The Interface of Science and Policy:
The Cases of Ozone Depletion and Climate Change[1]

by

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Overview

In contemporary industrial societies, there is an increasing degree of interdependence between scientific and public policy development. This is especially true in the broad area of global health and environmental risks. This interdependence suggests that we should be concerned about how to make the interplay of science and policy as "efficient" and "effective" as possible. In practical terms this means, for example, identifying specific obstacles to the attainment of a desired level of efficiency and productivity, as well as means of overcoming them. This paper uses the cases of ozone depletion and climate change in order to explore this subject. It sets up a simplified schematic diagram, describing stages in the pathways of both scientific and policy development, as well as specific feedback loops between the two domains. It raises two major questions for debate: (1) Is there an "ideal state" for science / policy interaction – using the area of climate change issues as the main case? If so, what are its characteristics? (2) Considering the situation in Canada at present, in terms of moving forward with the climate change file, what may be specified in terms of best practices for this interaction?

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Introduction.

In contemporary industrial societies, there is an increasing degree of interdependence between scientific and public policy development. This is especially true in the broad area of global health and environmental risks: We cannot assess risks without scientific characterizations of the hazards, and we cannot hope to manage and mitigate risks without having risk assessments in place.[2] Managing and mitigating environmental risks occurs largely in the domain of public policy, because due to externalities, extended cause – effect connections, lag effects, and other reasons, individual actions alone inevitably are insufficient to address such risks.

This necessary interdependence of science and policy immediately gives rise to questions about the desirable or "ideal" state of the relationship between the two – as a practical, rather than theoretical, matter. Let us say that we wish to have a relation between science and policy that is "productive." What concrete objectives do we have in mind in this context? I propose that there are two sets of objectives:

- **"efficiency,"** including factors such as
  - timeliness and ease of information flow;
  - early uptake of novel research results;
  - maintaining the requisite level of scientific competence;
  - ability to set priorities;
  - capacity for consensus-building in both domains.
- **"effectiveness,"** including
  - development of robust policy options for risk management;
  - ability to handle inevitable uncertainties;
  - promoting public understanding of science;
  - creating meaningful stakeholder engagement with industry and ENGOs;

[2] Both health and social policy are other areas in which there is strong interest in what is called "evidence-based policy." For a good review and list of citations see Sandra Nutley, "Bridging the policy / research divide," conference paper, 2003: http://209.197.113.29/pdf/Evidence%20and%20policy%20Nutley.pdf

- securing intergovernmental cooperation, both domestically and internationally.[3]

I hypothesize that the characteristics of a productive relationship, as specified in the criteria of efficiency and effectiveness listed above, would, if operative, create an ideal state of robustness at the interface of science and policy. *However, taken together, they represent a necessary, but not necessarily sufficient, basis for the achievement of appropriate risk mitigation solutions.* This will become apparent in the discussion of the comparative case studies of ozone and climate – in relation to which some commentators have raised very serious issues about what I may call the "forms of engagement" of climate scientists in the policy arena.[4]

Two Key Case Studies: Ozone and Climate.

There is a considerable literature in the field of policy studies on the science / policy interaction in the case of ozone-depleting substances – and its relevance to the climate issue. R. Grundmann and others claim that leading climate scientists consciously chose the path to success laid down by their predecessors on the ozone file:[5]

> The IPCC is modeled precisely after the WMO-UNEP assessment reports in the ozone case. In both cases, a standardization of scientific knowledge is seen as instrumental to get to the right policy decisions. This follows a linear or 'technocratic' policy model according to which first a scientific consensus has to be reached which then is transformed into political decisions.

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[3] It is no accident that efficiency and effectiveness are regarded as the hallmarks of what is known as "smart regulation." There are many other ways of expressing the desired criteria for the characteristics of knowledge that is useful for policy. Haas (2004, p. 574) offers several lists from the literature, including credibility, legitimacy, and saliency; or adequacy, value, legitimacy, and effectiveness.

[4] This paper restricts the comparative study of issues at the science / policy interface to the cases of ozone depletion and climate change. Of course, the range of case studies could be expanded to include consideration of many other instances of current global health and environmental issues, for example: (1) zoonotic diseases; (2) water resources and desertification; (3) malaria; (4) tobacco; (5) endocrine disruptors; (6) mining; (7) ocean fisheries (Myers/Worms article, *Nature,* May 2003: http://www.sciencedaily.com/releases/2003/05/030515075848.htm).

[5] Grundmann 1998, p. 36.

Such a view has been described – in the policy community – as "naïve." And perhaps ozone was the exception, not the rule.[6] Grundmann adds: "In very many cases no political action follows from conclusive scientific knowledge or consensus expert opinion because economic and political factors are much more influential." Let us first review the key milestones to date in those two cases, and then see what lessons might be drawn from the two taken together.

Appendix I contains a highly selective chronology of key milestones in the two cases. These are some of the observations on the cases that are pertinent to the lessons I wish to draw from them:

A. The Ozone Case.

(1) A rapid formation of science consensus following the initial path-breaking publications (5 years);

(2) Formation of an early international policy consensus against determined political and economic opposition (U. K. government; DuPont);

(3) Formation of an international policy consensus during the time when the "science action" leaders were hesitating to draw policy-relevant conclusions;[7]

(4) An environmental risk issue with limited impact on established lifestyles and seamless product substitutions (from a consumer perspective);

(5) A risk issue with dramatic "presence" (the ozone hole) and immediate and personal consequences of concern (skin cancer rates).

B. The Climate Case.

(1) A much slower formation of initial science consensus (1955? – 1985/1990);

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[6] Indeed, as Haas (2004, p. 580) suggests, perhaps IPCC was formed precisely in an effort to re-establish the political control over the science/policy process which had been lost during the ozone years: "The IPCC was established in 1988 as the principal international science policy advisory body for global warming, but it is widely believed to have also been formed politically in order for governments to reassert control over the science process in an issue which was accelerating on the policy agenda more rapidly than most leaders in the North were comfortable with."

[7] The "science action" phase (see Appendix II) occurs when leading scientists become strong advocates of policy prescriptions; for the hesitancy in this case (Rowland), see the ozone file in Appendix I, 1986.

(2) A "policy interruption" phase in the 1970s, freezing the early momentum in the policy arena on the issue;

(3) Much more limited international policy consensus [by comparison with ozone] for ratified and enforceable emissions reductions;

(4) Formation of a strong "science action" voice *against* a determined political and economic opposition;

(5) An environmental risk issue with profound potential impacts on established lifestyles, in terms of energy use patterns and other socio-economic and health impacts;

(6) A risk issue with limited personal "presence" in the short term (episodic extreme weather events) and remote consequences of concern (future rising sea levels, other vague and remote impacts); also, apparently contradictory types of impacts (cooling and warming).

For many commentators, item B(4) is a key factor in the comparison, and is the proof that a "science action" movement – where leading scientists act as spokespersons for dramatic policy-type actions – cannot triumph, at least in the short run, against opposition from powerful political and economic actors. But all of the differences listed above, as well as other salient ones, are relevant to the way in which the two issues have played out.

Commentary on the Ozone – Climate Comparison.

Reiner Grundmann of Aston University is one of the leading academic researchers on the relation between the cases of ozone and climate. What he calls "the technocratic policy model" is the idea that a scientific consensus can and should lead, relatively smoothly, to a policy consensus and, presumably, onward to policy action. In his view it is climate change that shows the limits of that model: scientific consensus is not the driving force of the policy process. However, his other point about the climate file is the more serious one:[8]

> In order to preserve a consensus (of which too much was expected politically), the scientific controversy was silenced.... The construction of the IPCC as an international epistemic community committed to a scientific consensus has proven, on this view, to be somewhat

[8] Grundmann 2002, pp. 412-413.

> counterproductive. The drive to establish a scientific consensus robbed the controversy of an essential dynamic.[9]

Whether or not one agrees with this judgement, it has the virtue of forcing us to state a clear position on the issues at hand here: What do we mean by a productive relationship between science and policy in the case of climate change?

To answer this question we may regard Grundmann's technocratic policy model as a useful foil. Its chief error is that it focuses on an outcome rather than a process.[10] A focus on process, on the other hand, would define a productive relationship between science and policy as one in which an elaborate series of feedback loops between the two domains are operating well. (See Appendix II for examples of feedback loops.) In other words, it is a relationship where the various outputs of scientists, from novel research results all the way through the statements of clear scientific consensus – which are recognized *on both sides* as having policy relevance – are taken up and evaluated seriously in policy deliberations.

The criteria of efficiency and effectiveness provide some benchmarks to ascertain whether that process is working as well as it should. But nothing in this conception implies that there can or should be any kind of direct chain from scientific consensus to policy consensus. Or, to use the words from the title of this event, "[directly] from research to action." In the domain of environmental risks, risk assessments that are ultimately derived from basic science should be seen – by the policy community – as an indispensable and necessary ingredient in good risk management. But they are never sufficient, in and of themselves; they may be trumped by political and economic forces, which means simply that societies will have to live with the choices they make.

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[9] "Epistemic community," a term coined by Peter M. Haas (2001), is defined as "a network of knowledge-based experts or groups with an authoritative claim to policy-relevant knowledge within the domain of their expertise."

[10] There is much useful discussion, with many examples, related to this process-orientation in Haas (2004), who states that, as a rule, "science is seldom directly converted to policy."

The science / policy interaction in the climate case has been strongly marked by such forces, which play these games by their own rules. The controversies stirred up by the community of "climate change skeptics" would never have reached the level of public attention they did, were it not for the financial backing of certain corporate and other interests. This has represented a strong influence in the U. S., where there continues to be an insistence that a full global policy consensus, including China, must come into being before that nation will agree to emissions-reductions targets.[11] In Canada, during the long run-up to Kyoto ratification, and continuing thereafter, there has been strong and determined opposition to mandatory emissions-reductions targets from powerful economic and political sectors. These are realities against which even the strongest scientific consensus is powerless – at least, in the (relatively) short run.

Those of us – including myself – on the policy side of this equation ought to acknowledge other truths as well. The scientific consensus tells us that 60% reductions in anthropogenic emissions from 1990 levels are needed for the stabilization scenario for GHG concentrations. Is it not prudent to confess that we cannot now even imagine a "stabilized" policy scenario in which this is remotely possible? That we may be confronting a form of global environmental risk that we cannot manage? (Some have predicted that the level of "dangerous" climate impacts may occur at the 450 parts per million (ppm) threshold, and that the year 2010 is the date when the window for constraining climate forcing around that level will start to close.[12]) Nevertheless, we are morally obliged to try!

Some perspective from other cases – which cannot be elaborated here – is helpful in this regard. Selecting a few from a longer list, one can say that the cases of tobacco, asbestos, and persistent organic pollutants illustrate well the dictum that the passage from scientific knowledge to appropriate policy action is often a long, troubled, and contentious one. These cases and others demonstrate that this troubled history can and

[11] See the book by Stewart and Wiener.

[12] Speth calls attention to the 2002 O'Neill and Oppenheimer paper in *Science* where this prediction is made.

does include episodes of bitter conflict over the meaning and application of knowledge, conflict which is sometimes exhibited in courtroom battles, often in intense lobbyist pressure on politicians, and occasionally even in deliberate attempts – undertaken by those with a claim to scientific credibility, and funded by economic interests – to obfuscate the scientific record and confuse the public.

The social, political, and economic stakes in the struggle over climate science and climate policy are so immense that no one should be surprise that trouble has developed in the zone of the science / policy interface in this case. And it will get worse – indeed, much worse – before any definitive resolution of this tension is arrived at. The key question is what we should be doing in the meantime.

And, I believe, our experiences with the climate file to date can allow us to draw some lessons, in the form of best practices, from what has happened so far. First, however, I would like to address briefly the contentious point, raised by Grundmann and others, about the "advocacy engagement" of leading scientists associated with IPCC. It may very well be true that experience with the ozone file led some scientists to exaggerate their expectations about the policy influence of science consensus.[13] So what? Surely, the important issues are ones such as the following: (a) Was the credibility of the overall climate science research effort – represented collectively in the peer-reviewed literature – significantly damaged as a result? (b) Would the fierce opposition to mandatory emissions-control measures for GHGs, organized by powerful economic and political interests, have been less forceful or successful (to date) if those scientists had kept a lower profile? (c) Would the majority of citizens, especially in North America, have supported necessary policy measures – especially the carbon (dioxide) tax, which will have to be

[13] Note that one can support this contention without accepting the legitimacy of any of the claims made by the so-called "skeptics" that the way in which the IPCC scientific consensus was forged was politically motivated and manipulated by certain scientific leaders. Haas, a reliable authority in these matters, affirms (2004, p. 582) that "there is no strong evidence that the state of knowledge about the phenomenon [of climate change] is directly biased or controlled by political influences." That said, he also argues that the IPCC outputs have very strong deficiencies as providers of "usable knowledge" for the policy process; his important argument may be found on pp. 581-4 of his 2004 publication.

implemented sooner or later – if these scientists had kept a lower profile? In my opinion, the answer to every one of these questions is: No.

So let us move on. As I mentioned earlier, my own forecast is that the degree of contentiousness in this file will get worse, not better, as time passes. In other words, the climate file will represent a severe test for efforts by governments, all over the world, to maintain a productive relationship between science and policy. All, including Canada, will require both an appropriate set of principles, and a robust set of good practices, in order to survive this test.

Principles and Practices: Suggestions.

The key principles identified in the May 1999 report from the Council of Science and Technology Advisors, "Science Advice for Government Effectiveness," remain, in my opinion, an appropriate set of principles for this relationship. They are:

- early identification of those issues for which science advice will be required;
- inclusiveness;
- sound science and science advice;
- considerations of uncertainty and risk;
- openness; and
- review, which includes two principles: (1) subsequent review of science-based decisions; and (2) evaluation of the decision-making process.

On the other hand, "best practices" should provide concrete and practical guidance to departments, as adapted to particular policy files and to the current state of affairs. It is timely for us to consider such matters on the eve of the first Meeting of the Parties under the Kyoto Protocol, especially since Canada is the host.[14] What follows is a first cut at specifying the most important best practices, and the issues that such practices should be capable of addressing, at the present time.

1. Review and modify, as required, and on a regular basis, the criteria for "efficiency" and "effectiveness" and evaluate performance on this basis.

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[14] http://unfccc.int/meetings/cop_11/items/3394.php . Given the extensive literature on the comparison between the ozone and climate files, the location of this meeting in Montréal is particularly appropriate.

Rationale: Specific criteria are needed in any framework dealing with the practical or applied aspects of a broadly-framed objective (here, seeking a productive relationship between science and policy). The criteria specified on page 2 above may be taken as a starting-point for an exercise of this nature.

2. Examine the key feedback loops at regular intervals and ascertain whether they are working well, or alternatively identify what improvements are needed.

   Rationale: See Appendix II for a schematic diagram of the science / policy interface. This diagram is intended to enable one to specify the types of feedback loops between the two domains that are needed in order to operationalize the objectives listed under efficiency and effectiveness.

3. Reaffirm commitments to providing adequate funding levels for both curiosity-driven and targeted research in climate change science.

   Rationale: Despite the significant level of investments in research of both types that has already been made, there is good reason – from a public policy perspective – to intensify this effort in the coming years. The basic reason for this is a simple one. As the reality about what is required for the GHG "stabilization scenario" to succeed gradually penetrates the public mind, the first (and most natural) reaction of citizens will be to question the science consensus. ("Why should we believe it, since it's mostly based on modeled data? Let's wait a while longer until we're really convinced." Et cetera.) The needed types of policy actions can gain public confidence only if new levels of research efforts are made, especially in targeted areas where – for example – results may be influential in increasing public confidence in the reality of "threshold zones" constraining the increase in GHG concentrations.

4. Greatly enhance the scope and content of public engagement efforts for climate issues.

   Rationale: The complexity of climate science is a significant barrier to public understanding of the issues and need for action. There are, to be sure, some good products to meet this need; for example, Environment Canada's 2002 brochure, "Frequently Asked Questions about the Science of Climate Change."[15] But a much larger effort is needed – not necessarily including the indulgence in expensive television advertising. Both the scope of the engagement itself, and the types of issues presented for public debate, must be significantly expanded.[16] So far as issues are concerned:

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[15] http://www.msc.ec.gc.ca/saib/climate/FAQ_2002/index_e.html

[16] In these contexts I usually recommend spending at least 50 cents in public engagement for every dollar invested in primary research. The research community reacts with alarm to this proposal, since many in that community see this as a zero-sum game, in which monies allocated for the public engagement exercises are "withdrawn" from research budgets. I cannot agree, of course. From a public policy perspective, unless public understanding of, and confidence in, the

- Citizens need to understand the full scope of the challenge inherent in the stabilization scenario (it is not ethically appropriate to postpone this discussion);
- Citizens need to understand better the type of tradeoffs inherent in the strategies of mitigation and adaptation – especially for Canada, with its huge northern-latitude territory;
- Citizens need complex climate information (including the models) to be represented in sophisticated animated graphics;
- Citizens need to better understand the range of policy options for controlling GHG emissions.[17]

On engagements: For all contentious issues of environmental science and policy, direct initiatives by governments should be complemented with third-party activities – which, in Canada, often must be funded by governments. For examples, see the website www.emcom.ca (on endocrine disruptors) and the elaborate public engagement exercise designed and carried out by the Nuclear Waste Management Organization (www.nwmo.ca).[18]

5. Use national-academy mechanisms for periodic review of "contentious" science issues.

Rationale: The U. S. National Academies' 2001 response to questions raised by the Bush administration about the IPCC3 report was a key milestone in the simmering controversy over policy interventions by climate scientists. National academies in both the U. S. and the U. K. have been very active on this file for many years. Canada will soon have, for the first time, a similar capacity, and I hope that the federal government will take advantage of this to request that certain specific topics be addressed by independent panels.

Concluding Comments.

In conclusion, I have the following points to make:

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climate science consensus can be greatly enhanced in the coming years, there will be little or no support for the needed policy actions that will reallocate considerable sums within the family budgets of Canadian citizens. Should this come to pass, these same citizens will not wish to be presented with fresh scientific results purporting to show that they are being extremely unwise and short-sighted in their desire to wait and see what happens to the climate.

[17] See the newspaper article by Marc Jaccard (February 2005) on the need for a carbon dioxide tax; and Jaccard 2002.

[18] There are many good suggestions in the paper by Kevin Jones.

- The nature of environmental risks – and especially, given its special complexity as a risk issue – climate change risk, reveal the close interdependence of science and policy;

- It is necessary to define what we mean by a "productive" relationship between the domains of science and policy;

- The comparison of the ozone and climate cases (in the record to date) displays both similarities and differences between them – but drawing the correct conclusions from the comparison requires due care;

- Given the scope of the social, political, and economic stakes in the climate change issue, no one should be surprised at the troubles that have developed so far, in so far as the relation of science and policy is concerned (and there is worse to come);

- Best practices for improvements in the science / policy interface, in the current context, include:

    - re-examining the key feedback loops to ensure that they are working well;

    - targeting new scientific research efforts, both inside and outside government, at the policy-relevant aspects of science that are especially pertinent to the new phase of international negotiation now starting;

    - enhancing the scope and content of the public engagement efforts for climate change issues.

Appendix I: Ozone / Climate Case Comparisons

A. Ozone Science/Policy Timeline:

[based on Benedick]

1974: Stolarski/Cicerone and Molina/Rowland papers
1975: WMO, "Statement on Modification of Ozone Layer due to Human Activities"
1976 U. S. National Academy of Sciences, *Halocarbons: Effects on Stratospheric Ozone.*
1977: UNEP, "World Plan of Action on the Ozone Layer"
1978: (March) U. S. – followed by Canada, Norway, Sweden – bans CFCs in all nonessential applications
1979: U. S. National Academy of Sciences, *Stratospheric Ozone Depletion by Halocarbons.* (Updates 1982, 1984)

1981: UNEP Governing Council, resolution on working toward an international agreement on protecting the ozone layer
1982: UNEP, Stockholm meeting of 24 countries, Ad Hoc Working Group ... for the Preparation of a Global Framework Convention for the Protection of the Ozone Layer
1983: First meeting of the Toronto Group: first discussion of reducing CFC emissions
1985: (March) Vienna Convention. Benedick, p. 45: "The Vienna Convention was itself a considerable accomplishment. It represented the first effort of the international community formally to deal with an environmental danger before it erupted." [U. K. leads opposition to any control protocol; no policy goal or methods on reductions are stated.]

(May) "Ozone hole" discovered (publication in *Nature*)

1986: WMO/UNEP assessment published (150 scientists, 3 volumes)
Rowland (writing in 1989): "... statistical evidence through 1986 gave no indication of any trend in global ozone significantly different from no trend at all."

Rowland (in 1986): "... the causes of the massive seasonal loss of ozone over Antarctica are not yet fully understood, and its implications for the ozone layer above the rest of the earth are also uncertain."

1986: (December) Beginning of negotiations on protocol. Countries having ratified Vienna Convention at that point: Canada, Finland, Norway, Sweden, U. S., Soviet Union.

1987: (July) NOAA: "... the scientific community currently is divided as to whether existing data on ozone trends provide sufficient evidence ... that a chlorine-induced ozone destruction is occurring now."
(September) Montreal Protocol adopted

1988: (March) Report of the Ozone Trends Panel: the "definitive proof" of the effect, as well as projections of much greater ozone losses than previously estimated; call for phase-outs

(September) Vienna Convention in force

1989: (January 1) Montreal Protocol in force

(May) Reports from international scientific expedition to the Arctic, and Helsinki Declaration on the Protection of the Ozone Layer: new calls for additional controls and accelerated phase-outs

1990: (June) London Agreement on phase-outs (in force August 1992)

B. Climate Change Science/Policy Timeline

[based on Fleming and Weart]

To 1925: Fourier, Tyndall, Arrhenius, Chamberlin
1950s: H. Suess, G. S. Plass, C. S. Callendar, C. D. Keeling: CO_2 measurements
1963: Conservation Foundation conference, New York: possible doubling of CO_2, impact on global temperatures, impacts on glaciers and sea levels
1965: First major scientific conference, "Causes of Climate Change," Boulder
First U. S. National Academy of Sciences report, *Weather and Climate Modification*, 2 vols., on possibility of human influence on climate

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1970s: the global cooling vs. warming conundrum: policy confusion

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1979: U. S. National Academy of Sciences, *Carbon Dioxide and Climate* (effect on temperature of doubling of CO_2)
World Climate Conference and WCRP, Geneva
1981: James Hansen, article in *Science*, "Climate Impact of Increasing Atmospheric Carbon Dioxide"
1983: U. S. National Academy of Sciences, *Changing Climate*
1985: Villach Conference, "international consensus"

1988: James Hansen, statement to the U. S. Congress
Toronto conference (limit GHG emissions)
IPCC formed by WMO/UNEP

1990: First IPCC report (identifies the need for 60% reduction in global emissions for GHG concentration stabilization scenario)

1991: U. S. National Academy of Sciences, *Policy Implications of Greenhouse Warming*

1992: UN Framework Convention on Climate Change (in force March 1994).

- Policy goal in Article 2: "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

- Policy directive (for industrialized nations) in article 4: GHG emissions to be rolled back to 1990 levels by 2000.

1995: IPCC2: "balance of evidence suggests a discernible human influence on climate"
Berlin Mandate (COP2), targeted reductions in various time-frames
1997: Kyoto Protocol adopted
2001: IPCC3
2002: U. S. National Academy of Sciences, *Abrupt Climate Change*

2005: (February) Kyoto in force

(February) Marc Jaccard, SFU, article in *Vancouver Sun:* policy recommendations for Canada (carbon dioxide tax)

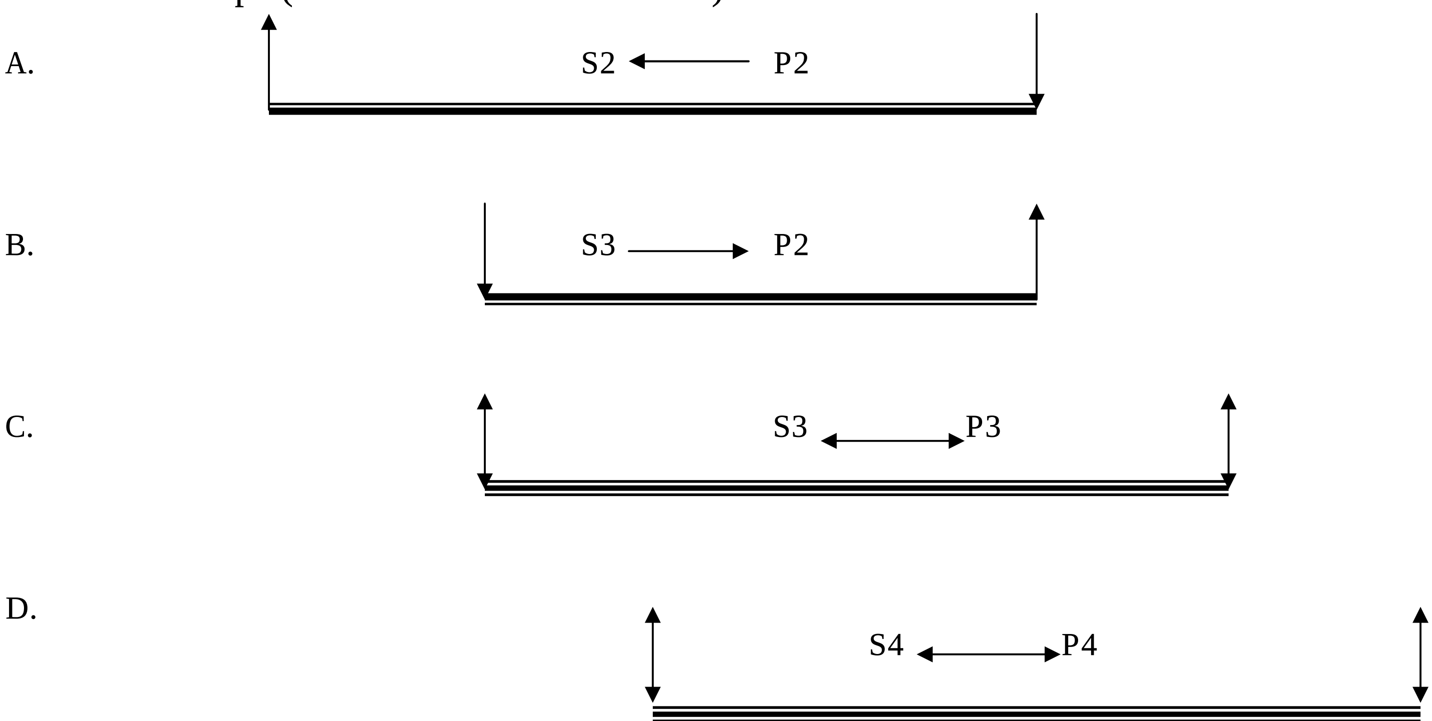
(May) James Hansen, article in *Science* (empirical confirmation of model predictions, and thermal inertia and lag effect – with policy implications)

Appendix II:
A Proposed Schematic for Stages in the Science / Policy Interface

Science ⟷ Policy (National/International)

S1.	S2.	S3.	S4.	P1.	P2.	P3.	P4.
Early Peer-Review pub.	Replication / Confirmation	Science Consensus	Science "Action"	Initiation	Analysis/ Formulation	Consensus/ Adoption	Action Implement.

Feedback Loops (illustrative of "ideal case"):



<u>S-P Legend:</u>

S1 = First publications in top journals of new scientific results relevant to potential policy concerns
S2 = Additional peer-reviewed publications confirming, replicating, extending initial results
S3 = Major conference publications, NAS panel reports, expert committees, etc.
S4 = Scientific leaders urge policy action based on implications of science consensus

P1 = Early confidential discussions about potential policy implications, "watching brief"
P2 = Responsibilities assigned in agencies for policy analysis and development; early public communications
P3 = Announcements of policy directions, engagement of stakeholders and other nations, international bodies
P4 = International agreement and treaty development; national laws, regulations, policies, budgets

Illustrative Feedback Loops:

A. Targeted research funding; sponsorship of conferences and workshops

B. "Pressure" by scientific leaders / researches on the policy development process

C. Regular interactions between scientists in government, industry, academia, including lobbying; battles over choices in policies and implementation strategies, both open and behind closed doors

D. Regular interactions as commitments and policy options are finalized and research continues; or, negative feedbacks and calls for corrective action, targeted research, policy adjustment, etc.

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