Global Climate Change:

Policy Making in the Context of Scientific and Economic Uncertainty

The Annapolis Center

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Preface

Global climate change has reached an accelerating level of scientific and political debate. This debate includes much excellent analysis of very complex processes, but it also includes an unfortunate amount of confusing and misleading rhetoric on various sides of the issue.

To examine and help clarify the range of understanding and uncertainty surrounding climate change, but not necessarily to force consensus on any aspect of the issue, The Annapolis Center held a two-day workshop on global climate change in Annapolis, Maryland, in July 1997. The meeting included a diverse group of participants representing the scientific, economic, and policy sectors. While the agenda was organized according to topic area, workshop participants were encouraged to make individual presentations as a way of eliciting specific reactions and stimulating focused discussion. (Please see the full list of participants attached as Appendix A.)

This December, the third session of the Conference of Parties of the United Nations Framework Convention on Climate Change will take place in Kyoto, Japan. With representation from over 160 nations, the meeting intends to adopt a treaty to establish targeted reductions in carbon dioxide emissions from industrialized countries beyond the year 2000. The impending debate on the merits of such a treaty adds additional timeliness to findings of the Annapolis Center's workshop.
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[1] The Annapolis Center is a national non-profit organization that supports and promotes responsible environmental health and safety decision-making. The center seeks to improve public debate about the potential risk from hazards and to insure that regulatory responses, if necessary, are appropriate to the risks.

THE ANNAPOLIS CENTER

promoting responsible environmental, health, and safety decision-making

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Executive Summary

Recognizing the complexity of the range of data and perspectives on Global Climate Change, The Annapolis Center hosted a workshop on July 17 and 18, 1997 to examine and help clarify related scientific, economic and policy issues. The workshop consisted of a diverse group of scientists and economists with appropriate and outstanding qualifications and a willingness to attempt to understand the underpinnings of climate change issues.

General Scientific Conclusions

- Our climate is by nature extraordinarily variable, and climate change in one direction or another is inevitable.
- Estimates of pre-historical and historical global temperature indicate a pattern of significant climate variability; thus, shorter-term measurements suggest little to no systematic change if natural variability is taken into account.
- The actual extent to which anthropogenic (human-generated) activities contribute to current climate warming still contains significant scientific uncertainties.
- The increase in fossil fuel emissions and other human activities worldwide are causing an increase in global atmospheric carbon dioxide and other greenhouse gases. Both theory and evidence suggest that the recent increase in global average temperature near the Earth's surface is consistent with increased greenhouse gasses, mediated by the background (natural) variability of climate.

The Role of Uncertainty in Science:

There are numerous types of scientific uncertainty associated with global climate change, many of which were addressed throughout the course of the workshop. The scope of the meeting could not delineate each individual point of uncertainty; for the purpose of informing future policy analysis and scientific research, however, the following general characteristics may be useful:

- There is important uncertainty regarding what is happening and why.
- There are numerous discrepancies among observed data, and between observations and predictions from simulation models, that also lends uncertainty to the assessment of climate change.
- There is a significant range of uncertainty regarding the projected increase in global mean temperature at various atmospheric levels, such uncertainty is low compared with that associated with regional manifestations of climate change. Moreover, natural variance, warming or cooling, is much larger (in some cases greater that 1-3° C) on the regional rather than on the global scale.
- At both global and regional scales, the *impacts* of climate change remain highly uncertain. This uncertain impact of climate change is further aggravated by the uncertainty about the capacities of societies to adapt to the natural variance in temperature change. The ability to adapt will vary greatly among regions.

General Economic Conclusions

In the latter portion of the workshop, attention shifted to the economics and policy of climate change. Those present on the following conclusions reached general agreement.

- Within the energy sector, the development of new, more efficient technologies can play an important role in influencing future carbon dioxide trends.
- Characterized by rapidly growing populations and the aggressive pursuit of economic development, many of the world's less developed countries will continue to increase fossil fuel emissions substantially over the next century.
- Regardless of the extent of future climate change--whether natural or human-caused--the ability to adapt to changing conditions is a critically important asset.
- On both a global and a national scale, it is extremely difficult to predict the future of carbon dioxide emissions and of economic growth; more challenging still is prediction of how climate change and various policy solutions will affect economic well-being.

The Role of Economic Uncertainty:

As with the climate process itself, detection of the economic "forcing events" presents challenges to addressing the economics of climate change. For example:

- To understand and forecast changes in carbon dioxide emissions rates, we have to understand how the economy is going to behave over the next 100 years.

Decision Making in the Context of Scientific and Economic Uncertainty:

Recognizing the inevitability of climate change, either natural, man-made, or both, and given the wide range of scientific and economic uncertainties, the remainder of the workshop discussion focused on how the international community might select courses of action. The following points were identified.

- Over the next decade our knowledge of the science and economics of climate change will certainly be enriched. In light of this probability, there was some discussion of whether and to what extent to delay taking action to reduce carbon dioxide emissions until more information develops.

- The majority, but not all, of the workshop participants agreed that in the context of the current range of uncertainties, the ultimate consequences of when we take action could be great. If the decision is made to take action, it must be done deliberately and with knowledge that the consequences could be grave.

Policy Considerations:

Workshop participants discussed a number of broad policy approaches and arrived at several guiding principles.

- No policy that has not already been implemented will be easy

- Any policy that seriously attempts to limit fossil fuel emissions and to slow climate change will by necessity incur substantial economic costs and will show no measurable effects on climate for at least several decades.

- In light of the current level of uncertainty regarding both the science and economics of climate change, extreme responses are inappropriate.

- Economic incentives may prove invaluable in discouraging growth in the emission of fossil fuels and encouraging the development of and transition to more efficient or non-polluting technologies.

Any policy, they agreed, should exhibit the following characteristics:

- It should be suitable for application, capable of being verified for compliance--and indeed, should be applied--on a global scale, with all countries participating and incorporating mechanisms and incentives to encourage such participation.

- Recognizing that economic well-being is among the most important factors in maintaining societal stability, the policy should be economically prudent, and implemented gradually with much advance notice, so that it reflects the natural ability of individuals to adapt to changing economic conditions.

- In light of the probability that important new information on the science of climate change is likely to emerge over the next decade, any climate change policy should be adaptive to changes in scientific information and understanding, and be flexible enough to respond to and incorporate that information.

- The policy should be evaluated on its scientific, technological, and economic merits and not on whether it furthers bureaucratic and political, or philosophical ends. Otherwise, social conflict will limit or defeat the policy's effectiveness.

Within this more general context of policy approaches, there was considerable discussion of the economics that could apply to emissions reduction policy and of the possible economic impacts of specific policies that are currently on the international negotiating table. The following observations were made:

- Participants noted that the most challenging obstacle to implementing a tradable permits strategy is the need to establish property rights for national emissions potentially worth hundreds of billions of dollars.

- The institution of a common carbon tax is perhaps the most widely discussed alternative, although other possible actions exist. Participants agreed that under such a scenario, all countries would have to participate, however, dependence on such tax revenues may compromise efforts to reduce emission.

Further Options:

Workshop discussions noted that regardless of the specific nature and extent of recommended policy changes, there is a great need for a more comprehensive national and international research agenda that is coordinated carefully with 1) related research efforts and 2) historical data. The following ideas were identified:

- Facilitate the availability and analysis of historical data sets.

- Maintain continuity of records of basic climate variables like global mean temperature and water vapor (at all atmospheric levels).

- Seek new sources of prehistorical climate data.

- Facilitate the "hard" sciences (physical and chemical) that address the injection of anthropogenic materials into the atmosphere and their evolution once placed there.

Policy Implications:

The Annapolis Center Workshop on Global Climate Change assembled a diverse group of participants of outstanding qualifications in an effort to understand the true scientific and subsequently economic underpinnings of global climate change. While the discussions revealed a great deal of uncertainty, the group succeeded in reaching a series of general conclusions, as described above. In this context, several points are worthy of note.

- Any near-term policy action or inaction must take place with the understanding that a firm, unqualified conclusion on the direction and rate of climate change requires significant new knowledge that will be gathered over many decades and must rest on a foundation of confirmed research.

- Any policy alternative is likely to generate substantial costs to the society so that a strong effort should be made to seek policies that minimize such adverse economic impacts.

- Any international plan to reduce carbon emissions should involve all nations.

- Any plan should be implemented gradually, allowing periodic review of its progress toward the clear goal of reduction in global climate change.

- Any plan should be flexible and adaptive to emerging knowledge, and should support the acquisition of such knowledge.

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1.0 Background

1.1 The Immediate Policy Context

The United Nations Framework Convention on Climate Change was signed in 1992 at the Earth Summit in Rio de Janeiro with the assumption that human-induced emissions of greenhouse gases will lead to global warming. The Convention established a process whereby national governments would share information on their own greenhouse gas emissions and their strategies to address climate change. It also included a commitment by all developed countries to make a concerted effort to return greenhouse gas emissions to 1990 levels by the year 2000.

In 1995, the Conference of Parties (COP) was designated as the Convention's main negotiating authority. At the COP's first session in Berlin, the Parties agreed that, in order to fulfill the objectives of the Convention, new commitments to reduce emissions beyond the year 2000 would have to be established. They created the Ad Hoc Group on the Berlin Mandate (AGBM) to draft such an agreement for adoption in Kyoto in 1997. A series of AGBM meetings has resulted in a range of proposals to limit emissions; as just one example, at a March 1997 meeting the European Union put forth a proposal to limit emissions to 85 percent of 1990 levels by the year 2010. To date, however, consensus has not been reached regarding specific targets or policy tools for emission reductions. The United States, for example, has yet to commit publicly to either a specified level of quantifiable emissions or a recommended set of policy tools for the Kyoto negotiations. Some believe that choosing 1990 as the base for emission levels favors some nations over others and creates unequal impact upon the participating nations.
Indeed, there is considerable debate, particularly in the U.S., surrounding the scientific bases for the assumption of global warming and both the appropriate level of emissions reductions and the issue of which policy measures can best achieve those objectives while minimizing economic hardship and social disruption. Moreover, there is general disagreement among policy makers and analysts regarding the more fundamental matter of whether emission targets themselves are the most appropriate and effective policy instrument for slowing long-term climate change should it occur.

1.2 The Scientific Context

The Kyoto meeting and The Center's workshop take place against a backdrop of ongoing scientific research and debate regarding the nature and extent of both historical and projected climate change. Established in 1988, the Intergovernmental Panel on Climate Change (IPCC) constitutes the primary source of scientific information to the Convention negotiations. Thus, the workshop participants set their discussion in the context of the IPCC reports. The IPCC has released two assessments of the science of climate change; the Second Assessment, completed in 1995, reached the following conclusions:

- The global average temperature in the 20th century ”is at least as warm as any other century since at least 1400 AD.”

- New estimates of natural internal and externally forced climate variability ”have detected a significant change and show that the observed warming trend is unlikely to be entirely natural in origin.”

- Relative to 1990, global mean surface temperature is expected to increase by between 1 and 3.5 degrees C by 2100, and the average amount of warming would probably seem greater than any seen during any similar period in the last 10,000 years…

Despite the seemingly definitive nature of these conclusions, the Report explicitly recognizes the range of uncertainty associated with climate change assessment. In particular, it offers the following caveat regarding the challenging process of separating human-generated from natural climate variability:

> ”Our ability to quantify the human influence on global climate is currently limited because the expected signal is still emerging from the noise of natural variability, and because there are uncertainties in key factors. These include the magnitude and patterns of long term natural variability and the time-evolving pattern of forcing by, and response to, changes in concentrations of greenhouse gases and aerosols, and land surface changes. Nevertheless, the balance of evidence suggests that there is a discernible human influence on global climate.”

2.0 The Science of Climate Change

2.1 General Scientific Conclusions of The Annapolis Center Workshop

The workshop began with a discussion of the scientific data underlying any prediction of global climate change. Initial attention was given to the detection and attribution of change based on data from ground-based, weather balloon, satellite, geologic, and other climate record sources. Differences among observed data from various sources were noted and discussed; these data were also considered in the context of general circulation computer models of the atmosphere, their ability to mimic past and current conditions, and their predictions of future climate trends. Although different data sources (for example, historical records, ground-based measurements, space-based measurements, and geologic data) exhibit varying levels of uncertainty and are not all in agreement, general consensus was reached on the following points.

First, our climate is by nature extraordinarily variable, and climate change in one direction or another is inevitable. The individual presentations and subsequent discussion revealed convincing evidence of significant historical and prehistorical climate variability, particularly as demonstrated by proxy records of winter temperatures over the past 10,000 years in the northern hemisphere. Annual and decadal variability is also demonstrated through data gathered during the 20th century and in geological records from ice, lake, and ocean cores. Special attention was given to historical examples of relatively extreme climate change, such as the transition from the Medieval Warm Period to the Little Ice Age (LIA) in the later part of the 15th century.

Second, estimates of pre- historical and historical global temperature indicate a pattern of significant climate variability; thus, shorter-term measurements suggest little to no systematic change if natural variability is taken into account. The workshop examined data and models of prior climate variability over time intervals of up to 100,000 years and as brief as 10 years. It should be noted that data sets, used in combinations, can be complementary and having several data sets allows better understanding of the complete climate system. However, participants generally agreed that time frames of 10 to 20 years are too brief to provide unambiguous evidence of climate change that is outside the range of variation observed during the last 100 years of instrumental record. Therefore, the record of the satellite-borne Microwave Sounding Unit is too short for its trend to be centrally relevant to the question of detection of anthropogenic signal in the climate record.

Third, the actual extent to which anthropogenic (human-generated) activities contribute to current climate warming still contains significant scientific uncertainties. There are numerous factors, known and unknown, both human-generated and natural, that combine in complex and nonlinear relationships to change climate over time. Natural occurrences include such processes as volcanic eruptions, El Niño and other atmospheric, quasi -periodic events, biological cycles, and complex atmospheric responses to natural variations in ocean temperature. In addition to rising concentrations of carbon dioxide, chlorofluorocarbons and methane, human-generated impacts include:

stratospheric ozone depletion, increasing sulfate and carbonaceous aerosol concentrations, and the possible effect of aviation on cloud formation, among others. The interaction of these various processes involves extremely intricate interrelationships, the workings of which remain unclear and are still being discovered. These interrelationships can result in either warming or cooling at regional as well as global scales.

Fourth, the increase in fossil fuel emissions and other human activities worldwide are causing an increase in global atmospheric carbon dioxide and other greenhouse gases. Both theory and evidence suggest that the recent increase in global average temperature near the Earth's surface is consistent with increased greenhouse gasses, mediated by the background (natural) variability of climate. .

Although the magnitude of human-generated impacts on climate is unknown, projected increases in carbon dioxide emissions are very likely to result in an increase in global mean temperature. Again, however, the extent, time frame and regional impacts of that projected increase are uncertain, as are global atmospheric, oceanic, and biological reactions to it.

One discrepancy in the climate data is the lack of a tropospheric temperature rise as monitored by satellites and balloons during the last 18 years and the apparent slight increase in the temperature at the earth's surface as extracted from surface (2m) temperature measurements. Current theory and computer modeling have assumed that the convective mixing should keep tropospheric and near-surface temperatures closely coupled.

2.2 The Science of Climate Change: The Role of Uncertainty

Workshop participants agreed with the IPCC Second Assessment Report that "Any human-induced effect on climate will be superimposed on the background 'noise' of natural climate variability..." The complex, largely nonlinear, coupled nature of the climate system introduces important uncertainty into the process of understanding past climate trends and predicting future scenarios. The observation of various climate processes in isolation from one another, measured with a diversity of tools and placed in the context of varying time scales, makes these uncertainties larger.

Workshop participants did not agree on the importance or relevance of scientific uncertainty to policy decisions. Several individuals emphasized that uncertainty is to be expected in studies of complex processes such as those that drive climatic behavior, in the key points such as the connection between carbon emissions and atmospheric temperature are well understood, even if details of those connections are unclear. Current uncertainties may influence the precision of predictions regarding carbon emissions and climate change, but the potential impacts of such changes, should they occur, are by no means trivial. Others argue that these uncertainties are relevant to judging the efficacy of proposed policy interventions, particularly where such policies have significant political or economic impacts. Indeed, no policy choice is immune to the challenge of scientific uncertainty.

There are numerous types of scientific uncertainty associated with global climate change, many of which were addressed throughout the course of the workshop. The scope of the meeting could not delineate each individual point of uncertainty; for the purpose of informing future policy analysis and scientific research; however, identifying their general characteristics can be useful.

In terms of the record and processes of climate itself, whether observed or modeled, there is important uncertainty regarding *what is happening and why.* We know that carbon dioxide and sulfate amounts in the atmosphere are higher and increasing at a faster rate than the climate system has experienced during the last 10,000 years. Furthermore, because of its long atmospheric lifetime, the elevated carbon dioxide amounts will remain for centuries, even if all emissions were stabilized or somewhat reduced immediately. These factors are imposed on a climate system, which our studies of paleoclimate show is capable of decadal-scale changes of a magnitude sufficient to seriously impact past human societies. Unfortunately, our present science cannot, at this time, identify the mechanisms underlying the major climate changes of the past 10,000 years, nor predict the climate response to the present and future levels of greenhouse forcing to a degree convincing to all or even many. Thus, it is difficult to identify the sum of the forcing events in climate change and, indeed, to tease out the impact caused by secondary events.

For example, the complexity of the atmospheric processes--the response to ocean temperature changes and to other natural feedback mechanisms, whether positive or negative, injects considerable uncertainty into the understanding of how various events combine to influence climate and which events force change. Wind patterns, cloud formation, water vapor, volcanic eruptions, El Niño effects, solar variability, biological effects, and others, all combine to create complex cycles that are at once naturally variable and might conceivably be influenced by human activity in many ways. Many of these elements are joined and affect each other in complex ways. .

There are numerous *discrepancies* among observed data, and between observations and predictions from simulation models, that also lends uncertainty to the assessment of climate change. These discrepancies are characterized by:

- *Disagreement among observed data emerging from a variety of sources.* Examples of this first type are discrepancies that arise through the use of varying tools and approaches to observing climate. As just one example, over a short time frame of the last 20 years, satellite, balloon, and surface temperature data indicate small but different temperature trends.

- *Disagreement between the characteristics of different models and the diversity of scenarios predicted by those models.* For example, the future trend of carbon dioxide emissions varies considerably from model to model; similarly, one model may include volcanic eruptions or aerosol concentrations as forcing elements, while others may not. In addition, some workshop participants questioned the representations used in various models. Thus, the levels of uncertainty within models and the extent to which they can accurately mimic the sensitivity of climate response are other potential areas of discrepancy.

- *Disagreement between observed data and predictions resulting from models.* In many cases, surface temperature does not closely match predictions from models. These various disconnects argue for more concerted and coordinated efforts to integrate observed and modeled data, with special attention to the coupling or decoupling of various processes and variables.

- *Disagreement between analyses of short-term versus long-term data*, particularly where data are used to evaluate natural climate variability. The annual and decadal temperature fluctuations of the past century are consistent with historical ranges of variation.

These "disconnects" are further enhanced by differences in the parameters, sophistication and calibration of measurement tools and models, mismatches between scales of measurement, and the diversity of scenarios examined.

Finally, while there is a significant range of uncertainty regarding the projected increase in *global* mean temperatures at various atmospheric levels, such uncertainty is low compared with that associated with *regional manifestations of climate change.* Moreover, natural variance, warming or cooling, is much larger (in some cases greater than 1-3°C) on the regional than on the global scale.

At both global and regional scales, the *impacts* of climate change remain highly uncertain. This uncertain impact of climate change is further aggravated by the uncertainty about the capacities of societies to adapt to the natural variance in temperature change. The ability to adapt will vary greatly among regions.

3.0 The Economics of Climate Change

3.1 General Conclusions of The Annapolis Center Workshop

In the latter portion of the workshop, attention shifted to the economics and policy of climate change. Again, workshop participants were invited to make individual presentations to stimulate and focus discussion. Unfortunately, not all of the invited participants representing the economic perspective were able to remain with the group throughout the second day, so their perspectives may have been missing from the discussion. However, general agreement was reached by those present on the following conclusions.

First, within the energy sector, the development of new, more efficient technologies can play an important role in influencing future carbon dioxide trajectories. A rapid transition to more efficient or alternative technologies that minimize or eliminate carbon dioxide emissions remains (if the increase in fuel efficiency exceeds the subsequent increase in fuel use) among the most important means to minimize potential human-generated climate change. However, the costs of reducing the world's reliance on fossil fuels, as an integral element of its economies, work against this potential transition, particularly since actions by a few countries may weaken their economies while not contributing significantly to reduction in climate change.

The world has benefited greatly from new technologies in the past, and plausibly can be expected to do so in the future, including greater efficiency in the use of fossil fuel and economic alternatives to fossil fuels. But the details of future technological change are highly uncertain. The cost-conscious pursuit of more efficient technologies and practices is a natural tendency of any capitalistic industrial endeavor; however, many participants felt that if more rapid transition is deemed necessary, external incentives would be required. For example, in the U.S. today, alternative sources of energy are available now and in the future, but they generally cost more than fossil fuels, hence, their wholesale adoption, other things equal, would reduce standards of living. Workshop participants also expressed the view that research dollars spent to reduce fossil fuel dependence does not necessarily lead to adoption of alternative fuels usage. Participants agreed that any effort to encourage a transition away from fossil fuels would have to be undertaken on a global scale to have any significant effect on emissions.

Second, characterized by rapidly growing populations and the aggressive pursuit of economic development, many of the world's less developed countries will continue to increase fossil fuel emissions substantially over the next century. If an international agreement is to be effective in mitigating increases in carbon dioxide, it will be critical that developing countries eventually participate. These countries must be encouraged to join the negotiating process in a way that does not threaten their plans for economic development. This is an issue of both fairness and practicality. Convention negotiations are proceeding according to the sentiment that: 1) the world's industrialized nations are largely responsible for past carbon dioxide emissions; and 2) many developing countries desire to achieve levels of prosperity similar to industrialized nations. "Principles of equity" suggest to these negotiators that industrialized nations have a responsibility to take the lead in reducing carbon dioxide emissions. In addition, for purely practical reasons, it is unlikely that developing countries will ever agree to reduce emissions if developed nations do not take the lead.

Workshop participants felt strongly that if larger developing countries such as China and India are not actively included in the emissions reduction process in the near future, it will be impossible to make significant progress in reducing global carbon dioxide emissions. This is essential because developing countries see improvements in their economic well being as involving growing dependence on fossil fuels, as occurred historically in today's wealthy countries. It was pointed out during the workshop that the benefits achieved by cutbacks in emissions in the developed nations could be more than offset by increases in emissions in developing nations.

Third, regardless of the extent of future change--whether natural or human-caused--the ability to adapt to changing conditions is a critically important asset. There are numerous examples of situations in which regions of the world have experienced the impacts of climate change, whether that change has been incremental or catastrophic, natural or anthropogenic. In many instances, extreme climate variability has disrupted entire civilizations and societies. In general, those nations with greater economic wealth and stability have also demonstrated greater capacity to respond and adapt to such changes. Thus, it follows that all nations would find it in their best interests to strive for economic well being in order to withstand the forces of change. In this context, the current correlation between economic wealth and the production and consumption of fossil fuels presents considerable conflict.

Fourth, on both a global and a national scale, it is extremely difficult to predict the future trends of carbon dioxide emissions and of economic growth; more challenging still is prediction of how climate change and various policy solutions will affect economic well-being. While various policies are being considered as part of the negotiations leading up to Kyoto, we cannot easily predict how economies will respond to those policies. For example, simply estimating the cost of climate change damage and abatement requires a three-part process of 1) determining baseline emissions, 2) calculating the potential damages from warming, and 3) calculating the cost of abating those damages. Because of the difficulty in quantifying many environmental damages, the task of assessing the cost of abating those damages represents an even more massive challenge. Thus, in an attempt to apply various policy measures and economic tools to a regulatory structure, the economics of climate change looms at least as uncertain as the science. It was observed during the workshop that a variety of studies show that the impacts on the economies of a developed country such as the United States would be substantial, when measured in terms of slower economic growth, dislocation of employment, and regional dislocation.

Further, consumption of fossil fuels, especially coal and oil, are intimately and integrally related to functioning of modern economics. Substantial reduction of consumption of fossil fuels will require major adjustments in the way we behave. While the growth of emissions can be plausibly bounded, the possible variation within those bounds is substantial.

3.2 The Economics of Climate Change: The Role of Uncertainty

As with the climate process itself, detection of the ”forcing events” presents challenges to addressing the economics of climate change. As stated above, great uncertainty exists regarding the future rates of change in the energy sector. This uncertainty is further increased by the facts that:

- ***to understand and forecast changes in carbon dioxide emissions rates, we have to understand how the economy is going to behave over the next 100 years***. Predictions of future economic behavior and applications of those forecasts to future global industrial patterns are highly uncertain.

4.0 Decision Making in the Context of Scientific and Economic Uncertainty

Recognizing the inevitability of climate change, either natural, human-induced, or both, and given the wide range of scientific and economic uncertainties, the remainder of the workshop discussion focused on how the international community might select courses of action. In approaching the daunting task of examining policy options, participants again acknowledged their inability as a group, in the context of the workshop, to explore all the details and variations. Furthermore, participants recognized that the considerable level of uncertainty does not necessarily imply that specific research or analysis flaws reside in one area or another. Nevertheless, the world's scientific community, through the IPCC report, has agreed that global warming is probable even though the detailed evolution of the climate system is not now understood. The workshop addressed the issue of what policy responses should be in the light of this uncertainty.

Over the next decade our knowledge of the science and economics of climate change will certainly be enriched. In light of this probability, there was some discussion of whether and to what extent to delay taking action to reduce carbon dioxide emissions until more information develops. Complete consensus was not achieved on this issue. A number of workshop participants felt that the current uncertainty is not adequate justification for delaying action to curb emissions: (1) particularly as no guarantee can be made that increased knowledge will necessarily result in diminished uncertainty on key issues in the near term and (2) other rationales besides climate change can justify some actions. Other workshop participants felt that the uncertainty surrounding future warming (for example over the next 30 years) validates delaying action. A range of potential tradeoffs exists between long-term and short-term visions, and the economic ramifications of acting now versus delaying action could be serious under either scenario. In sum, the majority but not all of the workshop participants agreed that in the context of the current range of uncertainties, the ultimate consequences of when we take action could be great. We know that certain immediate mandates to curb emissions will be costly, and their ultimate effects are uncertain. However, if the decision is made to take action, it must be done deliberately and with knowledge that the consequences could be grave. Thus, the importance of the issue and the cost of remedial actions warrant substantially more study. The wrong action could have unnecessary as well as costly consequences.

4.1 Policy Considerations

It was agreed that international negotiations and national decisions on climate change should consider, incorporate and proceed according to the following general observations:

- ***No policy that has not already been implemented will be easy.***

- ***Any policy that seriously attempts to limit fossil fuel emissions and to slow climate change will by necessity incur substantial economic costs and will show no measurable effects on climate for at least several decades.*** This is

not to say, however, that extreme action is or is not needed, only that the direct and indirect costs
of curbing carbon dioxide emissions must be taken into account when formulating policy. Policymakers should seek approaches that minimize damage to economic activity and human welfare.

- ***In light of the current level of uncertainty regarding both the science and economics of climate change, extreme responses are inappropriate***. As already stated, important uncertainty exists surrounding the nature and extent of climate change. The depth and range of this uncertainty is daunting in the context of future action. That said, we should not conclude that "climate change is not a problem," or "will never be a problem." On the other hand, we cannot conclude that climate change is so severe or well documented that extreme action is needed or justified. Indeed, given demographic projections for the next 50 years, such actions could have economic consequences that actually exacerbate other environmental problems or may work in the wrong direction.

- ***Economic incentives may prove invaluable in discouraging growth in the emission of fossil fuels and encouraging the development of and transition to more efficient or non-polluting technologies.*** Potential policies to emerge from this principle might be a research grant program to encourage alternative technology, the reduction or elimination of subsidies that encourage use of fossil fuels, tax credits on new technology investments, or increases or impositions of taxes on activities that generate significant fossil fuel emissions. Policies that are worth pursuing purely for economic efficiency and that improve the environment as well are sometimes referred to as "no regrets," "win-win," or 'twofer" approaches; such approaches received strong endorsement from several workshop participants and general acceptance by all. However, the political obstacles associated with the elimination of subsidies were noted. The imposition of taxes, while less widely supported in the group, also would generate political consequences as well as differential impacts of various parts of society. While the net economic impact of such reforms may be relatively benign, the costs and benefits accruing to different sectors and local economies will range in intensity. History shows that the response of groups of humans, (i.e., countries) to economic incentives is often very thoughtful, clever, and self-serving.

Workshop participants discussed a number of broad policy approaches and arrived at several guiding principles. Any policy, they agreed, should exhibit the following characteristics:

- It should be suitable for application, capable of being verified for compliance--and indeed, should be applied--on a global scale, allowing all countries eventually to participate and incorporating mechanisms and incentives to encourage such participation.

- Recognizing that economic well-being is among the most important factors in maintaining societal stability, the policy should be economically prudent and implemented gradually with much advance notice, so that it reflects the natural ability of individuals to adapt to changing economic conditions.

- In light of the probability that important new information on the science of climate change is likely to emerge over the next decade, any climate change policy should be adaptive to changes (meaning that it should permit reducing regulatory requirements as well as increasing them) in scientific information and understanding, and be flexible enough to respond to and incorporate that information.

- The policy should be evaluated on its scientific, technological, and economic merits and not on whether it furthers bureaucratic and political, or philosophical ends. Otherwise, social conflict will limit or defeat the policy's effectiveness.

4.2 Economic Policy Options: Tradable Permits and Mutually Agreed Actions

Within this more general context of policy approaches, there was considerable discussion of the economics that could apply to emissions reduction policy and of the possible economic impacts of specific policies that are currently on the international negotiating table.

Current negotiations surrounding the U.N. Framework Convention on Climate Change center on the establishment of specific national emissions reduction targets, with most proposals offering commitments to stabilize or reduce emissions to below 1990s levels. However, assuming a goal of eventual global participation, establishment of targets relative to 1990 levels, will not be acceptable to many rapidly industrializing countries. Targets based on population, gross national product, or "business-as-usual" trajectories would also encounter practical or political resistance.

To reduce emissions in the most economical way, two broad strategies, among the many possible, were considered: 1) tradable emissions permits and 2) carbon taxes. Both alternatives were discussed during the second day of the workshop.

4.2.1 Tradable Permits

Through the tradable permits strategy, each country would be allowed a quota of carbon dioxide emissions and could trade its right to emit. Presumably those sources with relatively low control costs would sell their emissions permits to sources with higher control costs, thereby receiving compensation for assuming a larger share of the emissions reduction burden. In this way, global emissions may be reduced while allowing individual countries greater flexibility in dealing with their individual emissions challenges.

Participants noted that ***the most challenging obstacle to implementing a tradable permits strategy is the need to establish property rights for national emissions potentially worth hundreds of billions of dollars***. Once those rights are established, the trading process could involve very large transfers of wealth between governments (for example, from developed to developing nations). Such a policy would also be difficult to revise over time, and this could impede new countries from entering into the process. Finally, *many participants felt that such a system has the potential to be bureaucratically burdensome and difficult to monitor*. Others felt that in any case the possibility of large transfers to governments would be politically unacceptable.

4.2.2 Carbon Tax

”Mutually agreed” or ”mutually determined” actions represent a potentially more flexible alternative to the tradable permits approach. Under such a strategy, negotiators could agree to a specific but flexible set of actions designed to result in reductions in carbon emissions. ***The institution of a common carbon tax is perhaps the most widely discussed alternative, although other possible actions exist***. The benefits of a carbon tax, it was suggested, include its flexibility (in that levels could be changed over time) and its potential to generate revenue. The revenues generated from such a tax provide an incentive to governments in that they could be used to balance budgets and also to compensate those who have been hurt economically by the resulting shift away from carbon-generating activities or to reduce other taxes. However, some studies show that the offset could be complete, but sometimes is not, and serious net adverse impacts would occur. A carbon tax removes the incentive to solve the overall problem. The tax could result in increases in revenues on which governments would become dependent.

Participants agreed that under such a scenario, all countries would have to participate. Further, some serious reservations were expressed that: 1) in order to have a significant impact on emissions, the tax would have to be quite large, 2) government dependency on revenue from a tax could serve as a disincentive for those governments to take other actions to reduce carbon emissions, and 3) the imposition of new taxes is generally unpopular.

4.3 Further Research Options

Workshop discussions noted that regardless of the specific nature and extent of recommended policy changes, there is a great need for a more comprehensive national and international research agenda that is coordinated carefully with 1) related research efforts and 2) historical data. Although the limited time frame allocated for the workshop agenda did not allow for an in-depth discussion of specific research recommendations, participants did offer several ideas for consideration. Among the ideas for consideration were:

- ***Facilitate the availability and analysis of historical data sets***. Certain data collections exist, the collection and analysis of which would be invaluable for understanding past climate change, checking climate model simulations, and helping to develop improvements in the climate models. Such data set examples include:

    - Traditional surface data for temperature and pressure. Such data is available from all parts of the earth, but is frequently in the form of written data logs, which need digital transcription, or are scattered over old data tapes, which NOAA cannot easily distribute.

    - Ocean data sets from national navy and commercial fishing fleets. Records of sea surface temperature and other meteorological data from the past two hundred years exist on paper and need to be digitized and subject to quality control.

- ***Maintain continuity of records of basic climate variables like global mean temperature and water vapor (at all atmospheric levels).*** Current data sets reflecting these variables need to be made consistent with historical and anticipated data sets; and monitoring and measurement tools must be calibrated to correspond with previously employed and now outmoded techniques.

- ***Seek new sources of prehistorical climate data.*** Each year new geological, biological, and archaeological records of climate changes are discovered and analyzed. Such research should be accelerated and integrated more fully in climate change models.

- ***Facilitate the "hard" sciences (physical and chemical) that address the injection of anthropogenic materials into the atmosphere and their evolution once placed there.***
    - Measurement of gaseous and particulate emissions into the atmosphere
    - Laboratory measurements of reaction rates for processes relating to the evolution of these materials
    - Numerical models that study this evolution, and incorporate the knowledge generated in the steps above, particularly those devoted to extracting climatic effects.

5.0 Policy Implications

The Annapolis Center Workshop on Global Climate Change assembled a diverse group of participants of outstanding qualifications in an effort to understand the true scientific and, subsequently, the economic underpinnings of global climate change. While the discussions revealed a great deal of uncertainty, the group succeeded in reaching a series of general conclusions, as described above.

Considerable uncertainty surrounds the connections between carbon emissions and projected changes in future climate. This doubt derives from differences in data and analysis, not to mention the inherent complexity of the climate system. In addition, large questions exist regarding potential policy decisions in terms of both their economic impact and their ability to solve and not aggravate the climate change problem.

In light of these uncertainties, and because the opportunities for and consequences of reductions in carbon emissions are not distributed equally among nations, participants in the third session of the Conference of Parties of the U.N. Framework Convention on Climate Change face daunting challenges to reaching consensus on specific policy options. There will be considerable pressure on all parties to demonstrate political progress on this issue, but it is possible that no action will be taken at this time. In this context, several points are worthy of note.

- Any near-term policy action or inaction must take place with the understanding that a firm, unqualified conclusion on the direction and rate of climate change requires significant new knowledge that will be gathered over many decades and must rest on a foundation of confirmed research.

- Any policy alternative is likely to generate substantial costs to the society so that a strong effort should be made to seek policies that minimize such adverse economic impacts.

- Any international plan to reduce carbon emissions should involve all nations.

- Any plan should be implemented gradually, allowing periodic review of its progress toward the clear goal of reduction in global climate change.

- Any plan should be flexible and adaptive (i.e., reduction or increase in regulation) to emerging knowledge, and should support the acquisition of such knowledge.

Biographies of Global Climate Change Workshop Participants

Norman L. Christensen, Jr., Ph.D., is dean of the Nicholas School of the Environment at Duke University and an ecologist whose research interests are broadly defined as the effects of disturbance on the structure and function of ecosystems. Dr. Christensen is a member of the Board of Directors of The Annapolis Center. In January 1997, Dr. Christensen was appointed by President Clinton to a 3-year term on the U.S. Nuclear Waste Technical Review Board.

John R. Christy, Ph.D., is an Associate Professor of Atmospheric Science at the University of Alabama in Huntsville. Dr. Christy has studied global climate issues since 1987 and has served as contributor for the reports by the Intergovernmental Panel on Climate Change (1992, 1994 and 1995). For creating a global, precise temperature dataset from satellites, The American Meteorological Society selected him for the 1996 Special Award. In 1991, he was awarded NASA's Medal for Exceptional Scientific Achievement for his work with satellite temperatures.

Richard N. Cooper, Ph.D., is Maurits C. Boas Professor of International Economics at Harvard University. He has written extensively on questions of international economic policy, including Environment and Resource Policies for the World Economy (1994). Since the early 1960's, he has served on several occasions in the U.S. government, as Chairman of the National Intelligence Council, Under-Secretary of State for Economic Affairs, Deputy Assistant Secretary of State for International Monetary Affairs, and senior staff economist at the Council of Economic Advisers.

Floyd Culler is President Emeritus of the Electric Power Research Institute. Culler is a member of the Board of Directors of the Annapolis Center. He is recognized broadly for his knowledge and leadership in all types of energy Research and Development analysis, and related environmental impact assessment. Culler has received many signal honors, including the International Atoms for Peace Award, the E.O. Lawrence Memorial Award, election to the National Academy of Engineering, recipient of the AIChE Robert E. Wilson Award, the ANS special Service Award, and the Walter Zinn Award. He is the United States member of the Scientific Advisory Committee to the International Atomic Energy Agency.

Donald Hagen, Ph.D., is a Professor of Physics at the University of Missouri-Rolla (UMR), a Senior Investigator in the Cloud and Aerosol Sciences Laboratory at UMR, and a Research Associate in the Center for Environmental Science and Technology at UMR. Dr. Hagen's expertise is in the areas of nucleation, condensation, and aerosol science and technology. For the last 10 years his focus has been on the environmental impact of combustion aerosols on the atmosphere.

Richard Lindzen, Ph.D., is the Alfred P. Sloan Professor of Meteorology at the Massachusetts Institute of Technology. He previously held the Robert P. Burden Professorship of Dynamic Meteorology at Harvard University where he also served as the director of the Center for Earth and Planetary Physics. He is a member of the National academy of Sciences, and has served on the Space Studies Board and on the Board on Atmospheric Sciences and Climate of the National Research Council. His research has focused on various aspects of atmospheric dynamics including the dynamics of climate change.

Jerry D. Mahlman, Ph.D., is Director, Geophysical Fluid Dynamics Laboratory, National Oceanic and Atmospheric Administration. He is a Lecturer with rank of Professor in Atmospheric and Oceanic Sciences at Princeton University and from 1986-89 served on the Climate Research Committee for the National Research Council. Dr. Mahlman's research career has been directed toward understanding the behavior of the stratosphere and troposphere.

Al McGartland, **Ph.D.,** Office Director for the Office of Economy and Environment within the Office of Policy Planning and Evaluation with the U.S. Environmental Protection Agency.

Loren David Meeker, Ph.D., serves as Professor of Mathematics and Research Professor within the Climate Change Research Center (CCRC) of the Institute for the Study of Earth, Oceans, and Space at the University of New Hampshire. Dr. Meeker has authored and co-authored over 70 publications in the mathematics, engineering, social science, biomedical, and geoscience literatures. He studies the processes which guide the evolution of natural climate through an analysis of the history of atmospheric composition recorded in glacier ice at sites thoughout the world.

Alan Robock, Ph.D., is a Professor in the Department of Meteorology at the University of Maryland. Dr. Robock studies climate change, soil moisture variations, effects of volcanic eruptions on climate and detection of human effects on climate. He has published more than 120 papers on his work. He also serves as the State Climatologist of Maryland.

William H. Schlesinger, Ph.D., is James B. Duke Professor in the Department of Botany at Duke University, he also holds a joint appointment in the Division of Earth Sciences of the Nicholas School of the Environment. He is the author or co-author of over 100 scientific papers and the widely-adopted textbook Biogeochemistry: An analysis of global change. Currently, Dr. Schlesinger focuses his research on the role of soils in the global carbon cycle.

Harrison H. Schmitt, Ph.D. is Chairman of The Annapolis Center. A former U.S. Senator, and Lunar Module Pilot on Apollo 17, Dr. Schmitt has the varied experience of a geologist, pilot, astronaut, administrator, businessman, writer, and U.S. Senator. Dr. Schmitt speaks and writes on a range of business, public, and governmental initiatives, particularly in the fields of space, defense, geology, energy, technology and policy issues of the future. He also contributes nonfiction articles on space and the American Southwest to numerous books and magazines.

Murray Weidenbaum, Ph.D., Chairman of the Center for the Study of American Business at Washington University in St. Louis, where he holds the Mallinckrodt Distinguished University Professorship. Dr. Weidenbaum is a member of the Board of Directors of the Annapolis Center. He served as President Reagan's first Chairman of the Council of Economic Advisers. Dr. Weidenbaum is known for his research on economic policy issues, taxes, government spending and regulation and has authored seven books, including Business and Government in the Global Marketplace.

Peter Wilcoxen, Ph.D., is an Assistant Professor of Economics at the University of Texas at Austin and a Nonresident Senior Fellow at the Brookings Institution. His principal area of research is the effect of environmental and energy policy on economic growth, international trade, and the performance of individual industries. He has published extensively on the subject and has co-authored a book on the design and construction of large scale economic models. He has also been a consultant to the U.S. Environmental Protection Agency.

The Annapolis Center Staff

Carrie W. Capuco, J.D. Ms. Capuco has over twelve years experience as an environmental educator and policy analyst. She has worked with organizations such as The National Geographic Society, National Wildlife Federation, the U.S. Environmental Protection Agency, the U.S. Department of Defense, and most recently, The Annapolis Center. With the Annapolis Center, Ms. Capuco manages the conduct of several projects. Among them are a Global Climate Change Workshop, a "Living With Risk" Curriculum development, and Epidemiology study, and a Comparative Risk research effort. Ms. Capuco has an undergraduate degree in Geology from the University of Michigan in Ann Arbor, Michigan, and a law degree from the University of Maryland.

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The Annapolis Center supports and promotes responsible environmental, health, and safety decision-making. The Annapolis Center is a nonprofit, 501 (C) 3 education organization.

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