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The Role and Responsibilities of the Scientist in Public Policy:
A Discussion Paper on Science and Government

Bill Jarvis

Public Policy Forum

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Note from the Series Editor

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This policy brief, the seventh in the series, was originally published in 1998 and is still highly relevant to the topic. Since it is no longer available on the Internet, it is republished here with permission of the Public Policy Forum and the author.

The ISSP also carries out adjacent activities on the topics covered in these briefs. We hope they will be well received and are looking forward to any feedback you may have. You may reach me directly at msaner@uottawa.ca.

Marc Saner
Director, ISSP

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On Science And Government

SEPTEMBER, 1998

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Foreword

The Public Policy Forum is founded on the belief that effective public policy and a strong, well-managed public sector are critical elements to Canada's success. The interaction of science and government lies at the heart of a number of policy and management issues confronting Canada's public sector at the end of the millennium. The impacts of these issues will affect all sectors of the Canadian society. This is the first paper by the Forum that focuses exclusively on the area of science and government.

The hypothesis on which this paper is based is that in Canada, as in most major trading nations, the role of science and technology (S&T) in the policy frameworks of governments has expanded considerably, and that this trend is likely to continue. The consequence of such an expansion is an increasing need for decision-makers, and those who advise them on a day-to-day basis, to understand the scientific issues and knowledge base which underlie policies.

For those involved in the operational elements of the government's S & T portfolio this situation creates both opportunities and challenges. The opportunity is to make effective use of the knowledge, expertise, and institutional setting, of government scientists to enhance the role of science in public policy decisions. The ultimate objective is to ensure that the soundest possible information, based on neutral, nonpartisan advice, is available to Ministers to help them in the development of policy decisions.

The challenge is to identify the most effective approaches to get access to Ministers, to sustain the Ministers' confidence in the neutrality and objectivity of the advice, and to fit the relevant scientific information into the most useful context for policy development.

The idea for this paper was borrowed from an article by Charles

Schultze of the Brookings Institute published in 1982. As chair of the Council of Economic Advisors in the United States administration, he observed some of the difficulties economists regularly had in making their views known in a way that could best inform decision-makers in the U. S. Cabinet. There are some interesting parallels between the economic advisory process in the 1970s and early 1980s, and the emerging needs for advice on science towards the end of the 1990s in both Canada and the U. S.

As in Schultze's article, much of the information in this paper is well known, and much of the advice is already part of the ongoing process within government departments and science agencies. The ambition of the paper is that, by bringing together a number of disparate ideas that impact on the effectiveness of science advice, it will bring a fresh perspective to the challenges and opportunities. The ultimate objective is to assist, through enhanced understanding, the effectiveness of advice on science to Ministers.

Acknowledgments

This paper has benefited from discussions with many knowledgeable people, both within the government administration and outside the public service. To all those who have patiently helped me to understand more fully the theory and practice of science in government I am sincerely grateful. Although the inspiration for the paper was drawn from many sources, the author is responsible for any problems, errors or omissions in the document. Thanks go to Jean McCloskey for providing the opportunity to undertake this work, and to David Zussman for his support and confidence. There were too many contributors of excellent ideas to name them all, but a few deserve special mention. John de la Mothe generously helped me get started on the path of the study of the sociology of science; Stuart Smith helped to establish the focus on taxonomy; Ralph Heintzman and Bob Slater provided important clarity on the issue of values; Michael Jenkins helped identify a "world view" of the science community; and Tom Brzustowski contributed ideas on the decision-making process. I am grateful to Eva Kmiecic of the Public Policy Forum and to Tom Ledwell for their very useful suggestions for alterations from initial drafts of the paper.

We can see as far as we do because we stand on the shoulders of giants. I have an intellectual debt to Charles Schultze of the Brookings Institute (whom I have never met, but whose works have been a great influence) and to the task force headed by John Tait that produced the paper on Values and Ethics in the Public Service.

Finally, thanks to the readers of this paper, for taking the time and effort. I hope you get as much pleasure from reading this document as I got in its writing.

The Role And Responsibilities Of The Scientist In Public Policy

The relationship between science[i] and government is an uneasy one. The issues involved have provided fertile ground for analysis, review, theoretical and empirical studies, and a seemingly endless stream of government reports, commissions and advice. At the heart of the relationship is a fundamental difference in the mode of thinking required to accomplish the central missions of the two endeavours.

At the core of science is a pursuit of truth. Regardless how hidden or difficult to articulate, natural phenomena can ultimately be explained by careful application of the scientific method. As a popular television program proclaims, "the truth is out there". But, nature only reveals her truth to patient, painstaking analysis that knows no time constraints, and proceeds step by step towards understanding.

The essential function of government is to make choices, normally in situations of considerable uncertainty and under the glare of public scrutiny, where the concept of a correct answer is rarely useful. Right and wrong give way to better and worse. Moreover, the decisions are inherently subjective, as much as they might be informed by various sources of information. Time frames are usually determined by non-controllable events and are often measured in hours. Choices must be taken which benefit some at the expense of others, and the only compass is the judgement and character of the decision-makers, helped by the information available to them at the time.

It is hard to imagine a more unlikely set of Siamese twins. And yet the symbiotic relationship between these two perspectives creates an unbreakable bond. Since 1945 the relationship has grown to

encompass an increasing number of areas of public policy. For military purposes, then for health and social development, and more recently to support and sustain economic growth, governments have become large, and in many cases, the most significant sources of funding for science.

Science, as it is structured today, cannot live without government support. Conversely, the responsibilities that governments have taken on, in many cases, require not only the development of scientific knowledge and technological solutions, but also well-founded scientific advice on which to base regulatory and other related decisions.

Nowhere is this duality more exposed than in the science communities[ii] that undertake these functions within government. Underlying this relationship is an explicit and implicit contractual base. The terms of employment (and compensation) provide that public employees have a duty to carry out government decisions loyally, and "to apprise their Minister of the political (and other) consequences of pursuing various courses of action".[iii] The duty of advice requires a crossing of the intellectual divide that separates science and government.

But this duty is not only a part of the contractual relationship. For government scientists and science-based organizations, the advisory role is by far the most effective way to sustain the governments' interests and belief in the relevance of science. To be successful those who provide advice on science must learn the craft in the same way that they have learned the craft of scientific inquiry and expression.

This paper argues that there is both a need and an opportunity for those involved in the science and engineering organizations and activities of the Government to expand their role in providing advice on matters of science to decision-makers. Great strides have been made in increasing the technological and scientific context for decisions. However, in spite of Herculean efforts to provide an effective response to these needs, many of those involved in the provision and use of scientific advice are deeply dissatisfied with the outcomes to date.

Research scientists sometimes feel that their information is corrupted or misused (or both) in the process of policy development. Science managers experience frustration at the difficulty of getting adequate attention to knowledge developed or accumulated in their laboratories. Policy advisors feel frustrated by the timeliness and relevance of the information they receive. And Ministers, looking for definitive information on which to base politically sensitive decision, are often faced with conflicting views, high levels of uncertainty, and advice that is more and more frequently challenged by interest groups.

OBJECTIVES OF THIS PAPER:

1. identify some of the barriers which impede the effectiveness of advice from public service scientists to decision-makers;
2. examine the conditions and opportunities which could enhance that effectiveness;
3. contribute to the development of guidance to those involved in the provision of scientific advice in order to serve decision-makers better, and to take better advantage of the scientific knowledge upon which these decisions depend.

At the core of this paper is a belief, by the author, that the Canadian public, and the political process, through which Canada is governed, can benefit considerably by an increasingly effective science advice function from within the government science establishment. In addition, improvements in the delivery of such advice can provide a strong inducement for continued support of government's scientific endeavours. Conversely, if this function is diminished, public policy in Canada will be impoverished by its absence.

The paper begins by developing a framework for the objectives of governments with respect to science, and the instruments used. Part II is a discussion of the value systems that underlie the expectations and behaviour of public service scientists. The next section identifies the responsibility of government scientists, within a Westminster-style government, to provide objective, neutral, and

nonpartisan advice. Part IV illustrates some of the challenges based on the source of the advice, noting that different functions provide quite different contexts for advice. Part V illustrates the perspective of the recipients of the advice, and the need to speak to the interests and needs of Ministers. The following section points out the multiple roles required of science managers in the government, and the crucial responsibility they have in linking scientific knowledge to policy advice. Part VII identifies five critical challenges that need to be addressed and the last section proposes outstanding issues that emerge from the discussions.

What are the factors that have created the opportunity to expand the access and effectiveness of the science community in helping to form public policy? First and foremost is the changing focus of government interests as governments evolve to respond to the needs of changing national and international conditions. The role of science and technology in matters of public policy has grown considerably over the past decade, at least in relative terms. This growth reflects, at least in part, the decline in the appetite for governments, not just in Canada, but in most OECD countries, to engage in activist intervention in their economies. At the same time, a new focus on the technological roots of economic performance

The array of economic intervention policies and programs which characterized governments' attempts to manage sectoral and regional growth and development patterns has all but disappeared as a consequence of:

- experience - the demonstration of the limitations of such approaches
- institutions - the opening up of international trading relationships with associated limitations on direct subsidies;
- philosophy - the underlying belief systems regarding the appropriate functions of governments .
- costs - the inability to control costs as incentives evolved into entitlements

has emerged[iv]. Science and technology (S & T) as a field of public policy and administration has not only expanded its relative share of discretionary government activities. It has also expanded the scope of its interests to include industrial development, trade (technology transfer) issues, and education (the development of new scientists and scientific literacy).

Finance Minister, Paul Martin, in his budget speech of February 1998, said, "there can be few things more critical to determining our economic success in the next century than a vigorous, broad-based research and development effort"[v].

This is not a uniquely Canadian phenomenon. "Science is playing an increasingly influential role in contributing to formulation of both UK and international policy and regulatory decisions" according to Sir Robert May, Chief Science Advisor to the UK Government.[vi] Steve Lakoff, in his presentation for the 1997 J.J. Carson Lecture, revisiting his work on science and government over the past forty years, noted that "we have entered a stage of social history in which many forms of knowledge, especially those with bearing on war and peace, the economy, health and the environment, have become indispensable in government." And the Japanese agency for science (NISTEP) in its recent Report #17 titled *Science, Technology, Society, and Communications* notes that "the relationship between science and society has become stronger and more complicated."

Associated with these trends is a new or expanded set of demands on scientists in the public service. The most important of these is the more active engagement of public service scientists in the provision of advice on science to decision-makers.

I. Objectives of Governments

As the Cheshire Cat said to Alice in Wonderland, "if you don't know where you are going, any road will do". The role of the science advisory system in governments must depend first and foremost on the governments' objectives that are influenced by science or executed through science. There are some elements of scientific advice that are, for the most part, independent from the ultimate intention of the decision. But there are others, where the role of the scientist is more complex with respect to the decision-making process, that need to take account of the objective being sought, and the role of the scientific advisor in the particular context. Recognizing and responding to these complexities is a crucial element of the advisory process.

Governments' interests in science stem from several key roles which society ascribes to government. The borders of these functions, how and where they are executed, and the resources necessary for their execution, are all matters of continuous debate and adjustment. But the key responsibility framework remains. These responsibilities (or objectives) are:

1. Expansion of our knowledge of the physical universe[vii];
2. Protection of the community through health, safety, and defense;
3. Stewardship of shared community resources;
4. Economic development through enhancing technology options;
5. The provision of scientific information to help society make decisions

The first four responsibilities require the direct application of science and scientific methodology. The last requires knowledge of the science but generally no direct application. These responsibilities require the performance of a variety of different tasks. Although these tasks are sometimes considered to be discrete, and associated solely with one or the other of the responsibilities, in the context of government interests in the 1990s, there is less and less a notion of boundaries between the different functions. These functions (or instruments) are:

1. Basic research;
2. Applied research (goal driven research);
3. Standard development and compliance testing;
4. Technology development and transfer;
5. Observation, monitoring, and information management.

Rather than a one-to-one correspondence, it is best to look at these tasks and responsibilities as a matrix. The strongest links are across the diagonal, but each element is related to and affected by the others. The following table is a conceptual illustration of the linkages arrayed as a matrix. The most important feature (for the sake of this argument) is that there are no empty cells.

Integration of Instruments and Objectives[viii]

Objectives/ Instruments	Knowledge	Protection	Stewardship	Economic Development	Decision Making
Basic Research	★★★★★	★★★	★ ★	★	★
Applied Research	★★★	★★★★★	★★★	★ ★	★
Standards & Testing	★	★★★	★★★★★	★	★ ★
Technology Development	★	★ ★	★ ★	★★★★★	★ ★
Monitoring, Information Management	★	★ ★	★★★	★★★	★★★★★

The ability to deal with issues that arise in managing governments' science portfolios depends on a clear understanding of the implications of this matrix approach to describing objectives and tools. Ministers and their senior advisors may tend to see S & T activities as a unified whole that can be shaped and tuned to be responsive to the government's priorities. At the operational level there are still strong tendencies to see isolated elements of this system as existing in their own discrete space, unlinked to the larger S & T system. Both of these perspectives are dangerously limiting. First, any prescriptive approach to managing S & T that does not explicitly deal with the diversity of responsibilities and activities represented in this framework, is likely to overlook key aspects of the governments' interests.

The consequences of these differing viewpoints can be to put vital interests at risk. Equally important is the second key implication of this matrix view. The objectives and tools of government science cannot be isolated one from another. The boundaries between basic research, technology development, and/or regulatory implementation are not fixed or discrete. *All these issues flow together, and the ability to integrate the pieces into the wider framework is an important ingredient of operational effectiveness.*

The implications are equally important for the process of providing advice emanating from government science-based functions. Each of the individual aspects of science activity carries with it its own perspective on policy advice (as discussed in Section IV below). A full understanding of both the diversity of perspectives and the horizontal and vertical linkages which affect them, forms one of the basic underpinnings for effective advice. This matrix provides a taxonomy to help understand and exploit the links between the operational science activities of the government and the objectives for which advice is needed.

II. Integrating Value Systems

A major element in the capacity to develop policy relevant scientific advice that is effective in government political and administrative decision-making processes is the ability to see the world as others see it. The 'world view' (that is the epistemological perspective) upon which any intellectual community builds its conceptual framework strongly influences its ways of expressing ideas, its belief system, and even its perceptions of reality. Effective communication requires at least an understanding of the 'world view' of the target audience, as well as an acceptance of the differences that may exist. These 'world views' are rooted in the value systems, which form the basis of the various intellectual communities. The next section explores the unique perspectives of the science community, and its relationship to government.

Science Values - a Case for an Ecumenical Approach

The paper on *Ethics and Values in the Canadian Public Service* by Tait et al[ix] points out the difficulties inherent in the adoption of a new set of values (public management values) in response to the need to modernize government. The paper is clear (and others such as Hennessy[x] support strongly) that these new values do not, and should not, displace the traditional values of public administration inherent in the Westminster system of government. Nonetheless, the paper points out that the new values may sometimes come into conflict with the more-established (and fundamental) values.

> "Renewal of the public service does not mean choosing between the "new" and the "traditional" values of professionalism but rather requires us, in some instances, to find an appropriate balance between them" (Tait et al, p.75).

In these circumstances, an understanding of, and a tolerance for,

this multiplicity of values becomes a necessary ingredient of a well-functioning government.

The issue of multiple values, which must in some circumstances inevitably come into conflict, is also addressed in the same paper. "Every human action or decision requires a choice between values, and in each situation some value or values may predominate over others. .... We need to develop a new maturity in our perception and understanding of competing values so that we may see them as complimentary rather than contradictory" (ibid p.48). The paper notes "what the philosophers call the hierarchy of values" as the central mechanism for reconciliation (ibid p.2). That is, for any decision or circumstance, some values must take precedence over others. A good example is the value associated with the rule of law, which in virtually all circumstances, must take precedence over other values for public servants.

The reconciliation of these sets of values certainly lies at the heart of a number of key issues in the management of the public service. However, as we examine the issues facing the government with respect to the management of the government's responsibilities in science, and the functioning of scientists within government administrations, yet another set of values emerges. The literature on the philosophy and the sociology of science (see for example Ziman J, 1984[xi], pp 81-100) provides a strong idea of a set of values that is intrinsic to the science community (as a necessary set of criteria for participation in the 'invisible colleges' that govern scientific communities).

Science values, as a coherent set of norms, were codified by R.K. Merton in 1942. As interpreted by Ziman (ibid, p.84) they include five principles:

- communalism; science is public knowledge, freely available to all;
- universalism; there are no privileged sources of scientific knowledge (the merit principle applied to knowledge);
- disinterestedness; science is done for its own sake;
- originality; science is the discovery of the unknown; and
- skepticism; scientists take nothing on trust.

These "professional values" of research scientists can certainly be as important to government scientists as the public service values articulated in the Tait et al paper (either the traditional values or the new management values). Even though they represent, as is usually the case with value systems, highly idealized interpretations of much more complex real-world applications, they are a powerful framework to help scientists understand the expectations of their profession. As should be expected, there are numerous situations in which these values may conflict with public service values.

The principle of communalism can illustrate the kinds of conflicts that can arise. It suggests that the fruits of science, the knowledge gained from scientific research, should be available freely to all. Communication of new information should be transmitted immediately by publication in the professional literature. There are at least two circumstances where conflicts might arise. The first relates to the value of loyalty to the government of the day. If the information has importance for the government's policies, the public service values would suggest that the Minister, under whose authority the research was conducted, should determine the timing and method of public release of the information. The second circumstance is where the research is conducted as part of a partnership agreement where the private-sector partner may believe that his/her commercial interests would be damaged by full release of the research results. This latter dilemma is, of course, a common situation in privately owned laboratories. But the public service value of always acting in the public interest can conflict with private interests in some circumstances. The enthusiasm to pursue public/private partnerships in government complicates the issue of communalism for government research where there is conflict between the values of client focus and of always acting in the interests of the public.

To function at a senior level of management within the public service, it is necessary to accept, and to exhibit behaviour consistent with, those public service values described by Tait et al. However, the more distant the public servant is from the central agencies, or from a role in direct contact with the political operations of government, the less urgent is the primary adherence to the public service values. Other, competing value systems start to play a much

more important role. These may be personal value systems, but often they are also value systems associated with particular professions: legal, engineering, medical, etc.[xii] Certainly the norms of professional behaviour expected of the scientific community represent such a system.

Effective communication between such systems cannot take place without some appreciation of the areas of differences and the areas of concurrence (Often identical words or phrases can have markedly different interpretations depending on the perspective of the reader.)

In the normal course of events, the balancing of these value systems within the structure of the public service works itself out in a practical manner reflecting the operational needs and responsibilities of the various functions and communities. However, in times of significant change to the responsibilities, operations, objectives, or funding, of particular communities within the government, differing value systems might be expected to find expression as increased tension between the senior executive/central agency perspective, and some of the operational perspectives.

III. The Role of the Scientist in the Public Service

The existence of an impartial, professional public service, able and willing to provide objective advice to support political decision-making, is still seen as a necessary condition of good government in a Westminster-style government such as exists in Canada. This remains true in spite of serious challenges to this principle over the past couple of decades: theoretical challenges from the Public Choice theorists; political challenges from the new right; implementation challenges from the introduction of new public management principles; and operational challenges from fiscal and human resource restructuring.[xiii]

Within such a system, the public servant, regardless of occupation or professional background, is required to do two things:

1. provide the Minister with the best possible advice regarding decisions the Minister must make; and,

2. faithfully execute the decisions of the government in a professional manner, consistent with the public interest and the highest standards of public service values and ethics.

This paper deals with the first of these obligations. However, it is worth noting that, where an organization has an operational role, the effectiveness of its policy advice will depend critically on the performance with respect to the second, operational, function. The confidence of the Minister, with respect to the loyalty and disinterestedness of advisors is one of the most important criteria for the Minister's receptivity to the advice provided. Conversely, an active and transparent role in the development of policy advice can provide a sounder basis for implementation, by creating deeper

links between the knowledge and experience of participants in the operational units and in the decision-making process. The assurance that the advice of government S & T officers is heard and is influencing decision can help build a more committed S & T delivery system.

The Advisory Role

The advisory role of scientists (and more broadly of science-focused organizations) within government can be divided into a number of different elements. The distinctions are associated with the objectives of governments described in section 2. These elements have certain characteristics in common, but they also have particular aspects suggesting separate examination. In particular, each of the elements requires a high level of scientific knowledge, often based on specific targeted research, as the necessary basis for the advice. On the other hand, the local interests of the scientists, their organizations and their partners, can vary considerably depending on both the objective of the science and on the approach to implementation. The intent of this section is to illuminate the aspects of these areas that can lead to effective advice consistent with the appropriate role for public servants.

The first element of this process is to recognize where the advice is coming from. As Sir Robert May, Chief Science Advisor to the U.K. Government, advises, "Efforts should be made to avoid or document conflicts of interest, so that the impartiality of the advice is not called into question"[xiv]. This is equally true for advice coming from sources inside and outside the government.

Why is this aspect of advice (that is, objectivity and neutrality) so important? Peter Aucoin points to this issue in discussing the role of the career public service in a Westminster-style government. He notes the challenges to the public service in terms of public trust, and identifies the theoretical background to these challenges.

> "The principle intellectual challenge to the idea of career public service as a condition of good government came from public choice theory. Although there are numerous

> articulations of this theory, the common point of reference with respect to relations between politicians and public servants is the assumption that career public servants are not primarily motivated by the public interest in good government but by the promotion of their own individual or collective self-interests. Public choice theory assumes, moreover, that these self-interests will often be at odds with those of elected representatives, as well as those whom they represent. And furthermore, the interests of the bureaucracy too often win out over those of its political masters and/or their constituents."

One can see from the experience of the past decade, the potential consequences of such a point of view. Public distrust of the neutrality and objectivity of the public service must eventually translate into a diminishing of the functions, the size, and the resources available to all of the public service. If the role of advice on scientific matters is to flourish within the science organizations of government, a sensitivity to the need for exemplary performance in identifying and managing motivations, and the outward appearance of such performance, is more and more a necessary condition. The alternative is that Ministers will get most of their advice from external advisory bodies, without the intermediation of professional public servants. Notwithstanding the important role of such external advice, the effectiveness of our system of government would be diminished if confidence in advice from the public service was eroded.

In order to manage these issues, it is useful to examine carefully the positioning of science agencies within the government on different issues. A key point is that the interests of the internal community vary considerably depending on the type of function being undertaken. The following is not intended to be a comprehensive view, nor can the ideas be generalized to all relevant science advice, nor should these comments be interpreted to mean that the current system is dysfunctional. However the ideas presented capture the types of issues which must be dealt with explicitly if the advice provided is to maximize its effectiveness and its value to decision-makers.

IV. Advice on Science: Where It Comes From

1. Government scientists are required to provide advice to Ministers on the broad context of the management of the governments' basic (non-goal driven) science portfolios. The focus here is primarily on the objective of the expansion of knowledge for its own sake. The key questions of how much funding should be dedicated, how it should be allocated, and where the activity should be undertaken, require expertise in the areas being examined. However, in this context the personal and organizational interests of the science community are clearly and closely tied to the outcomes.

The scientist community can and should be expected to argue in favour of science. Furthermore, each science function must undertake the role of argument in favour of the expansion of the activities with which it is associated. There will always be opposing views, from other interests to balance the advice the Minister receives. It is difficult, however, to imagine a circumstance when everything is known about any particular aspect of science. In this regard, the notion of an endless frontier[xv] can underlie the scientific advice.

Ensuring Balance

Understanding the self-serving nature of this advice, scientists should welcome and support the presentation of other views before the Minister to ensure appropriate balance. The standards of decision-making seen as serving the science community should be based on the same criteria as scientists hold for their own discipline.

Contrary views and peer review should not only be encouraged, but also ensured in the decision-making process. In particular, government scientists should make every effort to ensure that the portfolio of scientific work being done by government, or supported by government, is as effective as possible. This means making some tough judgements and hard decisions about halting projects whose contributions are not significant.

Unbiased Information

> Government scientists should always ensure that their first loyalty, with respect to advice, is to the Minister. This does not imply in any sense telling the Minister what he/she wants to hear. It does mean giving straight and unbiased information.

It would be damaging to the Minister's confidence in the entire advisory role of public servants if government scientists, in order to enhance the weight of their internal advice to Ministers, encouraged or participated in lobbying efforts by constituencies who share the scientist's interests. The distinction between the advocacy role and the advisory role must be clearly established and maintained.

2. The stakes tend to be significantly higher in the areas of advice regarding the government's role in protection, especially with respect to health and safety issues. The consequences of a poor decision can be irreparable damage to citizens. As some recent decisions have shown:

Information on Risks and Uncertainties

> The public expects a very high level of performance in these areas, and is inclined to look for someone to blame if things go wrong. The consequence is that advice to Ministers in these areas must be based upon all the latest scientific information, from all possible sources. Ministers need to be fully informed regarding risks and uncertainties.

Where the organization providing advice to the Minister is also linked by commercial partnership to any interests which will be affected by the regulations, it is incumbent on the organization to ensure both the reality and the appearance of objectivity. This is one of the difficult consequences of the expansion of partnered approaches to research. As most of the advice in this area concerns the development and implementation of regulations, typically based on very esoteric information, authority is often delegated quite extensively. Nonetheless, the Minister remains accountable, and judgment must be exercised to ensure adequate opportunity for ministerial discretion.

According to the "Science and Policy Law of Uncertainty"[xvi]:

- any question of science, on which a Minister requires clarity, is the subject of significant scientific uncertainty within the expert community;
- and, its corollary, the consequences of a wrong decision are very large.

Providing sufficient information to ministers to enable the management of risks and uncertainty is a major challenge. But, the consequences of unwarranted certainty are all too often catastrophic. Here, the ability of the science community to convey not only its best science, but also, its clearly identified best judgement, is most valuable.

3. Advice regarding the government's decisions on matters of stewardship present particularly difficult problems for scientists. This is because stewardship requires allocating rights and privileges to the use of communal resources amongst and between different interests in the society[xvii]. Essentially, the decisions must be based on scientific assessments of the public-use capacity of the communal resource, whether it is a river, a forest, or a species.

The demands from stakeholders generally exceed the capacity. However, measurement of the capacity is often highly uncertain, and sometimes even more philosophical than scientific. Advice on

the capacity of a river and its associated ecosystem to tolerate chlorine, on the effects of particulate matter in regional airsheds, or on the reproductive performance of fish stocks will be hotly contested by interested parties.

In such cases the process of developing the advice becomes a crucial factor in its usefulness to the ultimate decision-maker. Uncertainty must be explicitly recognized as a partial legitimization of competing views. Certainty, to be useful, requires at least an explicit consensus of all interested parties. Sometimes the science, in and of itself, is strong enough to provide the opportunity for clear advice. Scientists, by their very training, will tend to position themselves at the relatively cautious or conservative end of the spectrum with respect to stewardship issues (Below, I suggest that the opposite is true with respect to technology development issues). This is useful, as long as it does not become dogmatic.

This is an area (certainly not the only, but usually the most prominent), where the inclusion of advice from other disciplines (economics, other social sciences, ethics etc.) is a necessary condition for completeness of the advice. Just as professional expertise is a necessary condition for understanding the biological bases for forest management, it is also needed for the understanding of the social and economic consequences of forest management. The inclusion of good science within a well-coordinated horizontal (including across various research disciplines) body of information necessary for decision-making, is another important challenge for the science community.

4. Technology development is the area in which the most extensive use is made of partnerships with the corporate sector. This is to be expected, given that the intention of this research is to result in commercial applications. Such partnerships not only test the validity of expected commercial value, but also speed up the initial adoption of new technologies by the very companies that partner in their development.

Almost inevitably, the expert in the government on the likely value to the economy of a new technology is also a lead agent in a commercial relationship with private interests who stand to gain if the government invests in that area. *It is important to recognize how*

difficult it is to develop objective, independent advice for Ministers, in these circumstances.

The issue is highlighted by the decisions that Ministers are asked to make with respect to investments in research mega-projects. Those involved have professional reputations, career prospects, as well as invested human capital riding on the outcome of the decision. They are the experts in the field, and can therefore speak with scientific authority unlikely to be challenged by their peers. Providing Ministers with a balanced scientific view (and the appearance of such balance) is particularly difficult in such circumstances.

In general, the scientific community tends to align towards the optimistic end of the spectrum of views on the speed and expected efficacy of technology development. This is consistent with the deeply held belief that 'without scientific progress no amount of achievement in other directions can ensure our health, prosperity, and security as a nation in the modem world.'[xviii] Thus the view underlying advice on technology is that scientific research is a necessary condition for progress towards our goals as a society. The emergence of a body of theory in economics strongly linking economic performance to investments in technology has strengthened that view. But, what may be true as a general principle need not necessarily hold true for specific instances, when resource constraints force choices to be made between competing opportunities.

Ministers need reliable information to make those choices. If the scientific community cannot offer objective advice (which can include shutting down less prospective activities), then Ministers will perforce take advice from their policy advisors, absent good scientific assessment.

5. Public service scientists and scientific organizations are a key source of advice on the scientific aspects of policy decisions. These decisions can relate directly to some of the operational aspects of science in government (what is the best way to assess fish stocks, or what technologies should the government assist to establish leadership in the communications sectors). Frequently they relate to other decisions which do not have a direct impact on the science

operations of government (understanding the link between peaceful use of nuclear energy and nuclear weapons may be important for policies in international relations, for instance).

Often, the science underlying the decision is not conclusive (see Law of Uncertainty in 2 above).

Science and Judgement:

> It is important that the science community provide Ministers with their best judgment on these issues, even when significant controversy exists. However, the distinction must be clear between the science, and the judgment that flows from it.

If the science advice is not provided by the science community, it will surely be provided to Ministers by some other route (usually economists or lawyers). But it is not sufficient merely to make the information available. It must be made available in a form, and in a time frame, that is usable. Effective communication of advice depends, to a great extent, on seeing issues as Ministers might see them.

It does matter where advice on science comes from. Different perspectives will incorporate differing biases. The understanding of those biases, and the forthright expression of them in advice to Ministers, can greatly assist Ministers and add to the relevance and influence of the advice. Where judgements can be made based on deep understanding of the underlying science, they should be made and should be clearly distinguished from the science itself. The role of advocate should be clearly separated from the role of advisor. Such an approach, in the long run, will likely result in both more useable advice and more effective advocacy, because of the higher level of trust which such a separation would create.

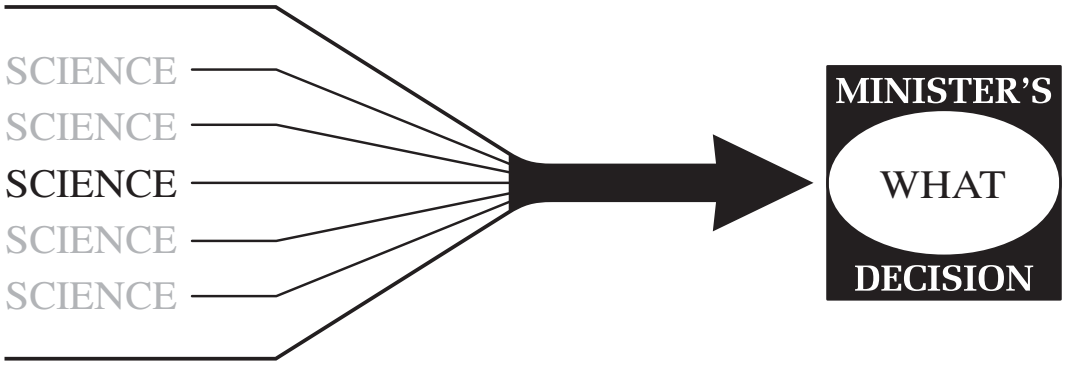
V. Advice on Science: Where It Goes

Communicating advice on matters of science is difficult at the best of times. Even for audiences that are intimately familiar with the subject under discussion, considerable care must be taken to express not only the information itself, but also the 'quality' of the information. It is not by accident that a very formal and elaborate process of reporting is the basis for scientific journals. When the audience is far removed from the science of the issue under consideration, the communication can be even more difficult. Excessively abstruse information will not even get forward for Ministers' review. However, there is an equally acute danger of oversimplifying science. The appearance of talking down to Ministers (or other non-scientists) will taint the desired communication just as much as obvious self-interest or excessive jargon.

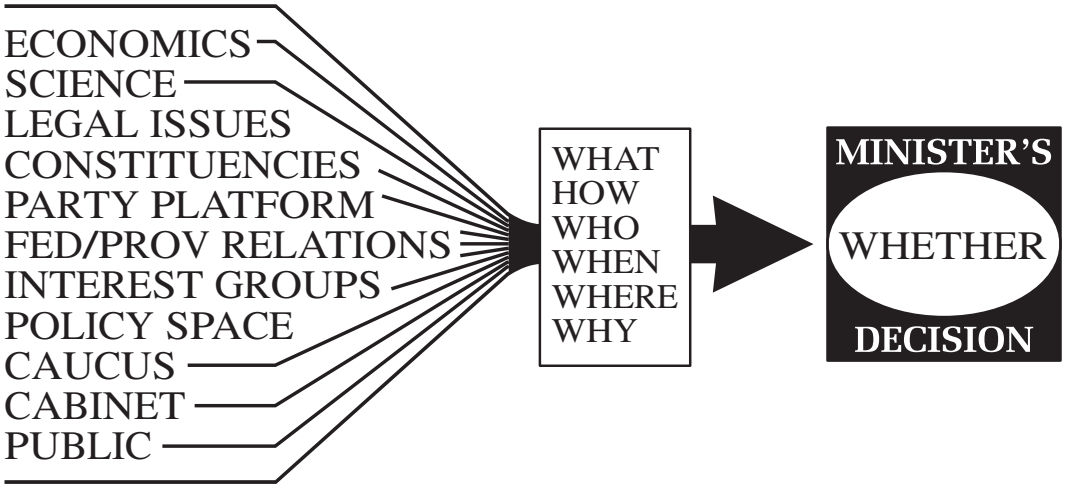
There is an approach, followed by virtually all successful policy advisors, to enable effective communication: that is, to see the world from the perspective of the audience. The following schematic[xix] illustrates the differing perceptions that bedevil much of the advice on policy that comes from the scientific community.

The perspective presented in the first model is the view of the rationalist decision-making process. As Frank Graves of EKOS pointed out in a recent speech, the mantle of the defender of rational government was taken on by the economics community in the 1970's and as late as the early 1980s. For a number of reasons, not least the changes to the understanding of the relationship of economic theory to changing economic realities, that role is no longer played (for the most part) by economists. The Science community, as its councils are more relevant to policy, have to some extent taken on that role. The belief that scientific assessments can provide sufficient bases for rationale policy is not generally reflected in real world policy choices.

Perspective Of Science Community



Perspective Of Ministers



The scientist turned policy advisor will quickly discover that, in the councils where scientific advice is used to assist the Minister in decision-making, the vast majority of the discussion has little to do with science. Most of the discussion centers around political feasibility, communications strategy, federal-provincial implications, timing, effects on individual constituencies, economic and social consequences, consistency with party platforms, public opinion and so forth.

In this environment, the scientist-advisor faces two opposing dangers. The first danger is that the science advisor will try to act as an economic or political expert. Not only is she/he likely to be less effective in these areas, but the scientific arguments will suffer

by attempts to rationalize them with economic and political arguments. However, it would be wrong to imagine that the various inputs into decisions are confined in watertight boxes. Much of the political discussion will overlap with the scientific issues, and the science advisor can bring a vital perspective to many areas of the discussion.

Focus on Scientific Viewpoint

> To be effective, the provider of science advice must understand and participate in the full array of issues, always remembering that the core of the contribution should be the scientific viewpoint, not watered down in advance by a particular viewpoint regarding the political or economic issues.[xx]

Sometimes the science community wishes that there could be a way to change the focus of Ministers. The importance of the scientific viewpoint, so palpably clear to the science community, needs only to be brought to the attention of Ministers and Deputy Ministers, in order to ensure both good decisions and a better recognition of the importance of science for the society. However, attempts to push the information into the political system normally resemble pushing on a rope.

The Client's Viewpoint

> Effectiveness requires speaking in the Minister's language, to the Minister's issues. Thus, a necessary condition for the effectiveness of advice is an appreciation of how the Minister perceives the issue.

Another necessary condition is the ability to get access to the decision process. Direct access, preferably with the scientific expert in face-to-face communication with the Minister (or Deputy Minister) is the most desirable for ensuring that the message is well-interpreted, and the Minister's questions can be answered. There is a direct feedback loop between the ability to communicate

effectively and access. Unless the Minister can see, clearly and immediately, the relevance of the information to his/her agenda in briefings on the scientific basis of policy decisions, access is likely to be sharply constrained. This is simply a reflection of the reality of the heavy demands on Ministers' time.

Direct access to the Minister, however, is not always an available option. Often science advice can only be brought forward as part of a broader framework of advice. In such circumstances, how can the accuracy and relevancy of the science advice be assured? *One positive step that can be taken is to understand the needs of the policy managers within the department who are normally responsible for coordinating the advice.* Recognition of the demands for timeliness, clarity, relevance and conciseness can enhance the accuracy, visibility, and the effectiveness of advice on issues of science that are ultimately incorporated into briefings carried forward by departmental policy advisors. It is useful to remember that their access to the decision process equally depends on their ability to direct information precisely to the needs and interests of the Minister. Their particular expertise, which the science community can use to its advantage, is to see the relative importance of all aspects of an issue, and to balance the various elements of information in a form most easily usable for decision-making.

Communicating with the Public

Decisions in a democratic country are always influenced by the perception that politicians have of the will of the electorate. Politicians who lose sight of this element of decision-making do not have good survival rates. On issues of science, a well-informed public becomes an important, and often a necessary condition for sound policies and their successful implementation.

The increasing engagement of the public, either directly or through organized interest groups, in decision-making at all levels of government, has created a much larger and more important role for all public servants in consulting with, informing, and responding to citizens. More and more frequently, the ultimate success or failure of a government policy depends not on its intrinsic merits (social, economic, scientific, political etc.), but on the ability to communicate the knowledge upon which it is based to a concerned

and often skeptical public.

In their book entitled Mad *Cows and Mother's Milk*[xxi], Douglas Powell and William Leiss demonstrate, through a variety of examples, how easily confusion in the public mind on the science of issues can frustrate or distort policy decisions. Their book, which focuses on public and scientific perceptions of risk, is an excellent illustration of both the need for, and the difficulty of, communicating on important issues of science with the public. Their recommendation is that government communicate its research and knowledge on issues of science related to public policy as early and as completely as possible.

In discussing the current situation of public access, through the media, to information on science they make the following points:

> "In 1919 the New York Times published a series of editorials on the public's inability to understand the new developments in physics, and what the newspaper regarded as the disturbing implications for democracy when important intellectual achievements are understood by only a handful of people. Not much has changed in the intervening period. Nelkin[xxii] has noted that public understanding of science and technology is critical in a society increasingly affected by the impact of technological change, one in which policy decisions are determined in large part by technical expertise." (page 230)

Their message focuses principally on the *management of risk through more open and targeted information dissemination*. This is one aspect of the use of scientific information to advance the legitimate interests of government. The ability of governments to manage the entire range of science-related policy issues (not solely, but including risk management), can benefit enormously from a public that is adequately informed, and has a high level of comfort with the integrity of the information available from government scientists.

One major difficulty in the provision of advice to the public (or even to Ministers) is the absence of an open and transparent mechanism to develop a consensus view amongst scientific experts.[xxiii] The

consequence of this inability is that, on many issues, the public is faced with the appearance of widely differing viewpoints from different experts. The development, on any question of science, of some sort of forum where experts in the field can debate their points of view and arrive at a consensus, or at least a majority view, can provide a much stronger authority to the information that is available to the public. Such a consensual view would need to deal explicitly with minority views, providing they were "well founded in science". On individual issues, consultative fora are frequently created. This satisfies the need identified only in part.

Forging Scientific Consensus

> Consideration might be given to the development of a national science forum (perhaps similar to the U. S. National Academy of Sciences) where complex issues might be adjudicated by knowledgeable experts in a truly independent forum. Such a forum would be composed of leading scientific experts from the field under review, and would, explicitly, not be expected to provide policy advice on the implications of their study.

Whether or not specific instances of ill-founded public concern can be overcome by an approach of more active information dissemination is arguable. However, it is clear that the science community in government can play a more active role in support of the development of sciencebased policies by helping the public to understand the relevant scientific knowledge as it is developed. If such communication is successful, it not only helps Ministers implement outcomes more consistent with the underlying science, it also boosts the influence and the credibility of government science and associated advice in the eyes of the Minister.

In general, there is a strong bias in the scientific community to communicate findings as soon and as completely as possible. However, that communication is typically aimed at the peer community of scientists who will pass judgement on the validity of the findings. The argument here is for a quite different communication function. In this case the audience is the informed

and/or interested public, together with the media which provide the vehicles for wide communication. Just as with the development of advice for the Minister, the need to see the world through the eyes of the target audience is a necessary condition for success.

Mechanisms to allow and promote the early and complete release of policy sensitive scientific information should be pursued actively. Whether it is a plan for the long term storage of nuclear waste, the introduction of genetically engineered food products, or the establishment of new target levels of safety for blood products, recent experience shows that without a well informed public, decisions which seem to conform to the best scientific principles can face insurmountable challenges. As Leiss and Powell illustrate, once the genie of contrary-minded information gets into play, it is very difficult to put back in the bottle.

VI. The Role of the Science Manager

The senior manager of the government's science based operations plays a number of crucial roles in the advisory system. It is here that the integration of the worlds of science and policy mostly occur. As such, the senior science manager has to encompass the interface between the public service worlds. To be successful, he/she needs to have an understanding of these roles, but also needs the assistance and understanding of those with whom he/she communicates, on both sides of the house.

The senior science manager in the Canadian public service is currently caught between three competing and sometimes irreconcilable functions. First, government scientists expect their senior managers to be sufficiently expert in their field of science to be able to understand, at a profound level, the value, the process, and the current or potential consequences of their science operations. As such, the manager is expected to argue for science, and particularly for the importance of continuity (and expansion) of the science within his/her organization. The manager is also expected to represent and defend the norms and values of the science community within the government.

The senior science manager is also expected, by management peers as well as Deputy Ministers and the Central Agencies, to bring professional management practices to the organizations and activities under her/his authority. The changes to accountability practices, client orientation, performance expectations, and service standards, necessary to rebuild trust in government, are often difficult to implement in science-based organizations for reasons noted in the previous discussion of value systems.

The increased need for effective advice on science for policy decision-making places a third important requirement on the senior science manager.

He/she is normally responsible for pulling the diverse elements of science together into a coherent body of evidence, ensuring that the views of other agencies both inside and outside government are incorporated, and transforming the results into language and advice that is relevant to decisionmakers.

For the enterprise, that is the operation of science-based functions within the government, to be effective and sustainable, the science manager must be able to undertake each of these functions. The question of which is the most important is moot. But, what is important is that both the scientists reporting to such managers, and the policy managers with whom science managers deal, comprehend the multifaceted nature of the activity. This diversity of objectives can leave the science manager vulnerable to criticism by those who may disagree with their advice or its consequences. A culture, as is reported to exist in some parts of the government, that classifies senior science managers as either know-nothings, or white coats, or political lackeys, can only destroy the credibility and the effectiveness of one or more of these required capabilities. This has important implications for training and information for managers and potential managers and for science workers in government. An understanding of the essential nature and the operational needs of these functions is, and will be, a necessary condition for success.

VII.Challenges to Science and Science Advice

Regardless of the efficacy of the science advice process, five important challenges will need to be addressed. These challenges are epistemological, social, moral, and political.

The epistemological problem addresses the very heart of science and the scientific method. The outcome of deconstructionist theories of language and knowledge is a view that "value-based" knowledge (based on belief systems, or formed by the local interests of particular communities) should be accorded the same priority and attention as "science-based" knowledge. The implications of this are that "good science" can no longer be counted on as the ultimate arbiter on questions of fact. Although rarely put in those terms, examples of this abound in issues of public policy: from a refusal to accept the scientific findings on the safety of irradiation of food to demands for the authorization of drug therapies which promise results not substantiated in clinical testing. Such problems are as old as science. But a government decision-making process which is substantially more open to "non-expert" input, combined with such a theoretical underpinning , (leaving aside its intellectual merit) mean that science advice faces increasing challenges on the basis of its fundamental principles.

More immediate is the challenge facing science and scientists regarding the moral responsibility for the consequences of decisions on what and how to undertake research. The ranking Democrat in the U.S, House Committee on Science, Congressman George Brown, challenged the members of the American Association for the Advancement of Science to use science for justice and equity. His message at the AAAS conference was of the need to develop a "value-based" science program. He introduced a second order problem to the effect that the U.S. strategy for investing in science and technology was not in itself based on good methodological

grounds with the implied conclusion that the unexamined pursuit of science for its own sake may not always provide net benefits to society.

At that same conference, Neal Lane, Director of the National Science Foundation and Director-designate of the Office of Science and Technology Policy in the U.S., reminded participants of the importance of their moral obligations. "It is not sufficient for those of us who have chosen public service on behalf of science and engineering to simply keep the research enterprise healthy and balanced, as vitally important as that is. A further goal for all of us must be to understand the physical, moral and social problems that hold our civilization in the grip of numerous contradictions." He quoted Einstein (1931) saying "Concern for man himself and his fate must always form the chief interest of all technical endeavors ... in order that the creations of our mind shall be a blessing and not a curse to mankind."

In a Westminster-style system of government, such a responsibility must be exercised primarily through the capacity to provide advice to Ministers. That does not eliminate the ethical dilemma for scientists who might disagree with the policy consequences based on science advice. But it does place an onus on scientists who have opted for a public service career to respect the institution of which they are a vital component. In fact it can be argued that the best defense of the integrity of the scientific viewpoint in public policy comes precisely through the cultivation of a high level of trust amongst politicians in the implicit contract which requires public servants to support the policies of the government in place.

There are increasing demands on the science community, and nowhere more so than in its advisory function, to be more inclusive of other disciplines. Horizontal thinking has become an expected element of all aspects of science. This is true not only across institutions and different scientific disciplines, but also including social sciences and humanities as an integral part of the process. In his book entitled *The Frontiers of Illusion*[xxiv], Daniel Sarowitz questions the idea of the limitless potential of the natural sciences on their own to provide solutions to human development issues. He stresses the importance of incorporating ideas from a wide variety of disciplines, to evaluate and decide on the direction for

societies' investments, and to create technological solutions to the real problems facing today's communities.

A fourth area of challenge to science is the need for demonstrated effectiveness, efficiency and economy. Peter Aucoin put the issue clearly in his book on *The New Public Management: Canada in Comparative Perspective*. 'Concerns for economy and efficiency have been given a new priority in public management. Enhancing cost-consciousness, doing more with less, and achieving value for money, became the objectives of this finance-centered perspective on public management reform'. The U.K. White paper on Realizing Potential (1993) referred to the "social contract' implicit for government funded science. "Funding from the State", the report said, "implies a responsibility to serve the community". All those who spend public funds are being held more directly accountable for the effectiveness of the spending. Certain, and shortterm outcomes are far easier to justify in these circumstances. Investments in science, for any of the public policy objectives defined in this paper, tend to be fraught with uncertainty, and are likely to realize benefits only over the longer term. To the science advisor, inevitably must fall the role of providing the justification for the continuation and extension of longer-term sciencebased investments within government, as well as the arguments for predictable and stable funding.

As science-based policy issues, decisions and their consequences become more open to public scrutiny, the need to communicate the science and to support Ministers' decisions provides another set of challenges. On the one hand, scientists as a community are still held in high esteem in public opinion according to assessments of the credibility of various groups in society. On the other hand, the misuse of science (by providing partial, unsubstantiated or just plain wrong information) to support the views of particular interest groups, is an inevitable result of a more open and inclusive political system. Much of the information is arbitrated by the public media.

Sometimes it may appear that all science journalists started their careers as sports writers: there are always two (and only two) sides to every argument, and there must be a winner and a loser. The Jerry Springer rule of journalism applies: what is reported is the least expensive to deliver and the most likely to generate a large audience.

Scandals, especially involving Ministers, are good; careful assessments of uncertainties and methodologies are bad. In these circumstances, the choice can often be between 'accurate fluff' and 'inaccurate fluff. This creates a real tension between being heard and providing 'good science'.

Nonetheless, the media are and will continue to be the main source of information available to citizens. Finding ways to provide broad public access to the best available science on issues of important policy concern represents another continuing challenge.

VIII. Outstanding Issues

1. Government Scientists: Should scientists who are to work for the government be provided with training aimed explicitly at helping them understand the values and ethics of government and how they influence the obligations on and the operations of science in government?

2. Operational vs. Policy Role: Should the science operational roles be more explicitly separated from the advisory functions? If so, what linkages are necessary to ensure wellinformed decision-making? What institutional forms could accommodate such a split?

3. Processing Science for Advice: Who is responsible for, and accountable for, the conversion of disparate scientific findings and/or knowledge into a form usable for advice to Ministers? Is this a discrete function? To whom should the function report (directly to Deputies, to senior science managers, to responsible policy senior managers, to science committees ...)? What about public communications on science issues?

4. Communicating Science: How can policy-relevant science be communicated more effectively to Ministers? ... to the Public? How can government policy-relevant science become more accessible to interested communities? Can a more open and neutral debate of scientific issues improve effectiveness and acceptability of decisions?

5. Science Advice in Decision Documents: Who is accountable for the "science consensus" incorporated implicitly or explicitly in Cabinet Documents, Regulatory Decisions, Budget Papers etc.? How can Ministers get assurance regarding the 'quality' of the science advice, its inclusiveness (horizontality), and its treatment of risk and uncertainty? Should decision documents require a formal sign off of the science?

6. Policy Community: What training and/or institutional

changes can help the policy advisory community to be more effective in including science in their advice and ensuring a high standard of interpretation?

7. Feedback: Are there effective feedback mechanism to help scientists understand the consequences of their advice? How can the provision of advice in confidence be balanced against a more open reporting on the decision-making process?

8. Role of the Senior Science Manager: This paper has argued that the senior science manager requires three quite distinct (and sometimes competing) professional skills; as a scientist, as a professional manager, and as an advisor. Is this a reasonable expectation? What kind of training and recruiting strategy is required? What kind of support capacity is required?

Conclusion

Advice on matters of science has a critically important role in the development of sound policies in many areas. If this were not the case, then scrutiny of the impediments to effective advice to Ministers from government scientists would be a matter of little interest to decision-makers. This paper has pointed out some of the barriers to effective advice, and areas where there exist opportunities to make significant improvements. In many cases the issues raised here may have been recognized and successfully dealt with by science-based units within the government. In others, the problems may not even have been acknowledged or properly diagnosed.

The paper covers a wide spectrum of issues, most of which can be captured, at least in essence in the following Ten Tests for Effective Advice on Science:

1. Am I fulfilling my 'obligation of employment' in the public service to provide effective advice through legitimate channels?

2. Is my advice based on a sound understanding of the objectives of government?

3. Are linkages to other sources of advice adequately exploited and represented?

4. Do 1 understand the implications of the multiple value systems (Science, Management, and Public Administration values) on my perspective and on the decision-maker's perspective?

5. Have I recognized and made clear the institutional biases that influence my advice?

6. Is the advice weakened by containing advocacy for the interests (especially financial) of my organization or clients?

7. Does it speak to the needs of, and in the language of, the decision-makers?

8. Is the advice based on a scientific consensus from a credible, transparent process?

9. Has the underlying science been communicated to the Public in a clear and credible manner?

10. Have I provided my expert judgement , based on my scientific knowledge, to the decision-maker?

There is no doubt about the importance of good scientific advice to public policy. For those who work in the science-based organizations within government the increasing relevance of science-based information provides important opportunities. This paper suggests ways of thinking about what can be done to improve the level of trust and confidence in the scientific basis of policies. it does so from one particular perspective - the role and responsibilities of the public service scientist. There are other elements of the process that can also contribute to the goal of more credible underpinnings for policy decisions. But the science community has much to gain by ensuring it is doing as much as possible to provide effective advice. If successful, the consequences in terms of demonstrating its relevance and accountability to the political process, and showing how science can play a constructive role for decision-making and public confidence, could help sustain the appetite for a comprehensive and vibrant investment by governments in science.

The hope of the author is that this paper can open a discussion and further thinking on this issue. As part of a variety of initiatives to assess the role of science in government, it can help in the development of recommendations for constructive changes with the objective of more credible, transparent, and effective advice for decision-makers.

NOTES

[i] For purposes of this paper, government science refers to activities associated with the conduct of research in the natural sciences and engineering, either undertaken in government facilities, supported by government contracts or partnerships, or the provision of grants for the purpose of scientific research.

[ii] Science community is used here and throughout the paper to represent those professionals who work in the science related functions of government as defined in the section on the objectives of government. It is a generalization, and loosely defined but captures the essence of a group defined by occupation and point of view.

[iii] Kernaghan, Kenneth, *The Responsible Public Servant*; published by the Institute for Research on Public Policy, 1990

[iv] See inter alia works by Lipsey, Porter, or Romer

[v] Budget Speech; March, 1998, p. 19.

[vi] May, Sir Robert: *The Use of Scientific Advice in Policy Making, Office of Science and Technology* (UK), March, 1997.

[vii] Whether or not expansion of knowledge is a fundamental role of government is an important question. Post-war evolution of science policy was based on this function playing a key and necessary role. Some recent literature, for example Donald Stokes' book *Pasteur's Quadrant* (Brookings, 1997) challenges this view.

[viii] The weights in the cells are quite arbitrary, and in practice will vary considerably depending on the specific application. There is a tendency, particularly for non-scientists, to perceive the instruments to be associated uniquely with one aspect of the objectives (on the diagonal of the matrix). The fact is that the realization of most of the objectives requires the application of all the instruments to some degree.

[ix] *A Strong Foundation: The Report of the Study Team on Public Service Values and Ethics*; Government of Canada; October 31, 1996.

[x] Hennesy, Peter; "*The Essence of Public Service*"; the 1997 John L Manion Lecture; reprinted in Optimum, vol 27, no. 3, 1997

[xi] Ziman, John; *An Introduction to Science Studies*; Cambridge University Press, 1984.

[xii] I am grateful to Ralph Heinzman and to Bob Slater for bringing to my attention the fact that there exist quite a wide variety of such value systems within the public sector. Most of these, I would argue, assimilate reasonably easily into the public service value systems, because of the limited numbers, and the integration of their tasks in the mainstream of government activity. Science, with a relatively large contingent of public servants, has traditionally operated somewhat separately from other government operations, and, from the nature of the activities, in partial isolation.

[xiii] *Aucoin, Peter; The New Public Management: Canada in Comparative Perspective*; pp 81-82

[xiv] May, Sir Robert; Ibid, p. 2.

[xv] The expression "endless frontier" is best known from the 1945 report by Vannevar Bush to the US president

[xvi] This "Law" has been coined for this paper, but is reasonably easily observable in practice. There is no doubt that exceptions can be found, but it forms a useful guide to advisers on science issues, and to decision-makers.

[xvii] This allocation is usually exercised implicitly in the limitations put on use (effluents, development etc.) rather than explicitly in the granting of rights.

[xviii] Bush, Vannevar; *Science: The Endless Frontier*, a Report to the President by the Director of the Office of Scientific Research and Development, July, 1945, p. 1.

[xix] The perspective of the Ministers is partly based on a framework provided to the author by Dr. T Brzustowski, President of the National Sciences and Engineering Research Council

[xx] This discussion is a restatement of advice prepared for economic advisors in 1982 by Charles Schultze of the Brookings Institute, published in the American Economics Association Papers, vol 72, no. 2. The article is entitled "*The Role and Responsibilities of the Economist in Public Policy*", and was a major source of inspiration for this paper.

[xxi] Powell, D and Leiss,W, *Mad Cows and Mother's Milk*; McGill-Queen's University Press, 1997.

[xxii] The quote from Nelkin, D is from his book *Selling Science: How the Press Covers Science and Technology*; New York: W.H. Freemen 1987.

[xxiii] I am grateful to Paul Dufour for bringing this issue to my attention.

[xxiv] Sarowitz, D; *The Frontiers of Illusion*; Temple University Press, 1996.

The Public Policy Forum is a national non-profit organization which seeks the commitment of leaders in government, business, labour, the association sector, the voluntary sector, academia and the media to work together towards developing and attaining a shared vision for public policy, public sector management, and its impact on the nation's business. Established in 1987, the Public Policy Forum has gained a reputation as a trusted facilitator and a driver of change. It does not promote any one interest or group, but rather seeks to encourage a frank exchange of ideas, opinions, and views, even when they are in opposition to each other. As a nonpartisan organization, the Forum encourages discussion rather than consensus or confrontation. Its continuing role is to capture the essence of this dialogue and to make something happen with the output.

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