look at an increased role for itself in such areas as priority setting.

Other advisory roles are fulfilled at other levels. Often such roles complement the central purpose of the agency involved. For example, the Australian Research Council (ARC), the National Health and Medical Research Council, and the Industrial Research and Development Board are grant giving bodies, but have advisory roles based on their specific areas of expertise.

Possibly filling a vacuum left by the effective death of ASTEC, the ARC is evidencing a growing assertiveness. It is actively talking up science to other stakeholders and adopting a policy setting role. As usual this has a lot to do with personalities, and in this instance the membership of ARC and their relationship to senior political figures.

The Stocker Report identified problems in the coordination of advice within individual departments and agencies. To address this, the report recommended the appointment of science advisers at senior levels, and improved communication between science and technology personnel within the larger departments. In practice, few departments followed this recommendation. The Government for its part accepted that these arrangements were best left for individual departments to address, and noting that many departments already have a chief science adviser or the equivalent, and exhibit a range of different mechanisms to coordinate activities in line with their own specific needs. This highlights the Australian Government's commitment to a pluralist system and a willingness to accept some gaps and overlaps as the price of a system which, it believes, is dynamic and responsive to user needs. Simultaneously, Australia has accepted the need to promote a level of coordination and complementarity within its science system to meet its national priorities. It is this unique balance that allows the characterisation of the Australian science advisory model as *consultative pluralism*.

A Shifting Context

The Australian science system has some parallels with that in the United States in its commitment to a range of different institutional arrangements and streams of advice, incorporating a series of checks and balances in the overall process. At the same time, its pluralist structure is characteristic of many OECD countries. Its continued reliance on a large and diverse, mainly publicly funded CSIRO is unique when similar organisations established in other former British colonies have either been totally eliminated or substantially changed. However the question of the CSIRO never quite goes away. The idea of breaking up CSIRO is always just below the surface and the comparison with the UK and New Zealand is always offered.

The pluralist structure of the Australian science system has been reinforced by the distinctive geography of the country and by its pattern of historical and economic development. Like Canada, it is has a large land base, yet a relatively small population and relatively high average income levels. It has a vast biological diversity, a dry but variable climate, and extensive mineral resources. The result is a series of scientific and technical problems almost on a global scale. These characteristics, combined with its relative geographical isolation, have helped shape its economic development, favouring sector based activities. The science system has traditionally reflected these sectoral interests. The Stocker Report itself, the recommendations included in the report, and the consequent structural changes to the science advisory system were predicated on the need to shift the advisory structure to meet changing national needs. The science advice arrangements as now constituted are designed as a coherent system which at the highest levels, can take into account a representative range of views. It is organised to ensure that decisions are seen to be legitimate and based on adequate research and information, including that of independent experts. It is also designed to allow high level decision making on broad national directions and priorities, and that these can be effectively translated into improvements at the operational level. (*Priority Matters*, 1997). Consequently, bodies such as the Defence Science and Technology Organisation, which funds about a billion dollars of research each year, are increasing their engagement in research both within the universities and elsewhere. At the same time, they are also making sure they get greater profile, and attention within the science system.

Australia has a mature, evolving science advisory system, supported by a well developed and capable science and technology support system that extends across most arms of government. It has strong international science links through APEC and the OECD and maintains an extensive series of bilateral activities. It has an extensive programme to raise public awareness of science and technology. This includes a National Science and Technology Centre with touring, interactive exhibitions and a range of educational programmes to raise awareness and promote positive attitudes to science and technology.

Lessons:

The recent restructuring of the Australian science advisory structure is a direct response to the changing global context within which all countries now function. The highly pluralistic, largely sectoral based system that has served Australia's needs well has been modified in the face of current requirements for increased coordination. Such coordination is a means to an end—to better address those issues which transcend traditional departmental mandates; to ensure the quality and consistency of advice; to promote timeliness and breadth of opinion in the advisory process; and to maintain and increase public confidence in the science advisory process.

The needs which the recent changes to the Australian science are designed to meet are the same as those in other countries examined in this report. They highlight the importance of developing arrangements in response to those needs within the context of each individual country's own cultural and historical context.

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CHAPTER 3

NON-GOVERNMENTAL ORGANISATIONS

The World Bank: Science Advice in Decision-Making

Purpose, Reform and Renewal

The purpose of the World Bank is to reduce poverty and improve living standards through sustainable growth and investment in people. In the context of a rapidly changing and increasingly interconnected global economy, the World Bank offers loans, advice and a wide range of customised resources to more than 100 developing countries and countries in transition.

It seeks to maximise the benefits, and cushion the shocks to poorer countries as they become more integrated into the global economy. The World Bank is the largest provider of development assistance. It also plays a vital role in coordinating with other organisations, to ensure that resources are used to full effect in supporting a country's development agenda.

In recent years the Bank developed The Strategic Compact, a plan for its fundamental reform and renewal. The goal is to make it more effective in achieving its basic mission of reducing poverty. To this end, it is now investing in and implementing a series of changes to transform the way it does business.

In all this the Bank is responding to the increasing globalisation of the world economy. It had been slow to respond to this emerging situation, where private capital flows are now five times greater than official assistance, where there are now many different actors playing a much greater role in development and where technological change has revolutionised the way business is done.

Protecting the Environment

For all its clients, protecting the environment is a priority which the Bank now emphasises. It screens all projects to determine whether they pose environmental risks. It undertakes environmental assessments on projects that may be harmful and it includes special measures in such projects to avoid environmental damage.

The Bank helps client governments assess their environmental problems and needs through national environmental action plans and regional studies. With its partners in the Global Environment Facility, the Bank is also addressing global environmental priorities such as loss of biodiversity, climate change, ozone depletion, and pollution of international waters.

Monitoring and Evaluation

The World Bank has long scrutinised its activities to draw lessons from experience and use them to improve effectiveness. Central to its Strategic Compact are improved performance measurement and increased capacity to monitor and evaluate work programmes—in order to use the lessons of experience and signal the need for corrective action in a timely manner.

Evaluation has been influential in the redesign of Bank processes and policies. For example, the Bank's independent Operations Evaluation Department (OED) study in 1998 led to the creation of an international commission that will set global standards for identifying, designing, constructing and operating large dams.

Based on methodologies developed in consultation with the OED, the Quality Assurance Group encourages quality in Bank performance by monitoring the portfolio, undertaking assessments of a sample of its work, and catalysing changes in Bank policies, programs and processes based on assessment results. The Group has a small core staff and operates mainly through expert panels, which are customised for each assignment and are drawn from Bank managers and staff as well as experts from outside the Bank.

Science Advice in World Bank Decision-making on Environmental Protection

The Bank seeks and takes science advice in many areas of its operations, including with regard to investing in people in order to reach minimally acceptable levels of education, health and nutrition.

Over the past decade the demand and/or the perceived need for science advice in the Bank's decision-making on the environment has significantly increased. This is largely because of heightened environmental awareness, as well as increased awareness that environmental issues are grounded in the natural and physical sciences, more than in human opinions or social perceptions. Environmental sustainability, for example, is now viewed by the Bank as a rigorous biophysical concept that follows biophysical laws not subject to negotiation, and is itself not open to 'interpretation'.

There has been a major increase in the use of science, especially environmental science, by the Bank. Indeed, twenty years ago simple scientific or technical words were prohibited or discouraged. However, today for example, 'eutrophication', is a term with which Bank staff are fully familiar and understand.

Nevertheless, there are still significant impediments to integrating science into the Bank's policy advice and decision-making. At the political level, for instance, decision-makers need improved understanding of basic environmental issues and need science information on the issues of the day. If an issue is even crudely quantifiable, it is easy and readily accepted. If it is non-quantifiable, it is almost impossible. For instance, what is the cost of the extinction of one specific species; or how much wetland can a country afford to convert?

There are no guidelines or procedures to assess the quality of the science advice provided to the Bank, although there is potential ridicule if bad advice is publicised. The Bank does have a set of environmental policies and procedures, especially for environmental assessment, which provides ample scope for advancing any environmental argument that may be needed. Ultimately the quality of advice is related to the quality of the staff.

The Bank does have policies regarding transparency with respect to public disclosure of the scientific analysis and evidence that contributes to its major programme and policy decisions and advice. It is important that they do. For instance, the scope of an environmental assessment has to be publicly aired before it is done. Then later, the first draft of the completed environmental assessment has to be made public to all stakeholders, and their comments accommodated. This step is viewed as important to reduce conflict of interest and to maintain quality. In addition, all new policies have to be publicly aired in draft form.

In recent years, there has been an enormous improvement and increase in transparency in the provision and use of science advice in the Bank's decision-making. Thus, for example, the environmental assessment process became mandatory only in the last few years. But there is still a lack of transparency in the Bank's use of much of its science advice.

Harnessing Science

The World Bank is characteristic of many intergovernmental organisations which have some strength and reputation in assessment activities using scientific information.

Most such organisations use *ad hoc* or standing panels of appointed experts associated with the agency. However, as the Carnegie Commission (1992) has pointed out, it is uncertain how such expert panels perform or match the best national advisory arrangements.

The characteristics inherent in intergovernmental organisations such as the World Bank militate against the objectivity, independence and rigour of science experts protected from the political system. Many intergovernmental groups are obliged to select expertise which balances the regional interests the organisation includes. It is difficult in such a context to separate the extent to which expert opinion is 'disinterested opinion' or reflects the official perspective of the country from which the expert comes.

Assessment by teams of experts drawn from different countries can help overcome such problems. Such a team approach may exceed the capabilities and quality possible within any one country, and generate analysis, assessment and input of the highest credibility.

In organisations such as the World Bank the role of science experts is usually to review existing knowledge and provide a critical scientific perspective or plans to deal with the specific problem concerned.

As in any national advisory group the aim is to clarify and inform decision making. To secure the best quality science advice requires the identification of the appropriate expertise; protocols to identify and minimise bias; guidelines for the involvement of funding groups or countries; review procedures; and clear policies for dissemination and publication of advice. That the World Bank cannot yet meet such criteria is unsurprising when individual nation states (where the constraints are less complex) frequently lack protocols to assure the use of the best science advice in decision making.

Lessons

The World Bank is characteristic of many multinational organisations in its use of science in decision making. Despite effective moves to strengthen and increase the transparency of its science-decision making system, the Bank remains constrained by the highly politicised and complex international context in which it must operate. To this extent the Bank points-up the problems faced *by individual nations. It also highlights those areas in the science-decision making system where guidelines might most effectively contribute to better decisions.*

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The Role of Academies in Advising National Governments

Types of Academies

Academies vary greatly in their histories, size and range of activities. Some have existed for hundreds of years, others have been created or recreated since 1945. The Thailand Academy started work in 1997. The Vietnam Academy is currently being formed.

Most Academies are recognised in national legislation and many have been created at the instigation of governments. It follows that Academies are commonly recognised and see themselves as working to foster national, as well as international good. This commitment to use their knowledge to benefit humanity is frequently identified in their objectives. Some Academies include only the natural sciences, others also include the social sciences and humanities.

Academies vary in their role. Typically they operate as national organisations, representing science in their own country to their national government and to the international community. They also operate as learned societies, promoting science though, for example, offering rewards for excellence in research, holding scientific meetings, and publishing journals. Some have their own private funds to support research, many also manage some publicly funded research within their own country. The Australian, Canadian, French and Mexican Academies have no funding role, but The Royal Society manages 1.5% of the UK research budget to support excellent scientists in any discipline. The New Zealand Royal Society manages the country's Marsden Fund for non-directed research based on excellence. Other Academies, such as the Chinese, the Bulgarian and the Swedish run research institutes.

The Academies all pride themselves in their independence and this is a fundamental characteristic of their role in the provision of advice. At the same time, most receive some regular, often significant public funding. However, The Canadian Royal Society receives no regular government funds. Additional funding commonly comes from charitable donations, members' subscriptions, commercial activities and the like.

The Role of Academies in Providing Advice

Many Academies have a formal advisory role through the participation of their members in high level advisory bodies. However, many Academies were either created with a formal obligation and responsibility to advise their government when required to do so or have taken on that role since their establishment. For example, the US National Academy of Sciences was established by Act of Congress with explicit instructions to investigate and report when requested by any government department. The Royal Society of New Zealand has a statutory advisory role to government. On the other hand, The Royal Society in the last 25 years, has increasingly taken on responsibility to promote independent, authoritative advice, to the UK Government.

In general there appears to have been a significant increase in the role of Academies as advisory bodies in the last two or three decades, and an increasing acceptance by Academies that 'advising' is one of their primary roles. (In this the Australian Academy of Science may be an exception. Its advisory role appeared to decline with the establishment by Parliament in 1977 of the Australian

Science and Technology Council as an independent advisory group reporting directly to the Prime Minister. The establishment of this Council was urged on the Government by the Australian Academy itself). Overwhelmingly, the prime target of advice is the national government concerned. However, the level and nature of the advisory role varies greatly.

The National Academy of Sciences in the US works with almost all government departments and even works with individual States where the issue concerned has some Federal component. Its mandate involves national and international issues involving science, technology, human health and environmental quality. It issues some 200 substantive reports a year in topics including agriculture, education, health, engineering, social issues, national security and international issues.

The Royal Society also works with a range of departments including The Office of Science and Technology, Trade and Industry, Health, Environment, Culture, the Foreign Office, and International Development, where there are issues concerning science. It also publishes statements with implications across all arms of government, advises statutory authorities, and puts out information designed to inform a broad, popular audience on controversial public issues such as BSE, cloning, genetically modified organisms and sustainable consumption.

Funding Advice

All Academies aim to cover their costs but do not seek to make a profit. Funding is necessary to support the provision of advice, but at the same time there is a necessary caution on the terms under which such funding is provided so that the independence of the Academy and the impartiality of its advice is assured.

The National Academy in the US does much of its work in response to requests from government departments and agencies and from Congress, although these requests may have their origin in suggestions from the Academy itself. Eighty-five percent of its funding comes from the Federal Government, the rest from State Governments, private foundations, industrial organisations and the private sources of the Academy itself. The Government pays the full cost of any project it requests. The Academy has now built up substantial private funds to pay for self-commissioned studies on sensitive issues where outside funding might be inappropriate or unavailable.

The Royal Society also receives some public funds to support its advisory role, but increasingly uses private sources for specific projects or draws on its own endowment income. Where appropriate and possible, it charges its customers full cost. Plainly, as with the US National Academy, the capability to access funds to support self-initiated projects gives any Academy a valuable independence to determine its own agenda and to act as an 'independent' voice for science in the public policy debate. The lack of funding available to The Royal Society in Canada, the consequent lack of staff, and certainly the absence of any endowment funds seriously constrains its advisory role. Other Academies, such as those in New Zealand and Australia are also constrained by lack of access to their own private funds. Consequently, the balance of self-initiated projects and projects initiated at external request varies greatly with the Academy concerned.

Quality Control

The measures taken by Academies to control the quality of their advice inevitably involves a range of different approaches and process issues.

The careful debate and selection of topics for investigation is a first step. Checks and balances in the development of reports, including management of peer review, format frameworks and signing off are all crucial elements in quality control. Careful selection of members of study committees to assure technical excellence, as well as absence of bias, conflict of interest, and overall balance in the composition of committee are crucial factors, although the weighting given to these factors varies with the Academy concerned.

Lessons

The impact of the advice from Academies is difficult to assess. The issuing of reports is frequently backed-up with public lectures and media reports and interviews. Briefings of officials and the fostering of personal contacts within Government are all recognised as necessary means to influence decisions.

The success of the Academies as sources of science advice for government decision making centre on a range of criteria:

Independence: Although the most obvious strength of the Academies is the quality and expertise of their members, it is the independence of the Academies, their capacity to stand apart from government, from individual disciplines, and the particular interests of any one scientific group that gives them clout.

Policy Awareness: The scientific and technical capabilities of Academy members is insufficient to allow the effective operation of Academies as sources of influence and advice. To succeed, the Academies require the capacity to understand the decision making process and political context.

Expert Status: Academies have their own strengths and capabilities. Some limit their membership to natural scientists, others include the social sciences and humanities. Whatever their composition, their strength lies in their expertise. It is important that they limit their advice to where their expertise lies and not assume that this expertise gives them a privileged knowledge of other areas, e.g. social issues or economics.

Involvement: Academies need to want to be involved in public policy and controversial areas of public policy. Not all members of Academies are willing to give their time to an advisory role. Such willingness is not a condition of membership. Members need to wish to be involved and this requires that they and the Academy define their responsibilities within a broad social and political context.

Sources:

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CHAPTER 4

CASE STUDIES

CASE STUDY 1

E.coli 0157 outbreak of infection: Central Scotland 1996

E.coli 0157 was first identified as a cause of human illness in 1982, in patients affected in two outbreaks of bloody diarrhoea in the United States. Both outbreaks were associated with undercooked hamburgers. There have been since numerous and increasing reports of infection with the organism from around the world.

In November 1996, the largest outbreak recorded to date was identified in Central Scotland. The outbreak was identified on 22 November 1996 and declared over on January 20, 1997. Four hundred and ninety-six cases of infection with *E.coli* 0157 were associated with the outbreak. Of these, 27 people were admitted to hospital, 13 required dialysis, and 18 people died. All of those who died were aged between 69 and 93 years.

The scientific characteristics and behaviour of *E.coli* 0157 are relatively well understood. The potential of contamination/cross-contamination with the organism, its virulence and severe effects are well documented. However, there remains scope for further research to fill gaps in knowledge about *E.coli* and to improve measures to identify and prevent infection with the organism.

In this case study, the emphasis is on the value of risk assessment and the Hazard Analysis and Critical Control Point (HACCP) System, enforcement, surveillance and communications as key determinants in the effective use of research and science in public policy.

A Butcher's Dishonesty

The outbreak began in November 1996 at a church lunch for pensioners in Wishaw, Lanarkshire. The food consumed was supplied by J. Barr and Son, Butchers. Although outwardly a small, local butcher with an adjacent bakery shop, the business was involved in a substantial wholesale and retail trade involving the production and distribution of raw and cooked meats and bakery products from its premises. It employed around 40 staff, some on a part-time basis.

By the evening of Friday, November 22, histories from 9 of the 15 confirmed or suspected cases indicated that 8 of these 9 had eaten food from Barr's. Late that same day, Mr. Barr was visited by representatives of the Health Board and local council. He voluntarily closed his whole business (including the bakery) on November 27.

The distribution of meat and meat products from Barr's proved to be diverse and complex and took several days to be unravelled using the company's records. This caused delays in the public identification of the outlets involved or potentially involved in the outbreak. Ultimately, some 85 outlets were identified throughout the central belt of Scotland as having been supplied by the company. This made the task of outbreak management and control extremely difficult. Subsequent evidence showed that the outbreak comprised several separate, but related incidents—the church lunch (attended by about 100 people) on 17 November, a birthday party in Wishaw on November 23, and retail sales in Lanarkshire and the Forth Valley.

The subsequent report of a Fatal Accident Inquiry severely criticised Mr. Barr and ruled that his dishonesty may have contributed to the ultimate death toll. It concludes that a combination of John Barr's dishonesty and lack of initiative by environmental health experts meant that contaminated meat to one outlet which killed 6 of the victims was not withdrawn from sale. Mr. Barr's failure to respond fully and honestly to investigators delayed the tracing of his supply of cold meats to Scotmid Store shops. He was also criticised for failing to maintain a safe shop. Five failures were identified, including not using temperature probes for cooking raw meat and a failure to separate equipment and processes for cooked meat and raw meat. He was blamed for concealing the true extent of his outlets from environmental health officials, and failing to ensure his staff and basic training in food hygiene. The environmental health officials were condemned for not demanding details of Mr. Barr's regular outlets for cooked meats, a problem compounded by Mr. Barr's lack of full and honest cooperation with these officials.

In October 1997, Mr. Barr pleaded not guilty to culpable and reckless conduct in connection with the supply of cooked meats. He was found not guilty at trial for lack of corroborative evidence. In a separate case in January 1998, he was fined the equivalent of $6,000 (Cdn.) over food hygiene charges.

Risk Assessment and the HACCP System

Risk assessment is the important first step of the Hazard Analysis and Critical Control Point (HACCP) System. A prerequisite is knowledge, understanding and expertise in identifying the hazards and assessing the risks involved in an operation. This requires a multi-disciplinary approach.

The HACCP System is based on 7 principles set out through the Codex Alimentarius Commission:

1. Conduct a hazard analysis. Identify the potential hazards associated with food production at all stages up to the point of consumption, assess the likelihood of occurrence of the hazards and identify the preventative measures necessary for their control;

2. Determine the critical control points. Identify the procedures and operational steps that can be controlled to eliminate the hazards or minimise the likelihood of their occurrence;

3. Establish critical limit(s). Set target levels and tolerances which must be met to ensure the Critical Control Point(s) is under control;

4. Establish a system to monitor control of the CCPS;

5. Establish the corrective actions to be taken when monitoring indicates that a particular CCP is not under control;

6. Establish procedures for verification to confirm that the HACCP system is working effectively; and

7. Establish documentation concerning all procedures and records appropriate to these principles and their application.

In a review of the *E.coli* 0157 outbreak in Central Scotland, the Pennington Group (1997)[1] wholeheartedly supported the implementation of HACCP but identified confusion about the application of HACCP both in a practical and legislative sense, and the need for increased awareness and expertise in tackling the hazards involved in food handling and production.

Enforcement

The successful application of HACCP requires the full commitment of management and workforce. It relies on businesses themselves, backed by appropriate external advice and assistance. It necessarily requires structured implementation and a lengthy introduction. Enforcement involves a long time lag.

Skills, resources and authority are required to ensure proper enforcement. There must be proper integration and articulation of the HACCP principles in legislation. The duration, quality and frequency of visits of inspection to premises carrying out food processes are essential components of success.

Surveillance

Collection, collation, analysis and dissemination of information are an essential part of the HACCP system. The best surveillance in the world cannot prevent all outbreaks. However, early identification of an outbreak can aid investigation and management, inform appropriate research and improve understanding. This requires necessary reporting and standardised clinical testing as well as preparation of full, written, published reports on major outbreaks.

Communications

Management of an outbreak should include clear and pro-active media management and a public relations strategy as well as the rapid dissemination of relevant information to doctors and hospitals. Public, media and political interest are legitimate and provide an opportunity to educate and inform the public on the circumstances of an outbreak and issues related to it. Ill-informed media commentary can sow uncertainty and raise concerns. Media demands can also distract attention and absorb scare resources from the task of outbreak management and control.

Lessons

The identification and management of E.coli 0157 rests on relatively mature science which allows a high level of precision and involves a low level of uncertainty. Gaps in scientific understanding exist particularly regarding the effect of particular aspects of animal husbandry, the distribution of infection within the farm environment and sources of spread of infection.

Policies for disease control and management are based on existing knowledge as applied within a sophisticated risk assessment/hazard analysis process. Despite such a rigorous policy process, problems identified include in particular issues of enforcement, surveillance and communication. It was these issues which led to the 1996 Scottish outbreak, the largest ever outbreak with the E.coli organism in the UK, and compounded the difficulties associated with its management and control. This emphasises the need to view research and science as vital components in good public policy but to recognise that the success of such policy also depends on the much wider social and economic context within which that policy is developed and implemented.

Source:

[1]*The Pennington Group* (1997) and interview with Professor T.H. Pennington, Aberdeen, 23 November 1998.

CASE STUDY 2

Disposal of the Brent Spar, United Kingdom, 1995

The Brent Spar was a spar buoy used for oil storage at the Brent field in the North Sea. It was commissioned in 1976 and taken out of service in September 1991. One-hundred and forty-one metres high, it had a capacity of 300,000 barrels (about 50,000 tonnes) and a gross mass of about 14,500 tonnes (half steel, half concrete and iron ore for ballast).

Deep sea disposal was selected by Shell as the Best Practicable Environmental Option (BPEO) in a process that culminated in 1994. This option was approved by the British Government in December 1994. The Agriculture, Environment and Fisheries Department of the Scottish Office and Shell Expro had commissioned a Site-Specific Survey of the three identified deep sea disposal sites in September 1994. A licence to dispose of the Brent Spar at the North Feni Ridge site was issued in May 1995. Simultaneously the Brent Spar was occupied by Greenpeace.

There followed a major international eruption of concern over the magnitude of the environmental impact likely to result from deep-sea disposal. In response to public protests (especially in Germany) Shell, at the end of June 1995, abandoned its disposal operation. The Brent Spar was towed to Erfjorden in Norway where it remains classified as a UK installation and subject to regular surveys to maintain its certificate of fitness. Since June 1995, Shell has carried out a comprehensive re-examination of decommissioning options and a parallel public Dialogue Process in support of the technical selection process. In 1998, the British Government and Shell agreed that the structure would be dismantled on-shore, in Norway.

This case study exemplifies the problems that can arise even when there is extensive scientific information and established principles for the review and selection of the best environmental option, but where inadequate attention is paid to social, ethical, aesthetic, legal and other factors. In particular, it highlights the inherent difficulties where plans for disposal and removal are not indicated, approved and accepted at the initial design and emplacement phase.

BPEO

The BPEO Selection Process is designed to ensure that the best available, relevant, factual information is identified and its reliability examined. It is designed too, to ensure that all possible options are reviewed and their environmental impact considered. Transparency and comprehensiveness are viewed as inherent components in the final decision.

The BPEO process is an approach which requires the establishment of technical feasibility prior to the identification of the best option in terms of cost and environmental impact. The case of the Brent Spar highlights the practical difficulties associated with implementing the process. These difficulties centre on several considerations:

1. The information available on multiple options is likely to be preliminary;
2. Such information can only be refined as the selection process proceeds;
3. The selection process requires the simultaneous consideration of multiple criteria;

4. Environmental impact must be included as one of the most important criteria, if not necessarily of over-riding importance.

Future use of the BPEO process appears to require clear guidance on its implementation. This should include the capacity to scope environmental issues to identify and eliminate detailed examination of those of insignificant effect. Peer review should be used to identify issues requiring in-depth evaluation and examination in terms of their capacity to meet safety and environmental requirements, and to minimise risk. An evaluation of the political and social acceptance of alternative options needs to be run in parallel with the technical assessment.

Procedures

The effectiveness of the BPEO process was viewed as flawed for a number of procedural reasons:

All the options considered and the identification of deep ocean disposal as the favoured option required a broad and in-depth understanding of the deep ocean environment—its dynamic characteristics, storm conditions, biological conditions and chemical anomalies. Much of the detailed information required was commercially sensitive and unavailable for wide peer review. The full range of possible deep ocean disposal sites was not fully considered, and there was a lack of explicit site selection criteria which limited the ocean areas considered. There was an underestimation of the need for a full evaluation of the biological activity around the selected site. The results of the site survey were relaxed once the survey contract was placed, and procedure used to evaluate the results of the survey were not made available to the public by the time the disposal was planned to take place. All these considerations had both national and international implications, whether in terms of the potential for disposal to contaminate international waters, for the optimum site to be located in international waters, that disposal might need to consider the disposal operations contemplated by other countries, and that the specialised scientific information and expertise of scientists from other nations might be invaluable in the evaluation of disposal options. All these procedural considerations support the view that there is a need in future evaluations of this type to ensure that all appropriate specialist advice is tapped both to ensure the quality of surveys and the evaluation of survey results. This amounts to a much wider process of peer review by outside bodies at every stage in the BPEO survey and in the evaluation of the survey results. This peer review process should include international bodies.

Environmental Impact

The minimisation of the environmental impact of the disposal of the Brent Spar in deep water, hinged on the success of the engineering operation and the competence of the firms concerned. However, the planned scenario which was argued as not resulting in the release of noxious or polluting substances into the ocean or on land was deemed, on review as possibly optimistic, and the value of a 'worst case scenario' as part of any environmental impact proposed. The environmental impact which was conducted emphasised the assessment of any potential impact on birds and fish, but lack of data on the physical, chemical and biological nature of the environment, including hydrographic conditions, background contaminant levels precluded consideration of the bathyal community and biomass.

The environmental risk of accidental spilling of oil, wax, or sludge from the Brent Spar was also difficult to assess, and where such a spill occurred would also seriously influence the scale of the impact, as would the appropriateness of any technology used to minimise the effect of any spills. On the basis of the information available, the environmental impacts of the disposal options were deemed acceptably small. A more fundamental concern, however, was the failure to address the need for an overall plan to decommission the several hundred off-shore structures in European waters or provide a comprehensive assessment of their potential environmental impact. Individual, case-by-case evaluations ignore potential cumulative environmental effects, are time consuming, and expensive.

Lessons

The scientific and technical basis used to identify the best option for disposal of the Brent Spar was good—despite evident gaps in data and information. The quality of any environmental assessment will always be contingent on how an issue is defined and the availability of information to address that issue. The failure of the process rested on two factors: Firstly the absence of a comprehensive policy as to how such marine structures should be disposed, determined prior to their initial commissioning, and secondly, the failure to properly assess and evaluate the political and social acceptability of the preferred scientific and technical options.

What emerged in the ensuing international public controversy over the disposal of the Brent Spar was the high value attached by the public to the protection of the marine environment, as a source of food, as a recreational resource, and as a valued ecosystem. The likely environmental impact of decommissioning off-shore structures is deemed relatively small. Certainly much smaller than existing threats posed to the marine environment from the destruction of coastal habitats, intensive fishing and the like. The mismanagement of the disposal of the Brent Spar deflected attention from much larger environmental threats and deflected political energy and financial resources from more pressing environmental needs. It highlights the importance of an open process which involves the public in decision making (which subsequently has occurred) and the need for a careful (if difficult) balancing of physical science and economic input with other social and political priorities.

Sources:

Natural Environment Research Council 1996: *Scientific Group on Decommissioning Offshore Structures*. First Report for the Department of Trade and Industry. Swindon, Wiltshire.

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CASE STUDY 3

White Spotted Tussock Moth (*orgyia thyellina*): Auckland, New Zealand, 1996

In July 1996, the Government of New Zealand requested the Ministry of Forestry to undertake a programme for the eradication of the white spotted tussock moth. This moth had been discovered in the eastern suburbs of Auckland in April of that year. The moth was a new pest incursion and considered a potentially serious threat to forest health. The eradication programme attracted a great deal of media interest, especially the aerial spraying of Btk using Canadian DC6 aircraft. Blanket spraying by DC6 continued from 5 October until 6 December 1996 and involved a total of 9 separate spraying runs over a total area of 4,000 ha. The programme to eradicate the pest wound up in July 1998.

This case study illustrates the use of independent science advice to develop public policy. It provides an example of a situation where the risks are high, the need for action urgent, but where the desired research and scientific information are incomplete. This case study also highlights the value of independent science panels and the difficulties of effective public communications for such issues.

Independent Science Panel

Although an independent science panel was fairly rapidly appointed under the auspices of the Ministry of Research, Science and Technology, many of the basic decisions regarding the approach to manage the Tussock Moth infestation had already been taken and there have been questions since regarding the extent to which science was properly incorporated into these early decisions.

The panel was broad-based and multi-disciplinary, including entomologists, a modeler, a public health expert, and spray experts among others. Government officials attended as ex-officio members. Part of the problem, over and above the apparent preemption of some decisions prior to the convening of the panel, concerned the lack of scientific knowledge of the moth—particularly in a New Zealand environment—and lack of research. Consequently from an early stage the panel found itself involved, if by default, in policy cf. science matters. Lines of reporting to Ministers were often confused and caused concern and disquiet, while issues such as approval of minutes became contentious when decisions were urgent, members were scattered and all were under enormous pressure as they attempted to juggle their regular jobs and panel activities. Particular difficulties arose over lines of communication between the panel and officials in individual Ministries, including access to data. There were also matters of conflict of interest, when members appointed for their own individual abilities felt vulnerable in the face of the priorities of their home institutions, or were already under contract to Ministries or agencies directly involved in those issues on which they were now required to give independent advice.

Some of these difficulties are inherent in the management of any independent expert panel; some are highlighted in a small country where the scientific population are all well-known to one another. Lessons learned from this initial experience and that of another science panel have since led to the design of a set of procedural guidelines which should resolve future problems.

Reporting, Consultation and Communications

The programme to eradicate the Tussock Moth involved three different groups of stakeholders. These were Ministers of those departments directly involved, other involved departments and Crown agencies, and the local community in the infected area.

Although the routine reporting to Ministers was adequate for the most part, the adequacy of reporting by Ministry of Forestry officials to the most directly affected Minister—their own Minister—was not always as thorough or as quick as required. There were also some problems in the flow of communications and level of consultation among departments. A key element in this was the priority, energy and time directed by forestry officials on operational matters to the exclusion of such necessary consultation within government. The result at times was that Ministers were required to make decisions on papers presented with inadequate briefing or time for proper consideration. The expert panel—by default—became an important forum where interdepartmental consultation and coordination took place.

Communications with the local community were outstanding. A Community Advisory Team was established by the Ministry of Forestry at an early stage. It involved wide membership, ran an effective public relations campaign and promoted the frank release of information and listened and responded to local concerns. The result was strong community support for the eradication programme.

Despite its flawless success as a public communications exercise, the communications programme created policy problems. It raised public expectations including certainty about the seriousness of the threat from the infestation that the eradication was accepted as necessary at all costs, and a belief that by December 1996, limited aerial spraying of Btk would have achieved that objective. The publicity promoted a degree of certitude that could not be realised.

More spraying runs than suggested were required and the length of the period during which spraying occurred was extended. Community resistance and tensions increased, encouraged by vocal environmental advocacy groups. Perhaps most importantly, the mismatch between expectations and the actual results may have threatened the credibility of any future programmes which may be necessary to address other pest incursions.

Risk Assessment and Cost Effectiveness

The original decision to attempt eradication using blanket aerial spraying of Btk was necessarily based on limited information and the programme designed was risk averse.

As the eradication programme evolved there was a reluctance to redesign the programme to secure the best chance of success, by using the increasing information which emerged. For example, the enormous increase in cost generated by the need to use DC6 aircraft, did not lead to a reevaluation of eradication/control options. Related to this was the need to consider the cost-effectiveness of both the programme of eradication and the overall response, given the potential cost of a continued infestation. Again, there was a failure to incorporate a proper cost assessment into the programme or to revise and reassess cost effectiveness as new approaches were required and costs increased.

As a result of this experience, several lessons were drawn. A generic approach for dealing with future decisions regarding pest incursions is now being put in place. This would allow the types of decisions required, their content and sequencing to be made without the inherent pressures generated by an emergency situation. This approach is based on the application of risk assessment, cost-benefit analyses, and other relevant techniques within a predefined methodology aimed to achieve consistency in decision making and the use of science across the widest possible range of events. It also includes specific provision for comprehensive review at predetermined stages.

Supporting this approach, also requires recognition that quality decision making requires sound analytical approaches—in particular risk assessment and cost benefit analyses—and that these must be applied in an integrated way. All this also requires quality information. When not available, the methodology should reflect that reality.

Lessons

The Independent Science Panel played a major role in the management of the Tussock Moth incursion, and was a major contributor to the eradication of the pest. The operation of the panel and the eradication programme as a whole provided a valuable model on which to develop guidelines for the use of science to manage any future pest incursions.

The pressures generated in an emergency situation which demands a speedy response stretch resources. In such circumstances the focus of attention on any one item, such as public communications, may deflect needed resources and energy from other equally important issues. Where there is a well established set of guidelines as to how to respond, these problems should be minimised. Such guidelines must allow proper consideration of all aspects of the management programme, including costs, communications, science, and social values. In particular, such guidelines should help promote the necessary on-going review of thinking that is necessary as additional information becomes available.

Sources:

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MRL Research Group 1996: *Awareness of Tussock Moth and Attitudes to Aerial Spraying*. Report to the Ministry of Forestry, Wellington.

CASE STUDY 4

An Integrated Transport Policy: United Kingdom, 1998

Discussion of the use of science in decision making is frequently based on the assumption that the science involved is physical science. Indeed vast areas of public decision making and policy rest solely on research in the social and behavioural sciences. Education policy, most social policy and much health protection policy are cases in point. Often too, realising the implications of the findings from the physical sciences requires their translation into a social context. One of the best examples of this is provided by the recent British White Paper on the Future of Transport (1998) the basis for which rests in large part on the British signature of the Framework Convention on Climate Change at the Earth Summit in Rio, in June, 1992. The United Kingdom's Report under the Framework Convention (1994) highlighted the projected continued CO_2 emissions from transport beyond 2000, including projected continued increases in road traffic and air traffic in particular and identified the need to consider a series of options, requiring further research. The implication was clear that what would be required was a fundamental change in patterns of transport use to meet the challenge of growing emissions. Following the Kyoto climate change conference in December 1997, the UK now has a legally binding target to reduce greenhouse gas emissions to 12.5% below 1990 levels by the period 2008 to 2012. This means a reduction equivalent to 27 million tonnes of carbon. There is also a domestic aim to reduce CO_2 emissions in the UK to 20% below 1990 levels by 2010. Four-fifths of CO_2 emissions in the UK are produced by road vehicles.

This case study illustrates the effective integration of the findings of research in the physical sciences into an area of social policy and the need to set those findings within an appropriate social and political context to secure success. It also exemplifies the increasing pressure on national governments for a national policy response to the findings of research generated on a global basis.

A New Deal

The new transport policy rests on the need to meet British obligations on targets for climate change. It recognises that the need for a new approach is urgent and that it is no longer possible to go on as before building more and more roads to accommodate traffic growth. The strategy reflects a move from consumer capture to a provider philosophy.

The strategy is designed to meet a wide range of stated objectives including greater economic efficiency, and increased prosperity, reduced rural isolation, and revitalised towns. However, the design for the changes required rests on the primary need to reduce CO_2 emissions. In the UK, these emissions from road transport are identified as the fastest growing contributor to global warming, as well as adding substantially to local air pollution that is damaging public health and hastening the death of thousands of people each year.

Proposed Initiatives

Fiscal incentives are identified as a powerful means to promote cleaner, more efficient vehicles and fuels. Fuel duties are seen as an effective mechanism to influence transport decisions and promote the use of more environmentally friendly fuels. Increased charges on the use of company cars, coupled with tax incentives to encourage the use of public transport are proposed, along side tighter emission standards which support the European Commission's strategy to reduce CO_2 emissions from new cars to an average of 120 grammes per kilometre by no later than 2010. This strategy alone has the potential to reduce forecast road transport CO_2 emissions in the UK by 8-14%. These improvements critically depend on the response generated by car buyers.

Motor taxation is identified as a means to encourage people to buy more fuel efficient models and to invest in regular maintenance and fuel saving technologies. It is estimated that fitting low rolling resistance tires can reduce fuel consumption and CO_2 emissions from cars by as much as 5%.

Tackling congestion will further improve fuel efficiency in urban travel and reduce the impact of road transport on climate change. UK evidence suggests that fuel consumption is at least 10% higher on urban roads and 25% higher in the centres of the largest cities as a result of congestion.

The joint impact of reducing local traffic levels and promoting a shift to public transport, combined with improved fuel efficiency of remaining vehicles requires an integrated package and local authority support. With the right package and the necessary user charges, it is expected to reduce road traffic and CO_2 emissions by up to 20% in the busiest cities. Overall, it is believed that even without a major behavioural change, the key transport measures planned will reduce forecast road traffic CO_2 emissions by 22-27% by 2010.

Lessons

The new British integrated transport policy is not a simple product of the growing body of evidence which points to a discernible human influence on the Earth's climate through the release of greenhouse gasses. This evidence, compiled internationally, and Britain's commitment to reduce CO_2 emissions in line with its international agreements is a driving force behind this radical shift in its transport policy. A powerful body of scientific evidence on climate change and public health in particular has coalesced with and supports a political desire to address transportation policy as a basis to promote the long-term economic, environmental and social well-being of the population. What is proposed is a package of radical social change. The scientific evidence has been used to develop a series of economic, technological and other 'solutions' and drive social change. The robust nature of that scientific evidence helps legitimise the proposals, strengthens their social acceptability. That the evidence used is drawn from a wide range of international sources is illustrative of the increasing use of international science to shape domestic political agendas. It is also a useful illustration of the importance of recognising the increasing multi-disciplinary nature of the science needed to address big emerging policy issues, and in particular the need to better integrate social and physical science in decision making.

Sources:

United Kingdom 1994: *Climate Change - the UK Programme.* United Kingdom's Report under the Framework Convention on Climate Change. HMSO, London.

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CASE STUDY 5

Use of Antibiotics in Animal Feed: The European Union, 1998

In December 1998, the European Union banned four drugs used to promote growth in animals, because of concern they could increase human resistance to medicines. The four drugs are zinc bacitracin, spiramycin, virginiamycin, and tylosin phosphate. Concern over the use of sub-therapeutic levels of antibiotics, as when antibiotics are used in animal feeds to promote growth, has existed for several decades. The emergence of antibiotic strains of bacteria is known to be most likely in such circumstances. The result is increasing evidence on farms of bacteria populations which are resistant to antibiotics. There is documented evidence that resistant strains of bacteria can and do spread from one animal to the other, or from one chicken or turkey to the next. The fear is of their potential transfer to humans, and that when these people become sick, the antibiotics prescribed won't work.

Feed additives currently account for 15% of all antibiotics used in the EU. The proposed ban, to take effect on July 1, 1999, will hit four multinational drug companies, potentially costing them hundreds of millions of dollars in lost sales. It has enormous additional implications for farm practices and trade throughout the industrial world.

This case study illustrates the impact of increasing economic globalisation on how science is used in public policy. The ban highlights the trend towards international policies following those set by 'lead' countries. It is a powerful example of the ramifications of an increasingly precautionary approach to the evaluation of scientific data and policy development. It points up the difficulties in addressing scientific uncertainty, and the legal ramifications of many policy decisions.

Scientific Data, Policy, and Process

The European Commission's proposal to ban the use of four antibiotics in animal feed was championed by the Scandinavian countries, particularly Denmark. Finland, and Sweden. Denmark had earlier imposed unilateral bans on certain feed drugs. Pfizer, the American based pharmaceutical multinational had already filed a suit against the Danish Government asserting violations of both Danish and European Community law by enacting a ban without sufficient scientific evidence.

Under World Trade Organisation (WTO) rules, any ban on antibiotics needs to be based on an internationally accepted scientific consensus. That consensus is usually developed through risk analysis. To date the required consensus does not exist, and many governments permit the use of antibiotics in animal feed. Lack of scientific consensus heightens the view of some critics (particularly in the United States) that the basis for the ban rests more on economics than science, and is a strategic move by Denmark, in particular, to extend its market share by emphasising its high sanitary standards and animal welfare rules.

From an EU perspective, the ban is based on science and indeed four antibiotics are still authorised for use as they do not belong to the antibiotic families authorised for use in human health, and for which there is no scientific basis to ban them.

The extent of the microbial threat to human health is well documented. The World Health Organisation held a meeting in Berlin two years ago to examine *The Medical Use of Antimicrobials in Food Animals* (1997); and the EU itself held an invitational conference on the microbial threat, resulting in *The Copenhagen Recommendations* (1998). That conference highlighted the European and global threat posed by the emergence of 'super-bugs' and made five key recommendations:

- The EU and Member States should set up a European surveillance system of antimicrobial resistance.
- The EU and Members States need to collect data on the supply and consumption of antimicrobial agents.
- The EU and Member States should encourage the adoption of a wide range of measures to promote prudent use of antimicrobial agents.
- The EU, Member States, and national research councils should make coordinated research on antimicrobial resistance a high priority.
- A way should be found to review progress with these recommendations and proposals.

In proposing its ban, the EU Commission consulted its Scientific Committee on Animal Nutrition (SCAN). SCAN examined the evidence on the individual antibiotics concerned, their use as feed additives, and risk to human health. Its opinion was that the data available are insufficient to support a ban, although it acknowledges that the probability that resistant genes will be transferred from animals to humans will be higher, the higher the prevalence is of resistant bacteria in animals. SCAN also stated that the possibility that an increase in the resistance pool in animals might pose risks to humans has been neither proved nor disproved.

The Commission, in turn, recognised the opinions of SCAN but supported a ban in the face of the potential risk involved. It highlighted SCAN's acknowledgment that a reservoir of resistant genes within the animal population poses a potential risk to humans. The Commission views its proposed ban as a necessary precautionary measure until such time as sufficient quantitative data are available on the extent of transfer of antimicrobial resistance from livestock sources to permit a full risk assessment.

A Research Agenda

Having determined to ban the use of certain antibiotics in animal feedstocks based on a precautionary approach to human health, the EU has also initiated a series of measures leading to a re-examination of the basis for its ban before December 2000. These measures include strengthening the science necessary to fight antibiotic resistance and generating that information required for a full risk assessment. The EU has also identified the need for a multi-disciplinary approach due to the different aspects of the resistance problem, and the consequent need for an integrated policy, centrally coordinated to address the issue.

The proposed measures include:

Elements of good practice

- The framing of guidelines by all Member States for rational use of antibiotics in human and veterinary medicine.
- Opposition to deregulation of sales of antibiotics.
- Restriction of the use of antibiotics in animals to well established veterinary purposes.

Monitoring antibiotic usage

- Establishment of an ongoing review of the volumes and patterns of usage of antibiotics in each Member State within a harmonised system to allow meaningful comparisons.
- Establishment of a European focal point for the coordination and exchange of information.

Surveillance of antibiotic resistance among bacteria isolated from humans and animals.

- Establishment of national surveillance systems with reports on developments in antibiotic resistance to be filed at least once a year.
- Establishment of a European focal point for collection and analysis of data from Member States.

Research Priorities

- Estimation of the risk of specific antibiotics losing their effectiveness as a result of resistance developments.
- Improved understanding of the transmission of resistant bacteria in different ecological niches, including in different animal populations and in the environment.
- The impact of antibiotic usage practices for the development of antibiotic resistance.
- Optimising antibiotic dosage.
- Development of new diagnostic technology.
- Development of effective bacterial vaccines.

In addition to these measures, the EU proposes a broad education campaign to boost public awareness of antibiotics and a survey of trainee medical personnel and qualified physicians and vets regarding their instruction and continuing professional education including antibiotic resistance. The EU will also promote the development of ethical guidelines on the marketing of medical products, including antibiotics.

A Changing Context

Although driven primarily by concerns for human health, the EU ban on the use of certain antibiotics in farming coincides with much wider and growing public pressure in many technologically advanced societies for changes in approach to farming in general, and to the raising of livestock in particular. These changes are commonly characterised in terms of sustainability, animal welfare, and broad sweeping ethical concerns.

To many, the use or abuse of antibiotics in livestock production is symptomatic of the industrialisation of agriculture and food production. The use of antibiotics is seen as a necessary and undesirable corollary of intensive livestock raising. To this extent, the EU policy towards the use of antibiotics highlights many of the characteristics of those emerging, high profile, controversial issues facing decision makers in the late 20th Century. It is multi-dimensional, the science is uncertain, it touches on both human and environmental health, has a large ethical component, and any decision has enormous financial, trade and political implications. Failure to act now could also generate massive social costs.

Lessons

The magnitude of the medical and public health impact of the use of antibiotics in animal feeds is unknown, however it is known that bacteria and genes, including resistant genes can be transferred from animals to people. The risk to humans is as yet unquantifiable, but increasing public concern, and acceptance of the need to use a precautionary approach requires policy decisions in the face of scientific uncertainty. In a global economy such decisions have enormous implications well beyond the countries immediately concerned.

The EU policy initiative has prompted a response by many other nations, including New Zealand and Canada, to better examine the risk posed by the use of sub-therapeutic levels of antibiotics in livestock feed in their countries. The uncertainty surrounding the scientific information highlights the need for guidelines (as proposed by the EU) to standardise the use of antibiotics. It equally highlights the need for better standardisation of scientific data within veterinary and medical sectors, and across different countries. It points up the importance of effective, coordinated monitoring systems to support scientific research. It also illustrates the package of initiatives required, in concert with a research agenda, to reduce the use of antibiotics as an important means of managing risk.

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CHAPTER 5

CONCLUSIONS

The nature of science and the role of science in public decision making are monolithic structures in the public mind. Governments, NGOs, and indeed the private sector are all trying to find a way through these representations. It is necessary to do so to untangle the different dimensions of science, including the diversity among different disciplines, the concepts of risk and uncertainty, and the challenge of science communications. The role of science in public decision making is further compounded by the cultural clash between scientists and decision makers, the characteristics of the political process, the need to view science in a cultural context, to respect different ethical and value systems, and to balance scientific capabilities against public acceptability, environmental concerns, political needs, and cost.

Making sense of the different dimensions of the relationship between science, society and environment is all the more difficult as nations and organisations reposition themselves to address increasing globalisation, dramatic advances in scientific understanding, a more informed public, and increasing scepticism of all forms of authority.

As this report has shown, these changing relationships have engendered a context within which a greater codification of approaches to the use of science in decision making is necessary. It bears recapitulation: *There are four main reasons why principles and guidelines are needed for the use of scientific advice in government decision making.* They provide a counter to the loss of public confidence in the credibility of science advice which has occurred due to some well-published policy disasters. Guidelines provide an assurance to political decision-makers that the science-decision making process is robust and able to withstand increasingly common legal challenges. Guidelines also provide an effective means to incorporate the precautionary principle in decision making. Quality control over decision making is enhanced where guidelines exist and their use monitored.

It is equally possible, as shown, to identify the costs of failure where guidelines have not been adopted or used: In particular, this is evident in a failure to properly articulate and implement the precautionary principle in science-based decision making. This leaves governments vulnerable to costly litigation. The absence of guidelines encourages inconsistent practices across government and weakens the integrity of the decision-making system. Urgent, controversial issues are more vulnerable to mismanagement where there are no guidelines available as a template for decision making and management practices are determined under pressure, on a case by case basis. Gaps in existing practices may persist where there is an absence of best practice guidelines against which procedures can be assessed.

Several points emerge from this work:

The role and impact of scientific advice in government decision making:

- There is an overwhelming consensus that the role of science in public decision making at all levels is increasingly important and involves pressing issues which must be addressed.

- No country is confident that it has the institutional arrangements in place or processes established which assure the promotion of best practices in the use of science for public policy. All countries are striving to improve their management and use of the science-decision making process. Most countries have made recent changes to their science-decision making system to address their own specific national needs and respond to globalisation.

Principles and procedures utilised by countries and NGOs, including the identification of best practices for:

Identifying issues for which scientific advice and research will be needed

- The British and New Zealand "Foresight" programmes are the two most explicit, comprehensive approaches to address this issue. In both countries these programmes are having, or are expected to have a fundamental impact on the science-policy agenda.

- In all countries and in all NGOs, although individual committees or groups may be identified as having specific responsibility to highlight emerging issues, in practice the process of issue identification is rarely properly systematised. All countries acknowledge the importance of the exercise. Most governments favour the use of multiple sources to feed issues into their decision making process. The identification of such issues may come from scientists, policy analysts, politicians, and lay persons.

- There is increasing recognition of the need for good international linkages to tap global understanding and insights. In this context the latent potential of diplomatic representatives is slowly being addressed.

- There is concern that government downsizing and budgetary constraints have reduced the capacity of in-house staff to identify emerging issues. This is compounded where scientists and officials are increasingly limited in their capacity to attend national and international scientific and policy fora.

- Most governments rely on the intellectual strength of their scientists and officials to identify future issues and the capability of their officials to feed these issues into the system. Increased interaction with NGOs and public interest groups is being used to identify emerging public/political concerns which may demand a policy decision.

Building science into government decisions

- The assumption that quality science advice flows from the selection of those individuals with high professional status is increasingly qualified. Although the excellence of those scientists used for advice remains a precondition, it is increasingly balanced by greater transparency in the selection process to avoid accusations of cronyism and to assure an appropriate representation of competing interests.

- Bad decisions based on what is subsequently shown to be poor science advice are encouraging the greater involvement of foreign experts in national advisory groups as a means of increasing quality and minimising any bias in the advice provided.

- Recognition of the need to 'ask the right questions' and view science in a social context is encouraging greater involvement of lay representatives on science advisory groups.

- There is broad acceptance of the need to bridge the gap between science and decision makers if the quality of decision making is to be increased, but there is no consensus on how this is best secured.

- While the gap remains, scientists continue to neglect decision makers as a prime client and decision makers neglect a valuable source of information for policy advice.

- Bridging this gap cannot be achieved by simply transferring more scientists into policy positions. The need is for policy makers to be 'science literate' and for scientists, in turn, to better understand and respect the policy process. Guidelines, as in the UK could help promote this. Improved regulations for the design and format of policy advice and the appointment of a chief science adviser are other options used.

- Although this report has focussed on the use of the natural sciences for decision making, the need to better integrate the social sciences in the decision making process is a recurrent and increasing international concern. In policy areas such as education, health, and social welfare which absorb large percentages of national budgets, social science research is particularly pronounced. However, all public policy impacts on people. Often the analysis of physical science data is only 'policy relevant' when translated into decisions designed to promote social or behavioural change. No country has found a satisfactory means to incorporate the findings from social science with those from the natural sciences and link both successfully into policy design. But the issue is recognised as of increasing importance.

Performing risk assessments

- Risk assessment is an accepted component in decision making within most countries and within international organisations. It is increasingly viewed as 'mandatory' in responding to high profile, controversial issues with a science component.

- Risk assessment is now commonly recognised as involving much more than scientific understanding and there is a growing acceptance of the need to separate risk analysis from the science/technology assessment process.

- The need to publicly acknowledge where data limitations compromise the rigour of the risk assessment is increasingly accepted.

- Risk assessment processes are increasingly being designed to incorporate cost-benefit analyses and ethical, social and political risks.

Communicating science/policy information and decisions

- The costs of attempts to maintain secrecy over the scientific information and advice used in decision making are increasingly accepted as far outweighing any benefits.

- Efforts to increase openness in the science-decision making process are commonly being prompted by the need to increase public and political confidence in the quality of the science used. They are also a response to a more informed, sophisticated public, increasingly prone to litigation and less susceptible to bland PR type announcements.

- Increased openness is consistent with the scientific tradition but also obliges scientists to engage in much wider debate.

- Although increased openness in the scientific information and advice used is being driven in part by political necessity, it is not perceived as a threat to either Ministerial responsibility or the confidentiality of government decision making. But greater openness, for most countries and NGOs, requires some cultural 'shift'.

- The need to more explicitly incorporate ethics and social values with science in decision making remains contentious but is increasingly accepted.

- The better inclusion of lay representatives on advisory groups is one mechanism to address ethical and social concerns. Increased openness of the science process is another, but the radical nature and speed of scientific advances and increased public and political concern for the social impact of science is pressuring for more substantial initiatives.

- The publication of the findings of scientific research used in decision making remains a major vehicle to ensure the quality of science and the professional standing of those scientific researchers involved.

- Increasingly, the Internet is being used as an effective, cost efficient means of promoting debate and peer review, and publicising major gaps in information and areas of disagreement in the interpretation of those research findings used in decision making.

- Public hearing of various forms offer an effective means of promoting public debate and increasing public understanding of the science-policy process but are time-consuming and costly. This approach is consequently best suited to those areas of science-decision making that are particularly contentious and/or address long-term issues.

- There remains an often unresolved conflict between the obligations of government scientists/employees who must obey rules of confidentiality and their belief that as scientists they have a right to speak freely and publicly about their work.

The use of science guidelines

- Whether in the implementation of the Guidelines introduced in the United Kingdom or in the application of international protocols for the use of science in decision making, the simple propagation of guidelines is inadequate to assure their success.

- The effective use of guidelines requires their recognition and understanding by all stakeholders. Allocation of responsibility for their implementation within the divisions of government departments and agencies is necessary, as is the monitoring and public reporting of their impact. This may require the appropriate training of the necessary personnel.

- The effective implementation of guidelines requires political will and commitment to the view that science is a necessary component in good decision making.

- Guidelines are emerging within international fora and will inevitably impinge on national institutions and procedures. To some extent the adoption of national guidelines for the use of science in decision making is a useful strategic move to 'get ahead of the game'.

In designing a route-map through the complex tangle of science-policy relationships, two signposts are clear: *greater openness* and *explicit guidelines.* Both of these components are increasingly recognised as the most effective means to increase the quality of advice to government while assuring public confidence in the science-decision making process.

For many countries this will require a new way of doing business. There is enormous international momentum for this change. And while such a shift will not obviate all future problems, it would make such problems easier to resolve.

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APPENDIX I

Terms of Reference

The Council of Science and Technology Advisors (CSTA) was established in May 1998 to provide the Cabinet Committee on Economic Union (CCEU) with external expert advice on internal federal government S&T issues that require strategic attention. The CSTA is a cornerstone of the federal government's 1996 strategy, Science and Technology for the New Century. The Council will integrate the diverse array of expert external advice the government now receives on science, technology through the S&T external advisory boards which report to Ministers of science-based departments and agencies. The CSTA is composed of representatives from these advisory boards and others that Ministers call upon for advice.

The CSTA has established a sub-committee to develop a set of guidelines on the use of scientific advice in government decision making. The Council will report to CCEU in the spring of 1999.

The purpose of this study is to generate ideas for establishing Canadian guidelines for the use of scientific advice in government decision making. The consultant is invited to report on the best practices of foreign governments and international non-government organizations (NGOs) and on case studies which demonstrate the importance of these guidelines. A similar contract, under separate cover, will provide insights into the principles and guidelines employed by Canadian federal science-based department and agencies (SBDAs) and provincial governments.

Statement of Work

Background

The emergence of the knowledge-based society has underscored the importance of sound social, scientific and technological advice as a key input to policy formulation both nationally and internationally. The issues facing governments are increasingly complex and have widespread and profound impacts on societies and economies. The consequences in inadequately or ill-informed decisions can be catastrophic.

Governments are grappling with issues that require risk assessments and decision in areas of intense public concern. Recent decisions in the areas of natural resources management and public health and safety have resulted in media reports which suggest that the public's confidence in the ability of governments to effectively use scientific advice in reaching policy and regulatory decisions is waning. The Government of Canada recognizes the importance of these concerns and has asked the Council of Science and Technology Advisors to develop a series of principles and mechanisms to ensure the effective use of scientific advice in reaching decisions.

Scope of Study

Scientific advice is broadly defined to include advice provided by internal and external sources to those involved in recommending and making policy and regulatory decisions within the federal government, including Ministers.

Best practices are being sought in the principles and procedures by foreign governments to ensure that government policy and regulatory decisions are informed by sound scientific advice.

The consultant will review and report on the principles, procedures and enforcement measures employed by foreign governments and international NGOs regarding the use of scientific advice in government decision making. The consultant will assess whether the principles and guidelines are adhered to and the impact of these guidelines, including the impact on public confidence in government decisions.

The consultant will identify the consequences of an absence of, or inadequate, guidelines and where possible, review cases where scientific advice is purported to have been ignored, altered or suppressed.

Methodology

The consultant will draw on his/her past experience, the available literature and consultations, as appropriate, with at least five major foreign governments (including Britain, USA, Australia, New Zealand and a Scandinavian country) and two international organizations (e.g. The World Bank) involved in making science-based decisions to report on the best practices employed by these organizations for the use of scientific advice in government decision making. The consultant will also investigate and report on the European Union's experience in this area, particularly recent concerns regarding scientific advice and government policy. In addition, the consultant will provide summaries of recent cases involving public concern regarding the organisation's ability to effectively use scientific advice in reaching decisions.

The final report will provide details on the best practices in scientific advice principles, practices and enforcement mechanisms currently utilized by other countries and NGOs.

Deliverable

The consultant will produce a report which addresses the following:

- The role, importance and impact of scientific advice in government decision making;
- Principles and procedures currently utilized by other countries and international organizations, including the identification of best practices for:
    - identifying issues for which scientific advice or research will be needed;
    - building science into government decisions (i.e., how is the best science accessed and built into decisions);
    - performing risk assessments;
    - communicating and presenting policy (including current departmental and government policies and procedures regarding public access to scientific findings, advice and

decision making); and

- implementing and ensuring the use of scientific advice guidelines.

- The consequences in cases where other countries and international organizations have not employed guidelines on the use of scientific advice in decision making.

The consultant will produce an executive summary addressing the issues outlined above and a detailed background report which summarizes the scientific advice principles and procedures of other countries and international organizations and provide detailed descriptions of the best practices in the areas outlined above. The report will also include the full range of results of consultations and literature reviews as well as the case studies described above.

The consultant will provide a bibliography of literature reviewed and a listing of consultations conducted. A status report will be provided on 18 December 1998 to discuss preliminary findings and results, and to report on any difficulties encountered in the course of the study.

Depth of Coverage

For each best practice organization identified, the consultant will provide information on:

- the impetus for establishing the scientific advice principles and practices;
- the implementation mechanisms utilized to ensure adoption of principles and guidelines;
- the time it took before best practices began to yield results;
- the problems encountered by the organization during implementation and strategies employed to overcome these challenges;
- the failures experienced by the organization along the way to arriving at the best practice and the lessons learned from these failings;
- changes in public confidence as a result of the new measures; and
- the feasibility of applying the best practices identified to Canada.

APPENDIX II

Compendium of Guidelines - Scientific Advice in Government Policy

United Kingdom - 1997 Policy Statement by R. May, Chief Science Advisor

A. Identifying Issues

1. Individual departments and agencies should ensure that their procedures can anticipate as early as possible those issues for which scientific advice or research will be needed, particularly those which are potentially sensitive. Early identification of issues should always be the aim.

2. No single approach is likely to be adequate. Instead, information should be drawn from a variety of sources and monitored by those responsible for the department or agency function as an intelligent customer for science, engineering and technology.

3. Sources may include:

    i) departments' own programmes of research. It is important that departments maintain adequate support for broadly-based longer term research to help them identify and/or respond to new and unexpected findings;

    ii) research from non-departmental sources, including international bodies (eg the European Commission);

    iii) departments' existing expert advisory systems, where members of committees may be specifically asked to draw attention to new areas in the scientific literature. Membership should be kept under review to ensure an appropriate range of scientific opinion is represented;

    iv) discussions with those in the Research Councils, industry, academia and elsewhere, including through the network of Foresight panels. These are likely to be most fruitful when held against the basis of long-standing relationships developed with departments;

    v) issues brought to the attention of Government by the interests directly concerned (e.g., individuals, companies, scientists or lobby groups) or by reports in the media.

4. Nonetheless, some issues will inevitably arise with little or no prior warning. Departments should ensure that they have the capacity to recognise the implications and to react quickly and efficiently to such crises.

5. It is important that there should be mechanisms for early identification of issues which affect more than one department/agency, or may have an international dimension, and for early

provision and exchange of information. The Office of Science and Technology has responsibility for ensuring that SET issues which cross departmental boundaries are effectively handled. It will keep emerging transdepartmental issues under regular review, in liaison with departmental Chief Scientists.

B. Building Science into Policy

6. Once a potentially sensitive issue has been identified, departments should consider how to access the best available scientific advice. They should ensure that they draw on a sufficiently wide range of the best expert sources, both within and outside Government. They should seek wherever possible:

   i) to take independent advice of the highest calibre (whether provided by eminent individuals, learned societies, advisory committees, or consultants). Efforts should be made to avoid or document potential conflicts of interest, so that the impartiality of advice is not called into question;

   ii) to ensure that Research Councils are invited, where appropriate, to provide scientific input and contribute to interdepartmental discussions;

   iii) to involve experts from outside the UK, for example those from European or international advisory mechanisms, particularly in cases where other countries have experience of, or are likely to be affected by, the issue under consideration;

   iv) to involve at least some experts from other, not necessarily scientific, disciplines, to ensure that the evidence is subjected to a sufficiently questioning review from a wide ranging set of viewpoints;

   v) to ensure that data relating to the issue are made available as early as possible to the scientific community to enable a wide range of research groups to tackle the issue. Scientific advance thrives on openness and competition of ideas.

7. Where the policy issue falls within European Community competence, or is likely to affect intra-Community trade, particular attention should be paid to encouraging a sound scientific basis for Community decision-making. This may involve contributing to Community-level scientific committees, briefing the Commission on developing scientific opinion, and exchange visits by scientific experts from other Member States.

8. Drawing particularly on the principles set out in paragraph 6, departments should involve the scientists whose advice is being sought in helping them frame and assess policy options. This will help maintain the integrity of the scientific advice throughout the policy formation process.

9. In practice, deliberations frequently involve a risk assessment of one type or another. Separate guidance on risk assessment is listed in the Annex. Recent public debate, to which the Minister for Science and Technology and the Chief Medical Officer for England have

contributed, has focused in particular on the presentation and communication of risk. The Interdepartmental Liaison Group on Risk Assessment (ILGRA), chaired by HSE, provides a forum for taking forward cross-Government dialogue on these issues.

10. Departments should systematically review priorities to see whether funding needs to be directed to programmes of further research to illuminate outstanding areas of uncertainty identified. Departments' R&D programmes should conform to competitive tendering rules and be subject to robust quality assurance systems involving peer review.

11. Scientific advice will often involve an aggregation of a range of scientific opinion and judgement as distinct from statements of assured certainty. Departments should ensure that the process leading to a balanced view is transparent and consistent across different policy areas, in the light of the guidance above.

C. Presenting Policy

12. In line with the Government's *Code of Practice on Access to Government Information*, there should be a presumption towards openness in explaining the interpretation of scientific advice. Departments should aim to publish all the scientific evidence and analysis underlying policy decisions on the sensitive issues covered by these guidelines and show how the analysis has been taken into account in policy formulation. Scientists should be encouraged to publish their own associated research findings.

13. Openness will stimulate greater critical discussion of the scientific basis of policy proposals and bring to bear any conflicting scientific evidence which may have been overlooked. These are good reasons for releasing information, an action which could in itself avoid greater controversy in the longer run. Departments must ensure appropriate procedures are agreed with the academic community and industry for handling intellectual property rights when information is released.

14. It is important that sufficient early thought is given to presenting the issues, uncertainties and policy options to the public so that departments are perceived as open, well prepared and consistent with one another and with the scientific advice. The difficulties associated with presenting uncertain or conflicting conclusions should not be underestimated.

15. In public presentation, departments should whenever possible consider giving scientists a leading role in explaining their advice on the science, with Ministers or policy officials describing how the Government's policies have been framed in the light of the advice received. Further advice is available in the Government's *Code of Practice on Access to Government Information: Guidance on Interpretation*.

16. Early communication with key interest groups may be appropriate. Consideration should also be given to providing early warning of significant policy announcements to other governments and international organisations, where there are likely to be implications for other countries. Where possible, scientists from such countries or organisations should be involved in the process of consultation and advice.

D. Review

17. Issues coming to Ministers for collective consideration should make clear to what extent it has been practicable to follow the advice in this note.

18. The Government's official committee on science and technology, EDS(O), will keep under review departments' and agencies' procedures for early anticipation and identification of issues for which scientific research or advice will be needed. OST will keep emerging trans-departmental issues under review. OST will also monitor implementation of the principles across departments, and include a report in the annual Forward Look of Government-funded Science, Engineering and Technology.

APPENDIX III

The European Commission - The Precautionary Principle - 1998
(Draft document for discussion)

The precautionary principle is a risk management approach that is exercised in a situation of scientific uncertainty, reflecting a need for action in the case of a potentially serious risk without awaiting the results of scientific research.

This approach should be based on the following six guidelines:

Implementation of an approach based on the precautionary principle should start with an objective risk assessment, identifying at each stage the degree of scientific uncertainty.

All the stakeholders should be involved in the decision to study the various management options that may be envisaged once the results of the risk assessment are available and the procedure be as transparent as possible.

Measures based on the precautionary principle must be proportionate to the risk which is to be limited or eliminated.

Measures based on the precautionary principle must include a cost/benefit assessment (advantages/disadvantages) with an eye to reducing the risk to a level that is acceptable to all the stakeholders.

Measures based on the precautionary principle must be able to establish responsibility as to who must furnish the scientific proof needed for a full risk assessment.

Measures based on the precautionary principle must always be of a provisional nature, pending the results of scientific research performed to furnish the missing data and perform a more objective risk assessment.

APPENDIX IV

Consultations

Antibiotics

- Stuart Macdiarmid, National Manager (Agricultural Security and Animal Health), Ministry of Agriculture and Forestry, Wellington, New Zealand
- Caryll Shailer, Veterinary Counsellor, New Zealand Embassy, Brussels
- Nick Whelan, National Manager (Animal Remedies and Stockfoods), Ministry of Agriculture and Forestry, Wellington New Zealand

Australia

- Roger Bradbury, National Resource Information Centre, Bureau of Resource Science, Canberra
- Kevin Bryant, Science and Technology Policy Branch, Department of Industry, Science and Resources, Canberra
- Ron Johnston, Professor, Australian Centre for Innovation and International Competitiveness, University of Sydney, Sydney
- Peter Newton, Chief Research Scientist and Head of Planning and Design Programme, Commonwealth Scientific and Industrial Research Organisation, Melbourne

Canada

- Paul Dufour, Industry Canada, Ottawa

European Union

- Dorothea Andei, Agriculture Division, Brussels
- Henri Belveze, Consumer Health Protection, Brussels

New Zealand

- Gerald Rys, Principal Adviser, Science Group, Ministry of Research, Science and Technology, Wellington
- Steve Thompson, Chief Executive, Foundation for Research, Science and Technology,. Wellington
- Ian Whitehouse, Strategic General Manager, Landcare Research, Christchurch

NGOs

- Peter Collins, Chief Science Adviser, The Royal Society, London
- Robert J.A. Goodland, Environmental Adviser, The World Bank, Washington, D.C.
- Viraj Vithoontien, Operations Unit – Montreal Protocol, The World Bank, Washington, D.C.
- Jean-Pierre Wallot, President, The Royal Society of Canada, Ottawa

Nordic Union (Denmark and Norway)

- Trygve Eklund, Deputy Director, Strategic Planning, The Research Council of Norway, Oslo
- Lars Horn, Assistant Director Bioproduction and Processing, The Research Council of Norway, Oslo
- Birger Kruse, Special Adviser, Strategic Director, The Research Council of Norway, Oslo
- Kari Balke Oiseth, Deputy Director, Dept of Research, The Royal Ministry of Education, Research and Church Affairs, Oslo
- Ove Poulsen, Ministry of Research and Information Technology, Copenhagen
- Grete Ek Ulland, Director, Dept of Research, The Royal Ministry of Education, Research and Church Affairs, Oslo
- Ragna Valen, Assistant Director, Medicine and Health, The Research Council of Norway, Oslo

United Kingdom

- Joe Brown, Science and Technology Unit, Scottish Office, Edinburgh
- Robin Cook, Senior Scientist, Fisheries Research Services, Aberdeen
- John De Mallo, Office of Science and Technology, London
- David Fisk, Chief Scientist, Department of the Environment, Transport and Regions, London
- Ian Lomos, Office of Science and Technology, London
- T. Hugh Pennington, Head of Departmentt of Medical Microbiology, University of Aberdeen, Aberdeen
- William Stewart, former Chief Scientific Adviser to Government of United Kingdom, Dundee

United States of America

- Jesse Ausobel, Rockefeller University, New York
- Don Barnes, Chair, EPA Science Advisory Board, Washington, D.C.

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