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IPCC WG III

United States Department of State

Bureau of Oceans and International Environmental and Scientific Affairs

Washington, D.C. 20520

March 17, 1994

Dr. James Bruce
Dr. Hoesung Lee
Intergovernmental Panel on Climate Change
Working Group III
c/o Technical Support Unit
145 King Street West, Suite 1002
Toronto, Ontario, M5H 3X6
CANADA

Dear Sirs:

Attached please find the United States' comments on the IPCC Working Group III Draft Second Assessment Report. Comments are organized by chapters, including a separate section on the Summary for Policymakers. We hope these comments are fully considered and taken into account in revising the text.

While the U.S. comments are extensive, reflecting the importance we attach to this assessment, we believe the present report, although uneven, is a good start on a useful final product. Our comments are reflective of the broad range of input we sought in their development: we circulated the draft text to an extensive group of experts both inside and outside of the U.S. government, in addition to providing public notification of the availability of the Report through the U.S. Federal Register. Comments received through this process were, where appropriate, incorporated into the U.S. recommendations included in this package.

We believe several chapters will need substantial strengthening -- or rewrites -- before they can meet the expected high IPCC standard. In particular, we are concerned that the current versions of Chapters 2 and 3 are inadequate, while chapter 6 will need revisions to accommodate concerns about an imbalanced assessment of the literature. Furthermore, we believe that chapter 12 should be entirely deleted, as it repeats information already published by the IPCC in the 1994 Special Report.

In addition to our concern over the uneven quality of the underlying chapters, we were particularly concerned with the Summary for Policymakers: This section often does not accurately reflect the substance of the underlying chapters, it contains significant amounts of material that is either poorly

explained or is of no consequence to policymakers, and it too often underplays or even entirely omits information that is of critical importance to the policy community. In our view, this section will require substantial revision -- and, we believe, a full rewrite. To assist in this effort, we have provided, in place of detailed line-by-line comments on the January 20, 1995 draft, a set of bullets containing the key points we believe ought to be extracted from each of the underlying chapters for inclusion in the SPM.

The United States appreciates the enormous time and effort that has gone into the preparation of this Report. Through these comments we hope to assure that the final product is not only accurate, but of value to the policy community. We look forward to receipt of the revised draft text, and wish the IPCC Bureau and the lead authors every success in their continued efforts to prepare this important document for publication.

Sincerely,

Rafe Pomerance
Deputy Assistant Secretary
Environment and Development

Attachments:
U.S. Comments on Summary for Policymakers
U.S. Comments on Draft Chapters
Computer disk containing all U.S. comments (in MSWord 5.1 Format)

cc: Dr. Eric Haites

United States Department of State

Bureau of Oceans and International Environmental and Scientific Affairs

Washington, D.C. 20520

March 17, 1994

TO: Dr. Eric Haites
IPCC WG III Secretariat
tel: 416/369-0900 fax: 416/369-0922

FROM: OES/EGC - Jonathan Pershing
tel: 202/647-4069 fax: 202/647-0191
home telephone: 301/929-0477

SUBJECT: U.S. Comments on Draft IPCC WG III Report

Attached is a copy of the U.S. comments on the Summary for Policy Makers for Working Group III, along with the formal transmittal letter. As per our conversation of earlier today, I have sent via Federal Express the full collated comments on the underlying chapters -- including a copy of the material on disk. I will forward to you a copy of these SPM comments via your office in Washington on Monday morning.

I apologize for the delay in getting these out; as you have likely heard from many other countries, the tight deadlines and the numerous comments received made this an extremely difficult task. I hope that your lead authors' meeting in Paris is a success, and look forward to hearing the outcome of the discussions. Please telephone if I can be of further assistance.

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To Sally Kane	From DAN Reifsnyder
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U.S. COMMENTS ON THE *SUMMARY FOR POLICY MAKERS* TO THE WORKING GROUP III 1995 ASSESSMENT

The U.S. review of the *Summary for Policy Makers* contains both general and specific textual proposals for changes. We believe that the *Summary for Policy Makers* as written could be greatly improved by a complete redrafting. We propose changes that reflect the following principles:

- The purpose of a Summary for Policy Makers is to identify those conclusions from the literature for which there is broad consensus among the professional community of economists and to explain these in lay terms for policymakers. As such it is an assessment of the state of knowledge, not a recipe for policy implementation.

- Conclusions in the *Summary for Policy Makers* should follow from conclusions found in the underlying chapters.

- Where there are established differences of opinion in the literature, the summary should represent all major differences of professional opinion. If one of those views is in the distinct minority, then the summary should characterize that fact as well, or include the minority view only in the technical material of the background chapters.

Attached below are general comments on the SPM. However, it is our view that simply making editorial changes at the margin of this document will not be the best way to prepare the final text. Starting from the ground up is required. Accordingly, we have included a list of "Major points that should be made in Summary for Policy Makers." We have attempted to word these proposed additional and substitute bullets with care so as reflect our understanding of the literature. We have not, however, attempted to order these bullets to provide a sense of a continuous flow for the entire text; rather these are points we believe ought to be included somewhere in the Summary. Some of these points are <u>not</u> made in the current chapters of this document. However, U.S. comments on each chapter reflect our view that these points should be developed in the appropriate chapters.

We hope that these comments will assist the Lead Authors and the members of the Bureau as they work to prepare a revised versions of the SPM for circulation to all governments.

GENERAL COMMENTS ON SUMMARY FOR POLICYMAKERS

We believe that the present Summary reflects primarily the literature of the economics profession and is not an in depth assessment of a broader social science literature that is relevant to an understanding of the climate change impacts and response strategies. This should be made clear to the reader. Accordingly, we propose that the following caveat be included at the beginning of the Summary in addition to being included in Chapter 1.

> "This document addresses various socio-economic issues relevant to global climate change. In examining these issues, the document relies primarily on scientific insights and perspectives from the economics literature. The document should not be considered, therefore, a comprehensive assessment of other social and behavioral sciences that may be of interest in climate policy debates."

- **Policy statements should be deleted.**
  The Summary for Policymakers at times violates the general directive agreed by the IPCC: IPCC reports should focus on the science and should not contain "policy judgments". For example, the second page states the policy judgment that "The precautionary principle (Article 3.3) and the estimated damages due to current emissions of greenhouse gases (Chapter 6) argue for action beyond 'no regrets' measures." Page two also contains the policy judgment that: "The Convention thus incorporates, and the literature assessed in the report (Chapters 1, 2, 8 and 9) supports a strategy of 'act - then learn - then act'...." Similarly, much of the language in the section on "The Benefits of Limiting Greenhouse Gas Emissions and Enhancing Sinks" is judgmental. The beginning of the Summary should make clear that the purpose of the report is to assess the application of socio-economic analysis to the climate change issue. The types of policies to be undertaken and their timing clearly falls under the purview of national governments, and soon the Conference of the Parties, not the IPCC.

- **References to the Framework Convention on Climate Change (FCCC) should be very carefully worded so as to avoid interpreting the Convention.**
  The document makes frequent reference to the FCCC and in many cases the document offers an interpretation of the Convention is not universally

shared by the Parties. The document and the Summary are better served by avoiding the FCCC to the extent possible. Instead they are to report on the state of economic science concerning global change

- **The organization of the Summary could be improved**
We recommend that the section entitled "A Portfolio of Possible Policy Actions" be moved to the end of the Summary. We suggest that the Summary follow the outline of the report. It should begin with a brief introduction to the economic tools that will be assessed for applicability to the analysis of climate change, and then go on to describe those tools, following the outline of the report. The decision making framework, with its emphasis on sequential decision-making, should come first. Next should come equity considerations and the discount rate, and the tools of analysis considered in the cost-benefit chapter. The report should then move on to the empirical study of damages, mitigation, adaptation, and integrated assessment. The analysis of policy instruments and the portfolio of possible policy actions should conclude the summary, in a non-judgmental fashion.

- **Uncertainties should be discussed more fully.**
The Summary fails to represent adequately the basic uncertainties and limitations in economic analysis of this issue. Economics must play a fundamental role in the analysis of climate change policies. At the same time, however, it must be made clear to policymakers that the core demands of climate change analysis occur in areas where economic analysis has its greatest difficulties. These demands include very long term forecasts of human behavior and economic activity, intergenerational investment and consumption issues, equity issues within and among nations, evaluation of non-economic impacts, human response to policies that are outside our experience, decision making under uncertainty, and modeling potentially catastrophic events. In part because of these difficulties, some parts of the report have fallen back to theoretical formulations which may be attractive in the abstract but which are unworkable at either the analytical or the policy level. The Working Group III report should make clear those issues where economics cannot provide definitive answers.

Given all the caveats which are still being given regarding the reliability of impact projections, WG III should not make more definitive scientific or impacts statements than either WG I or WG II. In a number of instances, the language chosen by the IPCC is very misleading to

policymakers even if it is literally accurate. Language that reflects the letter as well as the spirit of the findings is required if this document is to make a credible contribution to the debate.

The Summary provides at least five specific estimates of the damages of potential climate change, one estimate of emission reductions associated with removal of energy subsidies (which largely reflect action by non-Annex I countries), one estimate of the possible extent of negative to slightly positive cost energy efficiency measures (which is debated in Chapter 9, but the debate is not acknowledged in the Summary) and one estimate of the cost of enhancing carbon sinks. There are, however, no other estimates of the costs of limiting greenhouse gas emissions, to which Chapters 8 and 9 are entirely devoted. From a reading of the Summary, policymakers could be given the (perhaps erroneous) impression that large scale emission reductions can be accomplished nearly costlessly, and not provided with a clear sense of the controversy over this issue.

In some areas, the Summary selectively and inconsistently reports "findings.". For example, on page 7 (lines 21-25) it is stated that "Because of the large uncertainties surrounding estimates of damages due to climate change (Chapter 6) and the costs of mitigation (Chapter 9) make it difficult in practice to rely solely on cost-benefit analysis...." However, on page 8 (lines 12-14) it states that "Most estimates of the additional damage done by CO2 emitted now range from $5 to $25 (1990 $ U.S.) per tonne of carbon...." If the uncertainties are so large as to limit use of benefit cost analysis, then providing the estimate of damages without qualification about their uncertainty is inconsistent and misleading.

Potential damages and impacts are discussed as if they are absolutely real instead of being computer projections. Simply adding "potential" or changing "would" to "could" would correct many of these misleading statements in this section.

- **Document must be consistent with results from IPCC WGI and WG II**

  Another broad area of difficulty is the description of the science of climate change in the draft report.. Writers must: 1) assure that the description of the science of climate change contained in the Working Group III report is consistent with that in other recent IPCC reports such as the 1994 IPCC Special Report or the reports nearing completion by Working Groups I and II; and 2) carefully distinguish between an

assumption made in a cited economic analysis and the current knowledge of climate science.

•Cited work is of varying quality

Citation of work is incomplete and the work being cited is of varying quality. The document should make clear the distinction between peer reviewed and non-peer reviewed work. It is appropriate to include the latter, but the assessment needs to make clear that non-peer reviewed work does not have the quality control represented by a peer reviewed study.

MAJOR POINTS THAT SHOULD BE MADE IN THE *SUMMARY FOR POLICY MAKERS*

Points which should be included from Chapter 1 and 2 are as follows:

- Climate change represents a formidable global policy problem involving large uncertainties, a very long planning horizon, long time lags between emissions and effects, the potential for irreversible damages or costs, the possibility of a catastrophic loss, wide regional variation, and multiple greenhouse gases. [Pages 4-7]

- The literature suggests there is a useful although not definitive way to evaluate climate change-related decisions in the face of these problems.

- Features of the climate change problem which have implications for evaluating different courses of actions include:

  - The scale of the problems is global. The climate-atmosphere system is a global public good. Greenhouse gas emissions in one part of the world contribute to global changes in climate.

  - Countries are also linked in a global economic system such that actions taken in one country to limit greenhouse gases can have effects on the emissions from other countries.

  - Emissions and actions to reduce emissions will have consequences reaching into the distant future, some of which may be irreversible.

- Consequences of different courses of action are uncertain. Information on consequences is expected to become more complete and reliable over time, but we will never accumulate perfect information. Included in the uncertainty are potential climate-related catastrophic impacts on the environment and human welfare, and potential severe hardship resulting from actions to limit climate change.

- The consequences of different courses of action are likely to vary across individuals, regions nations and generations.

- Coordinated actions taken by groups of countries are expected to yield more desirable outcomes than independent, uncoordinated actions. Coordinated action can reduce the free-rider problem and the potential for emission reductions in one region or sector being offset by increases in other regions or sectors.

- A "sequential" decision process considers the consequences of decisions over long time horizons, addresses decision making under uncertainty and that can respond to new information with mid-course corrections; it is expected to yield more desirable outcomes than a process that takes a short-term view, that ignores the incomplete and imperfect nature of available information, or that ignores the potential for learning.

- Economic efficiency is one criterion for selecting actions. Economically efficient emission reductions are those with the lowest cost, regardless of who bears the financial responsibility. Equity, the varying consequences of actions for different individuals, regions, nations and generations, is another important criterion.

- Climate change responses can be differentiated into three categories:

  1) no regrets actions where costs are less than expected benefits, disregarding the climate benefits;

  2) actions whose costs are less than expected benefits if climate benefits are included; and

  3) additional actions whose costs exceed expected benefits and yet might be chosen by the risk averse to reduce the potential of catastrophic losses.

- There is tremendous variety in potential policy responses to climate change under the broad categories of mitigation and adaptation. (See SPM p 2-3 for list)

- A well-chosen portfolio of mitigation, adaptation, and research and development policies will yield greater benefits for a given cost than any one option undertaken by itself. [Page 8]

  Given its global nature, action to address climate change would benefit from collective decision making; however, the economics literature has much less to say about collective decision making than it does about individual decision making. [add to Sec. 1.3]

Points which should be included from Chapter 3 are as follows:

- Equity depends on both the outcomes of decisions and perceptions about the process used to reach decisions.

- There are substantial variations within and between the "north" and the "south" in terms of: absolute and per capita emissions; the likely impacts of climate change; institutional strengths and preferences; cultural perspectives, and endowment of natural resources. These may be affected by adaptation and mitigation.

- Both efficiency and equity concerns will influence the choice of mitigation and adaptation measures, and it may be worthwhile to conduct analysis of the efficiency implications of particular ethical principles, and vice versa.

Points which should be included from Chapter 4 are as follows:

- Climate change raises particular questions of equity among generations because future generations are not able to influence directly the policies chosen today. Intergenerational equity concerns have been argued on a number of bases including: ensuring future compensation for damages caused by current decisions; trustee obligations; and, society's consideration of current versus future consumption in a world of improving economic conditions.

- Literature in environmental ethics employs the "trustee rationale" to support setting policy goals that do not allow discounting the value of particular environmental assets, e.g., national parks. However, economic

models recognize the possibilities for substituting resources and also examine changes in environmental goods and services and their implications for consumption over time.

- A prescriptive (normative) approach that assumes that the pure rate of time preference for intergenerational decisions is near to zero, supports discount rates at the low end of the range once the projected growth in per capita income is taken into account. In contrast, an approach that emphasizes market considerations, because investments in climate mitigation compete with other investments that raise the level of welfare of current and future generations, generally favors adoption of real discount rates in mid- to high parts of the range. The market-based approach is also consistent with evaluations of mitigation options using current and projected market prices of energy rather than "normative" prices that attempt to correct for energy market distortion.

- The choice of discount rate matters significantly: the higher the rate, the less future benefits and the more current costs matter in the analysis. How best to choose a discount rate is, and is likely to remain an unresolved question in the economics literature. Partly as a consequence, different discount rates are used in different countries. Analysts typically resolve the issue by conducting sensitivity studies that vary the rates according to the different perspectives.

Points which should be included from Chapter 5 are as follows:

- An analysis of costs and benefits offers a useful framework for organizing information about the consequences of alternative actions for addressing the climate change problem.

- Traditional cost-benefit analysis developed originally for project-level decision making with 20-30 year planning horizons is being used in a more broadly defined context to deal with climate change.

- Cost-benefit analysis employs a variety of techniques to address issues important to climate, such as:

  --risk, uncertainty, and irreversibility;

  -- valuation of non-market benefits and costs; and

-- discounting, particularly over long time horizons.

- In addition to cost-benefit analysis, other techniques have been developed to respond to limitations in analyzing certain resource problems. These techniques include cost-effectiveness and multi-criteria analysis. Another class of frameworks includes decision analysis.

- However, in the application of cost-benefit analysis to the problem of climate change, there are important difficulties because of the global, regional and intergenerational nature of the problem.

  - Information on the consequences of climate change and actions to address climate change is limited.

  - Valuation of consequences is a central feature of cost-benefit analysis, but confidence in valuation estimates for many important consequences is low.

  - For some categories of ecological, cultural and human health impacts, economic concepts of value may not be widely accepted as appropriate.

  - Actions to address climate change will likely result in net benefits for some individuals, regions, nations, and generations while generating net costs for others. There is no widely accepted decision criterion for selecting a course of action based upon the costs and benefits of alternative actions in such a case.

Points which should be included from Chapter 6 are as follows:

- The estimates of climate change damages are dependent upon a host of assumptions regarding highly uncertain inputs to the analysis. Researchers have widely varying views on the probabilities that should be associated with different sets of assumptions. These studies should not be interpreted as best estimates, nor as providing upper or lower bounds on likely damages.

  -- A small number of studies estimate global damages for a scenario of 2.5 degree C warming and obtain a range of damages from 1.5% to 2.5% of gross world product (including market and non-market

effects as a result of a doubled CO2 environment and using highly varying estimates of damage from particular sectors).

-- None of the damage estimates reviewed represent damages for discontinuous changes in the climate or for catastrophic scenarios of climate change and climate change impacts. Furthermore, most consider only the effects of a doubled CO2 equivalent atmosphere for modeling.

-- Damages are expected to vary by region, and there is limited evidence that developing countries may experience greater damages as a percentage of gross domestic product than will developed countries.

-- The monetary estimates are based upon economic concepts of individual and social welfare, although not all analysts believe monetarization is appropriate. Methods exist to estimate damages in monetary terms for both market and non-market effects, but much less confidence is placed in estimates for non-market damages than for market damages. Examples of market effects include changes in the production and consumption of foodstuffs, forest products, energy and other commodities. Examples of non-market effects include changes in human health, flood protection, outdoor recreation, and preservation values for species and natural places.

- Comparisons of damage estimates from different studies suggest that damage categories of particular concern include agriculture, coastal zones, water resources and human health. However, there is little agreement across studies about the magnitude of damages for these and other categories of damages and little agreement in the relative ranking of damage categories. For example, research results are inconclusive about the severity of agricultural damages with some studies indicating the potential for agriculture to benefit.

- Of particular of concern are damages that may arise from the disruption of natural ecosystems (which provide a variety of services, including for example, aesthetics, biodiversity, waste assimilation and recreation) by climate change. There is a high degree of uncertainty about how these systems will respond to climate change and a low level of confidence in available valuation methods to adequately account for the importance of

these systems to human welfare. A few researchers have made monetary estimates of damages to natural ecosystems from climate change, but the estimates are speculative and not comprehensive. Further, some would reject monetary valuations of ecological damages derived from the economic paradigm of value on ethical grounds.

Points which should be included from Chapter 7, 8, 9 are as follows:

- The generic set of responses to climate change that have been identified in the literature are: mitigation including:

  Mitigation (reducing or changing the activities that lead to trace gas emissions; scrubbing -- removal of greenhouse gases from combustion by-products; and sequestration -- enhancing the uptake of greenhouse gases)

  Adaptation (acting to limit the impacts of changing climate)

  Geoengineering (large scale interventions in the earth system in an attempt to counter-balance the atmospheric changes and radiative forcing caused by greenhouse gases, e.g., some have suggested adding iron compounds to the ocean would increase its capacity to act as a sink)

- A complete evaluation of the costs of GHG mitigation would require a full and accurate technical description and pricing of all of the inputs and outputs in all markets affected by the policy, and would describe how output and prices in all markets are affected by the policy over time. This is a very difficult task in part because the economy can respond in many ways to changes in policy.

- An evaluation of full social costs and benefits of a policy will be particularly difficult:

  -- the greater the uncertainty and the longer the time frame;

  -- where market institutions do not exist;

  -- where market prices fail to reflect external costs such as pollution; or

-- where information costs play a significant role, as is the case with new technologies.

- Existing studies use a variety of methodological approaches and definitions of cost to assess the costs of mitigating GHG emissions. No existing study yields a complete evaluation of full social costs and benefits. Instead, studies present a range of cost estimates. Some provide estimates of direct financial costs of specific technological options while others provide estimates of the effects of broad policies on aggregate economic activity; still others attempt to estimate welfare costs. It is important to be clear about which type of cost is being estimated in any specific study.

- The range of methodologies can be grouped into generic classes:

  -- "Bottom-up" studies begin with detailed assessments of engineering costs of a wide range of available or forecasted technologies.

  -- "Top-down" studies use a wide range of methodologies to try to calculate the response of the entire national, regional or global economy to a policy option, typically to an emission tax such as a carbon tax.

  -- "Hybrid" studies, which use a combination of these two approaches, and preserve both the rich technical detail of bottom-up analyses with the behavioral aspects and interdependencies of different market sectors of top down models

- Bottom-up analyses generally:

  -- calculate the financial costs of these options, generally at current market prices, and compare the options to each other and to current technologies in the market. They do not focus on quantifying aggregate impact of technology adoption on related markets and on the overall economy.

  -- conclude that the best existing technologies yield very high energy cost savings relative to the cost of continuing to use installed equipment, so that it appears financially profitable to replace a large quantity of existing equipment. As a consequence, these studies generally conclude that a significant quantity of emissions

reductions - of 10 to 60 percent below what they would have been in a business as usual (baseline) scenario - can be achieved at net savings, where costs are calculated as the sum of the equipment and energy costs to individual equipment users. Most of the literature provides annual carbon reduction estimates of net savings of under 40 percent, although this varies across countries.

- Top-down analyses generally:

  -- evaluate costs as the difference between gross domestic product (GDP) in a no-policy "business-as-usual" base scenario and GDP in a policy scenario; some models attempt to quantify the change in overall economic welfare as defined by economists;

  -- represent markets in a fairly aggregate way, they do not provide for detailed assessments of particular technologies. Instead, they attempt to quantify in a more general way the response of the aggregate economy and the slow adjustment of all markets, thus trying to account for some components of full social cost not quantified in the "bottom-up" studies. The processes are modeled on the basis of statistical analysis of historical behavior;

  -- yield a range of cost estimates, and the results depend critically on the choice of modeling framework. On one end of the spectrum, general equilibrium studies, which provide for rapid adjustment of markets, yield relatively low cost estimates (e.g. $5/ton to $20/ton for stabilization of emissions at 1990 levels over the next decade or two); on the other end, macroeconometric studies, which try to represent the more gradual adjustment that is typically found in real economies, yield medium to high cost estimates (e.g. $40/ton to over $100/ton for stabilization of emissions at 1990 levels over the next decade or two).

  -- At the country-specific, regional, and world-wide scales, top down modeling of the use of emission taxes has most often shown reductions in economic growth of 0.5 to 2 percent that results from efforts to "stabilize" carbon levels (return them to annual levels that existed around 1990), or reduce annual greenhouse gas emissions by 20 percent of what initial baseline forecasts had placed them at in 2020.

- There is substantial disagreement over the reasons for the wide difference between the low mitigation costs found in "bottom-up" studies and the higher mitigation costs found in most "top-down" studies.

  -- Proponents of the low-cost view tend to view the high costs found in the "top-down" studies as evidence of a range of "market failures", such as lack of information, capital constraints and inadequate investment in research, development and commercialization of new technologies. They point to the low adoption rate of technologies that appear profitable as a priori evidence that there must be a range of market failures; they tend to conclude that the economy is operating inefficiently, and that its performance can be substantially improved at relatively low cost.

  -- Proponents of the high-cost view tend to believe that these costs generally reflect a range of adjustment costs, information costs, and other intangible costs that are not measured in detail but are nevertheless captured in the aggregate by the "top-down" models. They regard the low market penetration of what appear to be profitable technologies as a priori evidence that there must be a range of costs not captured in "bottom-up" studies. As a consequence, they tend to conclude that the economy is operating near its maximum potential.

- As a consequence of the high vs. low cost controversy described above, there is substantial disagreement over the extent of "no regrets" potential for GHG emissions reductions (i.e., reductions that can be undertaken at net economic savings). The extent of "no regrets" potential depends on how efficiently the economy is operating. The conclusion of some researchers that significant "no regrets" potential exists is based on their view that (i) significant market inefficiencies or market failures exist which give rise to increased GHG emissions (i.e., society is below its maximum production potential), and (ii) that policies can be designed and implemented at low cost that eliminate these market inefficiencies or correct these market failures.

- Confidence is greatest in the insights generated by modeling analyses than in the specific numerical results of any one analysis: The collective work that has been done examining the costs of programs to reduce carbon levels from energy use throughout the world suggests several other valuable insights important to decision makers:

- Economic instruments such as taxes and tradable permits are likely to be more efficient than regulatory approaches

- Encouraging energy supply or conservation lowers overall energy prices, resulting in some increased energy demand and emissions in certain end-use sectors; this is called the "bounce-back effect."

- Removal of some types of energy subsidies could stimulate energy efficiency gains than produce carbon reduction benefits.

- Existing evidence makes clear that both the technical potential and the cost (or cost-savings) of various non-carbon fuel alternatives and of energy efficiency improvements vary substantially by geographic region and across different social, political, and economic systems.

- Infrastructure decisions on energy supply and energy use systems are critical. They can enhance or restrict the types of future options countries will have to address the greenhouse gas problem through energy efficiency improvements and fuel switching.

- There are large differences in the costs of reducing greenhouse gas emissions among countries due to their state of economic development, infrastructure choices, and natural resource base. This suggests that international cooperation can significantly reduce the global price tag for emissions reduction such as joint implementation. Some research has shown the potential for substantial savings that are possible in a global emissions trading program.

- Given the nature of the current global economy, some research suggests that the lack of international cooperation may lead to significant levels of "leakage" of carbon as manufacturing activities shift between nations, if some countries act to address the issue and others do not.

- The timing of programs for emission reductions is a critical policy variable in determining the costs of reductions. Costs are sensitive to the timing of programs because of its potential influence on the rate of capital turnover and the rate of technological innovation and diffusion.

- Research on carbon sequestration has focused on improved forest management using forest plantations, forest management to slow deforestation and increase regeneration on degraded lands, expand agroforestry practices combining forestry in agriculture, and production and substitution of bioenergy fuels for fossil uses. Studies of carbon sequestration estimate costs ranging from less than $1 to about $50 per metric ton of carbon, although a few studies provide estimates as high as several hundred dollars per metric ton. A substantial amount of enhanced carbon sequestration can occur at the bottom end of the cost range.

- Recent studies have highlighted low-cost options for actions to reduce methane releases from natural gas systems, coal mining, waste disposal, livestock, and other anthropogenic activities. Additional research has demonstrated the potential for greenhouse gas emissions reductions in fertilizer production and use, aluminum production, and CFC replacement manufacturing. In the United States, actions to reduce releases from methane sources, aluminum production, and the manufacturing of CFC replacements have been shown to save money.

Points which should be included from Chapter 10 are as follows:

- Integrated assessment is a new multidisciplinary approach that combines and synthesizes results from a wide range of disciplines to evaluate possible consequences of policy actions; such integrated assessment frameworks have been developed for application to climate policies The models are useful because they can provide insights about the climate change problem not available from a examination of individual disciplinary studies. For example, by evaluating the sensitivity projected policy impacts to varying assumptions about uncertain components of the climate problem, integrated assessment models may be able to contribute to the setting of research priorities

- These frameworks include simplified representations of future emissions and the costs of emission reductions, the accumulation of greenhouse gases in the atmosphere, consequent changes in climate, the impacts of climate change on humans and ecosystems, and related feedbacks.

- However, integrated assessment models are still immature:

  -- The models are sensitive to input assumptions, such as damage functions, that are often calculated by other researchers

-- Models have yet to fully assimilate research results from relevant disciplines -- and furthermore, such disciplines are themselves constrained in their ability to provide explicit results

-- Models have not at this stage examined the implications of nonlinearities in the climate system or in climate change damages.

Points which should be included from Chapter 11 are as follows:

- A clear distinction needs to be drawn between policies for global climate change mitigation and adaptation. Mitigation reduces emissions and thereby reduces potential changes in climate, while adaptation reduces the damages caused by whatever climate change does occur (such as by developing drought-resistant plants). [Page 17]

- Some adaptation policies can be effective unilaterally. Research has shown that unilateral policy instruments designed to mitigate global climate change will be considerably less effective. [Pages 7, 36-37]

- There is tremendous variety in potential policy responses to climate change. Research has identified voluntary actions, carbon or energy taxes, carbon quota or tradable permits, removing energy subsidies, performance or technology standards, product bans, demand side management, sink enhancement, and research on greenhouse gas abatement technologies and on climate change effects. [Pages 5-8, 18-22]

- Market-based policies are generally considered most cost-effective by researchers in this area. A choice of tradable emission permits at the international level could provide flexibility for instrument choice at the level of individual countries, which may have different sets of criteria for assessing policy instruments. Some market-based policies may have higher administrative, monitoring, and enforcement costs than some non-market-based policies such as technology standards. [Pages 9, 31-34, 41-45]

- A system of joint implementation of carbon emission reductions if properly designed could be a cost-effective method of targeting for reduction those emissions involving the lowest mitigation costs. [Pages 29-30]

Points which should be included from Chapter 12 are as follows:

- The U.S. Government recommends that this Chapter not be included in the Working Group III report. This material is already published as part of the 1994 special assessment; we believe that if necessary, individual chapters and the Summary for Policy Makers can and should refer to that document whenever relevant to points are being made. Inclusion of this section would unnecessarily reopen these points for discussion at the Working Group III plenary.

IPCC WGIII

March 20, 1995

To: J. Stiglitz
R. Squitieri
From: S. Kane
Subject: WGIII Review from the USG

After 12 hours of interagency work on the USG review on Friday (over 40 hours in total), the following comments can be made.

1. The review process like the writing of the chapters was uneven. *Chapter comments ranged widely in content and quality.*

2. *The summary conclusions on CBA have been softened but still acceptable.* With the "policy review" that was instituted, CEA could not insist on further changes without endangering the whole process.

3. *Questions remained about the role of the SCOPE chapter -- report summary versus a review of the economics framework and tools for analysis of climate change.*

4. *The role of the Framework Convention on Climate Change in providing the context for the report has not been resolved.* Department of State wants as few references as possible, to prevent any constraints on future negotiations.

5. *Jim Bruce and Eric Haites would like to add author(s) to the decision framework chapter.* Even without Parikh's sections, much work remains on the chapter. They have asked the US for $ to support any additional authors that could be added (authors would be US).

Attached:

chapter comments

Copies not yet available:

comments on summary for policy makers

U.S. GOVERNMENT COMMENTS ON INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE WORKING GROUP III DRAFT ASSESSMENT

CHAPTER 1

GENERAL COMMENTS

Alternative Approaches

The chapter should expand the discussion regarding alternative approaches in the debate over sustainable development (page 38), for example approaches advocated by Daly and Cobb (footnote 101), and writers in ecological economics such as Norgaard and Howarth. (For example, Richard B. Norgaard with Richard B. Howarth, "Climate Rights of Future Generations, Economic Analysis, and the Policy Process," written testimony submitted to the Committee on Science, Space, and Technology, U.S. House of Representatives, Washington, D.C., hearing on "Technologies and Strategies for Addressing Global Warming," July 17, 1991; also Richard B. Norgaard, "Sustainability as Intergenerational Equity: The Challenge to Economic Thought and Practice," World Bank Discussion Paper, Washington, D.C., 1991). Recognizing that these are not dominant views in the economics profession, and without judging the appropriateness of the alternative approaches, we recommend that for the sake of completeness the chapter expand the coverage to flesh out the alternative approaches.

Equity and Efficiency

(Page 2 Line 1, and Page 15, Line 37; also Page 18 Line 23) Rather than stating that efficiency and equity can be separated, say something to the effect that both need to be considered; that for purposes of analysis it is sometimes useful to think of equity and efficiency sequentially, but technically they cannot be separated when there are public goods involved. A further difficulty in separating efficiency and equity is raised by the possibility that equity may be defined not just on the basis of outcome, but also on the fairness of procedures (see chapter 3, section 1.3). There is no guarantee that a process that is accepted as equitable will yield an outcome that maximizes a social welfare function where the arguments of the social welfare function include only outcomes (distribution of consumption goods for example) and not "fairness" of processes. For example, note the opposition by some countries to inclusion of joint implementation in the process by which abatement responsibilities are allocated. If joint implementation or other transfers of abatement responsibility are barred because these processes are viewed as inequitable, efficiency, as usually defined in welfare economics, may suffer.

Population Growth

Population growth is underemphasized (receives mention on Page 17 Lines 21-23 and Page 19 ine 41). Given that emissions are to a first order of approximation proportional to population, the importance of population growth should be highlighted. See specific comment on Page 17 Lines 21-23.

Nuclear Power

Given that it causes very little CO2 byproduct, nuclear power should be included in the discussion. This is not to judge whether nuclear power is a viable option, just that it should not

be ignored. For example, pages 13-14 depict a transition in stages from oil and gas, to coal, to an unspecified backstop technology. This would be a natural place to incorporate a discussion of nuclear power. Note the discussion of nuclear power in Chapter 7 page 17.

Diagrams referred to in the text need to be provided.

SPECIFIC COMMENTS

Page 1, Lines 6-8.
There are a number of problems with the sentence "The risks of climate change are highly asymmetrical, with a large probability of a small loss, and a small probability of a large loss." They are:

1. The wording suggests that the problem is one of "risk" in Knight's terminology, where the probability of all possible outcomes is known versus "uncertainty", where probabilities are unknown and not all possible outcomes are even foreseeable (see footnote 15 of chapter). Climate change is an example of uncertainty, not risk. The statement should be changed to convey that the problem is one of uncertainty in which probabilities, to the extent that they can be assigned at all, are subjective and controversial.

2. The statement is imprecise because it provides insufficient context regarding the time frame or extent of climate change to which it applies. There may be wide spread agreement that large losses are improbable for the range of warming thought to be likely over the next century baring large positive feedbacks in the earth's systems. But for climate changes beyond this range, the potential for large losses increases. Scientists have not even begun to assess the potential implications of climatic changes that could plausibly occur over a 200 or 300 year time horizon, or that could result if there are positive feedbacks that are triggered by modest warming. Further context needs to be added to the statement to assure that readers do not draw the misleading conclusion that, because 2xCO2 is thought unlikely to cause large losses, higher concentrations beyond 2xCO2 that business-as-usual will very plausibly lead us to are also unlikely to cause large losses.

3. The statement refers to losses that are aggregated across the globe. Hidden in this is the likelihood that some will gain, some will lose, and some losers will lose big. The statement should be revised to highlight the differential impacts which are central to international deliberations on climate policy.

4. The statement describes the situation as "asymmetrical", which should be deleted. While there is a (perhaps small) possibility of cataclysm from carbon emissions, is there also not a (small) possibility of carbon emissions heating up the atmosphere enough to save us from a potential next ice age? Asymmetry may not be what the authors really intend, perhaps just the notion that there is a chance of cataclysm.

These problems are serious and need to be rectified. The sentence is prominent in the summary of the introductory chapter, is likely to be quoted and cited widely, and could therefore have a strong influence in shaping perceptions of the importance of the climate problem among scientists, policy analysts, policy makers, and the public. To assure that this does not result in a widely held and inaccurate perception of climate change, we recommend that the sentence be replaced with the following:

The consequences of climate change are highly uncertain and subjective probabilities assigned to different possible outcomes can vary substantially across researchers. However, for the most likely range of warming over the next century, the probability of a small loss is thought to be large and the probability of a large loss is thought to be small. For greater warming, such as that which might be experienced over the next two centuries, or which could occur sooner if modest warming triggers the release of large amounts of carbon from the biosphere and oceans to the atmosphere, the probability of a large loss increases. These losses refer to global losses which represent an aggregation of individual losses. Impacts will differ across individuals, groups and regions. For some, the probability of large losses can be high over the next century despite the expectation that the aggregate global losses will be small.

Note: The same or similar statements appear in several places in the chapter. Similar modifications to convey that the problem is one of uncertainty and not risk, that the likelihood of small versus large losses is dependent upon extent of climate change, and that global losses mask regional losses are needed wherever they occur.

Page 1, Lines 8-10.
No regrets policies are most commonly defined to be policies which have negative of zero net costs - omitting any benefits from avoided climate change from the calculation of net cost. Going beyond no regrets policies can be justified without recourse to principles of risk aversion. If the expected value of climate change impacts is a loss of welfare, as suggested by Chapter 6, this alone would justify policies that have positive costs. If we add in principles of risk aversion, this implies that not only would it be rationale to go beyond no regrets policies, but that it would also be rational to go beyond policies that would maximize expected welfare (provided the marginal benefit of the policies exceeds the marginal costs). Suggest replacing the sentence "Even in the presence . . . that incur net costs" with following:

> Irrespective of the possible consequences of climate change, policies that mitigate against climate change or assist adaptation to climate change and have negative or zero net costs are clearly justifiable. Such policies have been termed no regrets policies and a number of countries have begun efforts to identify and exploit such opportunities. If the risks suggest that climate change is likely to cause damages, as is argued in Chapter 6, then the expectation of damages provides a rationale to go beyond no regrets policies to those that incur positive net costs. In addition, the principles of risk aversion and portfolio balancing provide further rationale for even more aggressive policies. The costs of such policies might be justified as a risk premium to be paid for the added security of reducing the likelihood of large climate change damages.

Page 1, Lines 12-14.
Delete "to the same extent" from the end of the sentence. The meaning is vague and potentially misleading. Countries have different baseline climates, will experience different degrees of warming and other climatic changes, and have different vulnerabilities to climate change. Emissions from one country will therefor clearly not affect all other countries equally.

Page 3 Line 16.
Insert "deforestation", which is a major contributor to net CO2 emissions.

Page 3 Line 42.
"Thus, avoiding climate change lies beyond normal economic analysis". Insert "human-induced" before "climate change", since some natural climatic changes may occur anyway.

Page 4 Lines 11-15
It is unclear what the purpose of this sentence is. It should be deleted.

Section 1.2
It should be discussed that some climate change may occur from natural as well as anthropogenic causes.

Page 6 Line 38:
"How" is actually even more an efficiency question than "how much" is, because once a level of emissions is decided, efficiency can best determine"how" reductions are achieved. But deciding on that level depends on valuations of things on which people can disagree and for which there is no market valuation provided, so efficiency alone cannot determine. Consequently, we suggest replacing "how much" with "how".

Page 7.
The discussion of the contribution of economics in section 1.3 should be expanded to include the economics of irreversibilities and option value. The discussion should include their implications for decision making under uncertainty, ie the rationality of preserving options by limiting actions that have undesirable and irreversible consequences. The discussion should be balanced and recognize that both emitting greenhouse gases and abating these emissions have irreversible consequences.

Note that the discussion of irreversibilities on page 4 discusses irreversibility only as a physical concept and does not discuss its economic implications.

Page 10 Lines 2-3.
It would be useful to expand on the notion of intergenerational insurance, including tradeoffs between bequests of physical capital and atmospheric quality. Are we to allocate part of the capital we would normally bequeath to all future generations to an insurance pool to insure among them? How could such an insurance scheme be implemented?

Page 11 Lines 3-7
In line 3, revise "often" to "sometimes." In lines 6-7, delete the sentence: "Moreover, because

option b) may be perceived as too expensive to get political support, policy paralysis often results."

The Parties to the FCCC have not posed the policy question of global climate change as a choice between doing nothing at all or committing to an all-out effort. To say that it is "often" posed this way is to give too much centrality to various outliers. Further, to whatever extent there may be elements of "policy paralysis" in the ongoing INC/FCCC negotiations, it is not the "result" of an all-or-nothing framing of the issue so much as a complex web of differing perspectives on how to address various political and economic issues pertaining to the implementation of incremental steps to address the climate issue. Similarly, if there are elements of policy paralysis in the formulation and implementation of National Action Plans, e.g., the difficulty thus far in obtaining congressional support for full funding of even the limited steps taken in the Clinton administration's Climate Action Plan, it is not primarily because the administration or most Members of Congress have posed the problem in all-or-nothing terms.

Page 11 Lines 28-31
Revise to read: "For example, government and private-sector decision makers with responsibility for energy technology development and investments in power plants, manufacturing equipment, vehicle fleets, and other energy-using infrastructure and capital stock, must seek the correct balance and timing between 1) .....[etc]"

The draft language, which appears to pose "immediate investment in new plant and equipment," "aggressive R&D on greenhouse abatement technology," and "deferring large investment for 10 years" in either/or terms, is perhaps too simplistic to be a relevant example for decision-making. The options need to be posed integratively. Capital stock is replaced and R&D is conducted on an ongoing basis.

Page 14 Line 5.
The first paragraph is misleading, though
subsequent paragraphs clarify the argument. Coal is also exhaustible, but because there is much more of it, its exhaustibility is less relevant than that of oil and gas.

Page 17 Line 7.
Revise to read: "the burden of the tax is progressive in its distribution across countries...". (Presumably the authors are not trying to make the statement that a carbon tax is progressive within any given country.

Page 17 Lines 21-23.
Revise to read: "The controversial issue of population growth, while central to the question of economic development, bears on climate change through its effect on emissions. Population growth may also exacerbate the ecological and socioeconomic impacts of climate change, and will affect mitigation and adaptation costs and strategies. This chapter will limit its treatment of population to its effect on emissions, although to address climate change adequately as a problem of sustainable development will require a fuller treatment.

Page 18 Lines 6-7.

"... benefit all energy-importing countries." Exporters may be better off with higher demand levels.

Page 18, Line 36.
Uniform prices on emissions (not of energy).

Page 19, Line 20-30.
This paragraph needs to be much more specific to be clear. What is meant by "governments that believe they have a comparative advantage in assuming climate risks"? If it's those who are richer, care less, or believe themselves less vulnerable, say so. How can one government "assume a larger share of climate risks"? Are you talking about insurance contracts in which a country would renounce access to collective aid from future climate harms?

Page 22 Line 16.
Use "over-valued" rather than "over-priced". The resources have been overvalued; the extractions from the resources (the flows of oil) have been underpriced from an after social-cost tax point of view. With a social-cost tax added, producers would receive less net of tax than before. (Note that correcting any problem of mispricing of resources due to monopoly control of them, would push prices in the other direction).

Page 25 Line 14:.
Use "bringing closer" rather than "increasing".

Footnote 59 (referenced at Page 25, Line 37)
These ranges across models don't look like "marked variation", they look like a pretty tight bound for knowledge about economic facts 15 years hence. (Maybe the reason they converge so much is that they're under-stating our ignorance about economic change over a 10-20 year period).

Page 26 Line 29-40.
Add text here to clarify the range of policies which are considered "subsidies" for purposes of this argument. The assertion that all energy subsidies should be ruled out as part of an appropriate climate policy strategy is debatable.

While preserving the general thrust of the argument that correct energy price signals can improve allocative efficiency and reduce greenhouse gas emissions, might the draft, which seems to be focused here primarily on large-scale energy subsidies seen as especially prevalent in developing countries and in former Soviet Bloc countries, be overlooking certain types of what might be seen as subsidies that arguably could play a positive role in an effective climate change mitigation strategy? For example: government research, development, and demonstration subsidies for advanced non-carbon energy supply technologies; transitional investment and production tax credits for solar photovoltaic and wind energy technologies in order to expedite sufficient commercialization to achieve production economies of scale; or use of favorable government procurement policies as a market development tool for more energy-efficient building technologies and energy end-use equipment, in order to help achieve economies of scale. Does the draft mean to rule these out, or are they not considered to be "subsidies?" This could use

some clarification.

Page 28.
This section citing specific instances of efficiency-increasing policies and present distortions is excellent. This is much more valuable than general assertions that energy is subsidized. Why not provide specific references to specific countries' policies, or to estimates of the magnitude of distortion they represent?

Page 28, Section 1.5.2.6 Title
Efficiency affecting, not increasing, policies.

Page 28.
Include changes in highway funding levels to promote energy-efficiency goals (note this is not in the National Action Plans).

Page 35 section 1.5.5.2.
Once again, no mention of nuclear. The effect on nuclear of energy taxes should be included, accounting for both carbon-intensity and supply elasticity.

Page 35 Line 9.
What is meant by the second sentence?

Page 35 Line 14.
The third point ignores the fact that imposing a carbon tax would force carbon-related activities to pay closer to their social cost, representing a movement towards efficiency (from a global point of view).

Page 42, Lines 23 and 24.
Author (Solomon) cited in footnote comments that changes he previously sent in have not been incorporated. The two lines ought to read something like this (changes in caps):

"... would be to DECREASE boreal forest area, and, by a smaller percentage, to INCREASE tropical forests. On balance, THE CLIMATE RESULTING FROM A doubling OF co2 concentration would modestly INCREASE THE AREA SUITABLE FOR FORESTS, IF TODAY'S AREA OF AGRICULTURAL LAND USE WAS UNCHANGED (SMITH AND SHUGART, 1993). If LAND ON WHICH AGRICULTURE IS PERMITTED BY CLIMATE INCREASED IN PROPORTION TO POPULATION INCREASES, LAND SUITABLE FOR FORESTS WOULD DECLINE WITH CO2-INDUCED CLIMATE CHANGES (SOLOMON ET AL., 1983)." References: Smith, T. M. and H. H. Shugart, Jr. 1993. The transient response of terrestrial carbon storage to a perturbed climate. Nature 361:523-526. Solomon, A. M., I. C. Prentice, R. Leemans and W. P. Cramer. 1993. The interaction of climate and land use in future terrestrial carbon storage and release. Water, Air and Soil Pollution 70:595-614.

Page 43, Lines 22-23. Allen Solomon also comments: "There was simply no evidence presented anywhere (that I was able to find) nor do I know of any literature which supports this idyllic picture. If it is true that some species will be given new opportunities by the climate-

induced destruction of endangered ones, it is the plentiful "weed" species, not other endangered ones, which will be provided the new opportunities. This sentence needs to be deleted".

We suggest correction of the text according to the commentor's suggestion, unless the authors have documentation for their assertion.

U.S. Comments
IPCC Working Group III Draft Assessment
Chapter 2: Decision Making Framework

1. The chapter presents normative conclusions unsupported by scientific argument, including many statements about the North's responsibilities to the South. These judgements are inappropriate in an IPCC report and should be deleted. For example:

   Page 4, section 2.1.2.1. "[Rapid temperature change] must be avoided because apparent and hidden costs of global and local irreversible damages and extensive adaptation are high." Conclusion not derived from the analysis.

   Page 8, lines 10 ff. " ... if humanity lived a lifestyle corresponding to about 0.66 tonne of carbon equivalent emissions per person, per year ..."

   Page 8, lines 14-15. "In other words, responsibility of marginal damage begins after going above this limit."

   Page 9, line 13. "... North could lead."

   Page 9, line 22. "It is not correct to say that everyone emits."

   Page 9, lines 29-30. "If North's contribution to past and future concentrations are put to zero, South can go on with its development for another century without worrying about the climate problem."

   Page 11, lines 22-24. "In fact, since developing countries are more vulnerable and have contributed little to the pollution so far, they could have unequal rights, and could have more say in this matter."

   Page 14, line 20. "While the rich can argue ..."

   Page 15, line 6. "... the practice of discounting the future is severely questioned," etc. Sentence should be deleted, as Chapter 4 settles this issue. Also, Cline's estimate cited in first paragraph is not widely accepted by economists. This reference should carry a note to that effect, or be deleted.

Page 15, line 12. "Ethically, generational welfares are to be treated equally."

Page 15, line 6. "This substitutability assumption is highly questionable." The section should either make the case for its assertion, or be silent.

Page 16, lines 2-4. "But, if the present generation is responsible for the losses of the future, as is the case in the climate change problem, then not doing anything is morally unacceptable."

Page 16, line 28 through page 17, line 5. "Therefore, if no decisions . . . this principle of accountability after 1990 could lead to prudent behavior and act as some deterrent to all against wasteful consumption."

Page 18, line 25. "Thus risk tolerance of, say South should matter more than that of North."

Page 19, section 2.3.3.4. "Currently there are many countries whose use of environmental space far exceeds their justifiable share of that space. J. Parikh has indicated that these privileges are worth US $70 billion per year."

Page 20, line 28. "Remember that if 550 ppm is chosen, it is difficult to go back to 440 ppm, but vice versa is possible."

Page 44, line 6. "... *implies that the industrialized nations should take strong measures*..."[emphasis in original].

Page 54, line 14. " ... would it not be cautious to insure ...?"

2. As a result of its many normative conclusions, the chapter does not present the issues in a balanced way. For example:

Page 3, lines 2-5. "Some expect ..." This is what economists generally believe, and should be presented as the prevailing view.

Page 5, line 8. [Insert **words in bold**:] "... could have more **or less** impact ..."

Page 9. Granting that irreversibilities are a matter of concern, the draft shows only one side of the issue, focusing as it does only on the irreversibilities of climate change, not the irreversibilities in investment.

Page 16, section 2.3.3.1. First paragraph should also

note that cutting back on growth in the North -- for example as a result of climate change programs -- is likely to hurt residents of the South as well, through a drop in southern exports.

Page 18, line 5. "That is, due to delay in abatement, global risks are externalized." Alternatively, spending a lot now on the wrong programs could easily impoverish our descendants.

Page 27, section 2.5. Why begin with the quote from Dowlatabadi and Morgan? Placed at the top of the section "Economic Formulation of Individual and Collective Decision Making", it suggests that the most important consideration is the prejudices of the decision makers. These may indeed be important, but the contribution of scientific analysis lies elsewhere.

Page 55, lines 5 ff. Paragraph is highly speculative and does not belong here.

3. The chapter must clearly set out alternative decision frameworks, explaining how adopting different frameworks may lead to different conclusions (Lester Lave of Carnegie-Mellon University wrote about this some years ago). As one example, in a recent paper, Nordhaus shows that just switching from the cooperative to the noncooperative strategy greatly influences the expected costs of greenhouse mitigation.

4. The chapter fails to focus attention on its major conclusions; the conclusions it does highlight are often at variance with economic theory and empirical results. For example:

   Page 56, line 23. "To illustrate, the Alliance of Small Island States (AOSIS) has proposed that an "International Insurance Pool" be established...." Here, a tangential discussion deflects the reader's attention from the major arguments. This should go in a footnote or be deleted.

5. Logical foundation for many claims is shaky.

   <Summary, page unnumbered> lines 23-24. Causal relationship not established.

   Page 5, figure 2.1. Delete temperature estimates. It is not the accepted view that for 2°C warming, damage would be "substantial." Also, graph appears to present probability density functions (but then what is the curve that starts highest on the probability axis?). If that is the case, the areas under the curves should

be the same, the tails of the curves should extend to the left of the origin (implying some probability of benefits from warming), and other logical problems should be corrected.

Page 8, bottom. The risk analysis at the bottom of p. 8 is faulty, or at least based on special assumptions. The authors should first state the general optimization problem to be solved, then state the asserted qualitative properties, relating them to particular empirical parameters. If new technologies will become available in the near to medium term, it may be much less expensive to wait to reduce emission levels beyond modest amounts. This is one of the basic findings of studies cited elsewhere in the IPCC report. If the authors of this chapter disagree with those studies, they should state the reason, not just assert an alternative conclusion. Although the argument that follows on page 9 states that sudden reductions may imply large fixed costs, the risk analysis does not take this into account.

Page 9, line 1. "Therefore, small but regular .. if not impossible." Even if this were correct, it is not self-evident and does not fit here.

Page 9, lines 12-14. These lines do not follow from the previous discussion, and in any case are not generally accepted. "Risk minimization" implies infinite risk aversion, as assumption rejected by virtually all the theoretical and empirical literature.

Page 12, line 7. Parry and Rosenzweig (cited) do not find large vulnerability in food supplies, contrary to impression left by text.

Page 18, line 27. "Most models developed in the North do not effectively build in the perspectives of the South in adapting to climate change." Economic models, like physical models, should be value-free. Do we speak of Northern physics and Southern physics -- or just good physics and bad physics? An economic model may be flawed for several reasons: it may be poorly formulated, or based on flawed estimation results; it may be internally inconsistent, or may predict poorly. We may say that it fails to reflect available resources, or misstates likely behavioral responses, but not that it does or does not "build in perspectives of the South."

Page 35, line 8. "... there might be as many rationalities as there are cultures." This statement seems out of context and contributes little to the scientific argument being made.

Page 40, line 29. "... 5 percent chance of a climate-related catastrophe within their lifetime." It is difficult to imagine what climate-related catastrophe could occur by, say 2050.

p. 60, line 4. "An operational model to analyze the optimal portfolio of climate change policies for a country is not feasible given the state of our knowledge." The sentence should be modified to incorporate the recent literature that reports on several modeling efforts to evaluate optimal portfolios of countries (e.g., see recent papers of the Energy Modeling Forum at Stanford (projects EMF-12 and EMF-14). No economic model will produce an error-free, bullet-proof answer to anything. This limitation should not be used as a reason for dismissing findings in the literature.

6. The chapter uses terms in a way that will be unfamiliar to economists and decision analysts. For example:

Page 1. The questions posed here are not well formulated. Key terms are not well defined. For instance, what does "tolerated" mean in question 1? Question 3 confuses issues of efficiency (where abatement occurs) and finance (who pays the costs of abatement).

Page 2, point 5. "In this connection, we note that according to the earlier IPCC report, even present information is adequate to go for the goal of reducing global emissions by 60% for stabilization." The sentence is difficult to follow. Does "go for" mean justified by a cost-benefit analysis? The earlier IPCC report did not present such an analysis. Also, what emissions level is implied by stabilization?

Page 5, line 15. "Acceptable cost" has no generally accepted definition in economics.

Page 7. "Risks are measured in CO2-years." What is the basis for this claim?

Page 8, section 2.2.3. "... trend risk and not a sudden risk..." What does this mean? Line 28: "... higher abatement costs are justified in case of trend risk..." Why is this?

Page 11, line 1. What is the "apex forum?"

p. 11, line 12. "Again, it concerns differently economists and environmentalists." What does this mean?

Page 22, above table. "purchasing power parity." The term seems misapplied.

Page 29, line 26. "From such a standpoint, a subjective probability can always be formulated as a 'bet on a certain event'." What does this mean?

Page 40, line 15. "According to Shlyakhter et al. (1995), *those risks that fall below a particular threshold of probability*--and thereby are ignored by a particular group or society--are called "*de minimis*" risks."[emphasis in original]. This is a definition and should not be presented as a research result.

Page 55, footnote 19. "*The more risk averse you are, the more you will insure* (Chichilnisky, 1994)."[emphasis in original] Since this is not a research result, it should be deleted.

Page 56, line 8. "Economics is about differences in preferences leading to trade (Chichilnisky, 1994)." Since this is not a research result, it should be deleted.

7. The chapter's discussion of the Bayesian approach is misleading and unhelpful.

Summary, lines 18-21. "Bayesian scheme has two limitations with respect to climate change: first the existence of strong uncertainties, and, second, the existence of low probabilities attached to large potential damages. Alternatives, however, are available: risk assessment (Chapter 7), fuzzy logic, or evidence theory." These statements make no sense. Bayesian methods have been developed exactly to deal with problems involving significant uncertainty. Further, there is nothing in fuzzy logic or evidence theory that obviates any of the problems mentioned.

Page 28, lines 17-20. "... Bayesian approach, which represents information in the form of conventional, necessarily precise probability distributions..." The sentence can be rewritten along the following lines: "The field of decision analysis is conceptually grounded in the theory of Bayesian probability, which construes probabilities about possible states of nature as being fundamentally subjective or personal in character."

Page 29, Footnote 5, characterizing knowledge as all or nothing; in reality, of course, this is just an extreme case.

Page 32, lines 10-16. What is meant by, "Shifts to the

Bayesian decision theory ...."?

Page 32, lines 16-17. It is true that the characterization and evaluation of uncertainty involves many judgements. It is quite a leap to say that such judgements are necessarily "political."

Section contains numerous misstatements, including:

Page 38, lines 11 ff. "A risk averter can be a diversifier and spread his portfolio over different assets--or a "plunger" and invest wholly in bonds and money." "Cautiousness: Defined as decreasing risk aversion ... (Schaifer, 1961; after Pratt, 1995)." If some group of experts uses terms in a different way than that found in the main body of peer-reviewed literature (such as Raiffa, 1964), the less familiar terminology should be clearly identified.

p. 56, line 9. "Betting on climate states ..." What does this mean?

8. Many quotations are inaccurately stated or incorrectly referenced. For example:

Page 40, Lines 16--17. The sentence needs to be surrounded by quotation marks, and the italicized text should be unitalicized. These lines should read (1995), ''those risks that fall below a particular threshold of probability---and are thereby ignored by a particular group or society---are called de minimis risks.''

Page 40, Line 17. The word ''decide'' in the quote from Shlyakhter, Valverde, and Wilson (1995) should be italicized.

40, Lines 19--20. The last sentence is, for the most part, a direct quote from the paper by Shlyakhter, Valverde, and Wilson (1995). The text should be surrounded by quotation marks, and should read as follows: ''Although there is no clear definition of de minimis risk, it can generally be seen to be closely akin to a related concept---the probability of surprise.''

Page 40, Line 21. The text surrounded by quotation marks is from Shlyakhter, Valverde, and Wilson (1995), and the sentence should include a citation for that paper.

Page 41, Line 1. The words ''70 year life'' should be changed to ''30 year life.''

9. Other problems:

The treatment of adaptation is much too narrow. No acknowledgement is made of the adaptation constantly occurring. No attempt is made to show climate change in the context of the broader category of adaptation.

10. Conclusion: Because of these limitations, the chapter is not yet in a form that can be reviewed effectively by experts or governments.

Also: Granger Morgan, listed as a contributing author, notes that he was never consulted about being listed, and insists that his name be removed.

U.S. COMMENTS ON CHAPTER 3: EQUITY AND SOCIAL CONSIDERATIONS

Chapter 3

Conclusions for the Chapter

Introduction to Equity

- Equity has both consequentialist -- flows from outcomes of decisions -- and procedural dimensions.

- Equity issues involved in responding to climate change may be divided into five distinct categories:

  A. distributing the costs of adaptation'
  B. the unequal costs of climatic impacts
  C. distributing future emissions rights;
  D. distributing the costs of abatement;' and
  E. ensuring institutional and procedural fairness

- Equity and social considerations are central to the implementationof climate change response. There are a variety of ethical constructs which influence the positions of participants in climate discussions, and successful efforts to take further steps will require the merging of these different perspectives.

Principal differences among regions and countries

- Five main differences among countries that are important to climate change:
  A. Income and consumption
  B. Emissions - past, present and future
  C. Impacts - the distribution and vulnerability to climate change
  D. Social considerations, institutions, and institutional capability
  E. Endowment of resources that may by affected by responses to climate change.

- Historical emissions have originated mainly in developed countries, but the pattern of emissions is changing, even over the last five years and is expected to continue changing. By the time a doubling of concentrations from pre-industrial levels is reached, the majority of cumulative emissions will have originated in the developing countries.

- There are substantial variations within the "north" and within the "south" in terms of absolute and per-capita ;emissions, the likely impacts of climate change, institutional strengths and preferences, and endowment of natural resources that may be affected by mitigation.

Distributing the costs of coping: impacts, ;risks and international insurance

- Developing countries are expected to have a more difficult time coping with the impacts of climate change because of limited financial resources
- A key question will be how best to share the risks of these impacts. :This has some features of an insurance problem.
- There are three broad kinds of costs that may be incurred in coping with climate change
  A. preparation (or protection) to minimize the potential impacts of climate change
  B. costs arising directly as a result of changes in the resource base and the social costs that may follow from this
  C. costs caused directly by extreme events

Distributing future emissions and abatement costs

- Both efficiency and equity concerns will influence the choice of mitigation and adaptation measures. While a robust literature suggests that in general equity and efficiency cannot be meaningfully separated, it is nevertheless worth while to conduct analysis of the efficiency implications of particular ethical principles, and vice versa.

- Even if there is agreement on the underlying equity principles, major practical differences and dispute may arise because of all the uncertainties surrounding climate change and the effects of response strategies.

- Mitigation options will have differing impacts upon developed and developing countries. Even actions taken in developed countries alone will have impacts on the development patterns of developing countries.

- Because of the global nature of the energy markets, action by the developed countries alone will have virtually no impacts on the rate of climate change.

GENERAL COMMENTS ON CHAPTER

- References to the Framework Convention on Climate Change (FCCC) should be very carefully worded so as to avoid interpreting the Convention on matters for which there are still international differences.

- The document makes frequent reference to the FCCC and in many cases the document offers an interpretation of the Convention is not universally shared by the Parties. The document and the Summary are better served by avoiding the FCCC to the extent possible. Instead they are to report on the state of economic science concerning global change. The section therefore on the equity interpretation of the FCCC should be dropped.

- It is quite noticeable that there are few references before page 58 to any of the literature written during 1994. Also it is imcomplete in presenting literature relevant to the chapters subject. For example, there is some recent literature that can be helpful in addressing some serious omissions. These include the Eyckman et al. (1993) axiomatic approach to establishing equity criteria, the establishment of a stronger philosophical basis for international equity criteria by Kverndokk (unpublished Ph.D. thesis, University of Oslo, 1994), and the recent conceptual and empirical work by Rose and Stevens (1993; 1994).

  Rose and Stevens (1994) set forth ten international equity criteria and translate them into operational rules for assigning tradeable permits among countries . The rules are the basis for establishing a mathematically precise basis for allocating permits or requiring specific post-trading welfare outcomes.
  Also see: Eyckmans, J., S. Proost and E. Schokkaert. 1993. "Efficiency and Distribution in Greenhouse Negotiations," Kyklos 46: 363-397.
  Kverndokk, S. 1994. "Philosophical Bases for International Equity," unpublished Ph.D. Dissertation, University of Oslo, Norway.
  Rose, A., and B. Stevens. 1993. "The Efficiency and Equity of Marketable Permits for CO2 Emissions," Resource and Energy Economics 15: 117-46.
  Rose, A., and B. Stevens. 1994. "Equity Aspects of Marketable Permits for Greenhouse Gases: Global Dimensions of the Coase Theorem, Department of Mineral Economics, The Pennsylvania State University.

- It is important to distinguish between fundamental equity criteria and what has been termed by some as "reference bases". The former refer to general concepts of distributive justice or fairness and the latter to specific measures or indices to which the equity principles can be applied according to the policy issue under examination. It is not surprising that many analysts emphasize the latter. Reference bases are more concrete and less controversial than ethical principles. On the other hand, their equity implications are often ambiguous or not really what is claimed. Examples are population, which is consistent with several conflicting equity criteria and land area, which is at best only weakly related to some criteria. In addition, there are dynamic versions of these reference bases, relating to past (cumulative) and future (development-related) emissions, the damage these cause, and the cost of mitigating them.

  Reference bases have the desirable properties of focal points, a term Schelling coined to represent a key, facilitating feature of negotiation processes. Toman and Burtraw (1991) suggest that "negotiators will seek out rules of thumb ...," but also note that because of strategic considerations, it is unlikely that " ... simple rules of thumb alone can successfully guide the negotiation process." They go on to state: "Thus strategic and procedural aspects of negotiation can be viewed as essential to the evaluation of a commonly shared standard of equity that must accompany an international agreement" (Toman and Burtraw, p. 12). Morrisette and Plantinga (1991; p. 6) have likewise stated: "Success,

however, will depend on how the different stakes of nations can be dealt with in the negotiation process in an equitable manner." Some believe distributional principles need a solid philosophical foundation to be effective. If global warming were an uncomplex issue that could be settled in a short time, we would endorse the more pragmatic "rule of thumb" approach. But as the issue is complex, and negotiations are likely to take years, and to go through several stages, it is imperative to them to have a solid foundation. Countries are more likely to rally around higher ideals under such circumstances, and these equity principles need to be thoroughly articulated, and their full implications understood, before a sound agreement can be reached. See also:
Morrisette, P., and A. Plantinga. 1991. "The Global Warming Issue: Viewpoints of Different Countries," Resources, 103: 2-6. Washington, DC: Resources for the Future.
Toman, M. and D. Burtraw. 1991. "Resolving Equity Issues: Greenhouse Gas Negotiations," Resources 103: 10-13, Washington, DC: Resources for the Future.

The reader is left with the feeling that the problem of equity has not been fully analyzed after completing this chapter. This feeling arises because the perspective taken seems more rooted in fundamental philosophical notions of what is equitable than in the more practical. Thus, while it is perfectly reasonable to examine the views of various philosophers with respect to equity and apply these to the climate change convention, such an approach leaves a number of important issues incompletely analyzed. Three seem particularly evident:

1) The impact various schemes to deal with equity will have on country and individual incentives to deal with climate change.

2) The acceptability of various schemes to the electorates of developed countries.

3) The acceptability of such schemes to the electorates of developing countries.

An additional question associated with these might be the impact of equity schemes on the overall costs of dealing with climate change, since conceptually the lower this cost the easier it should be to deal with 2) and 3) above.

The first of the above considerations is hardly dealt with at all in the chapter. Yet it seems fundamental. If for example responsibilities for dealing with climate change are differentiated among countries in order to achieve equity, but this results in some countries having little or no incentive to deal with the problem, then not only is there danger that the overall proposed solution will not work, but also that sooner or later the scheme will be seen not to be working by those with responsibility and their electorates will repudiate or

ignore their commitments.

It also should be clear that redistribution schemes among countries to achieve a more equitable sharing of the burden of dealing with Climate change forces a direct conflict between items 2) and 3) above. Notwithstanding the feelings of intellectuals in the developed countries, political leaders there will be hard pressed to devote significant shares of national income or wealth to ameliorating the impact of dealing with climate change elsewhere, in development countries. And, similarly, politicians in developing countries will have a difficult time accepting responsibility for dealing with the problem at all if they must devote much national resource to that purpose. These various dilemmas form the core of the equity problem, but are not well developed in the equity chapter. Improvement of the chapter requires not only recognizing the problem in this way, but also possibly suggesting certain that exist in the literature for dealing with it. The following are possibilities:

1) Distinguish responsibility for dealing with climate change from the distribution of the cost for doing so. If all or nearly all countries everywhere do not take responsibility, poor incentive effects are likely to overwhelm proposed solutions.

2) Recognize the political difficulties of imposing costs within a country to reduce impacts on other societies. This problem may imply phasing in any such costs over a longer period of time than otherwise would be the case, and doing so in ways that provide positive feedbacks of one sort or another in the countries doing so.

3) Stress the need to find economically efficient means to deal with climate change in order to minimize the total cost of dealing with the problem.

4) Assuming that cost burdens are to be imposed disproportionately on developed countries but also assuming that electorates in these countries generally are not responsive to developing countries' requests for large scale resource transfers, recognize that a set of readily defensible principles under which climate change help occurs among nations needs to be reached and agreed to by the developed countries. The point is that climate change cannot simply be seen as a convenient excuse for developing countries to seek (additional) resource transfers (which would weaken political support in the developed countries), but rather that such transfers are a sensible and well-justified means to deal with the situation.

SPECIFIC COMMENTS ON CHAPTER 3

PAGES: i, LINES: 2885-6
In general, there is little mention of empirical findings on the subject of equity. Perhaps this is to avoid endorsing any of the various studies or of biasing future negotiations. However, it perpetuates some of the vagueness that has always surrounded the topic. It also undercuts the Chapter 3 authors' statement in the Summary (p. i, lines 2885-6) "... analysis can clarify the implications of alternative choices and their ethical basis." We suggest including a table or tables of empirical findings of a major study or comparing the results of several studies on the implications of alternative criteria in terms of the assignment of emission rights, trades, transfers, and welfare impacts.

Note that much of the previous discussion has referred to the marketable permits approach but applies equally well to equity aspects of a carbon tax given the equivalence of these two policy instruments (see, e.g., Pezzey, 1992). Specifically, the criteria can be used to decide how to redistribute carbon tax revenues across countries (see Rose and Stevens, 1994; pp. 20-22). See also:
Rose, A., and B. Stevens. 1994. "Equity Aspects of Marketable Permits for Greenhouse Gases: Global Dimensions of the Coase Theorem, Department of Mineral Economics, The Pennsylvania State University.

Page: 23, 37, 40
One of the advantages of Rose and Stevens' study is the uniformity of models and data used. Also, the study represents the most extensive empirical estimation to date of the welfare implications of alternative international equity criteria. The results of this study or of any similar study, might be presented in an "Insert" format, as has been done with the WRI data controversy (p. 23), the cost of risk-bearing (p. 37), or insurance (p. 40). See also:
Rose, A., and B. Stevens. 1993. "The Efficiency and Equity of Marketable Permits for CO2 Emissions," Resource and Energy Economics 15: 117-46.
Rose, A., and B. Stevens. 1994. "Equity Aspects of Marketable Permits for Greenhouse Gases: Global Dimensions of the Coase Theorem, Department of Mineral Economics, The Pennsylvania State University.

Pages: i, 34, 48-58
Another matter that the chapter does not address adequately is the difference between criteria applied to allocations of emission rights and criteria applied to welfare outcomes. The authors of Chapter 3 make an important distinction between these on p. i by separately listing as two of the equity issues: 1) distributing future emission rights and 2) distributing the costs of abatement. On p. 34, they generalize the latter to aggregate welfare impacts between countries. Rose and Stevens make similar distinctions between allocation-based criteria and outcome-based criteria. The two categories will differ in terms of implementation, uncertainties, and welfare outcomes. For example, the criteria that are applied to allocating emissions rights may have eventual welfare impacts that are surprising,

unintended, or untenable (see the sovereignty, vertical equity, and egalitarian criteria, respectively, in Table 5 of Rose and Stevens, 1994). Outcome-based criteria pin down the welfare implications, but the initial allocation needed to achieve them may not be readily apparent to many countries. Mistrust or concerns about imperfections in the permits market may undercut the viability of some of these criteria. Again, these distinctions are important, and the authors make a good start at addressing them; however, the distinctions are not carried through very well in the discussion of "Specific emissions allocation proposals" (p. 48-58). See also:

Rose, A., and B. Stevens. 1994. "Equity Aspects of Marketable Permits for Greenhouse Gases: Global Dimensions of the Coase Theorem, Department of Mineral Economics, The Pennsylvania State University.

COLLATED COMMENTS IPCC WORKING GROUP II DRAFT ASSESSMENT

Chapter 4: Intertemporal Equity and Discounting

Lead Reviewer's Overall Summary and Comments for Review Process:

The chapter lays out the central issues of the longstanding discounting debate in economics somewhat independently from the specific program of global climatic changes (GCC). What connections there are to GCC are made strictly from the view of largely deductive economic theories. The chapter attempts to distinguish a "prescriptive" and "descriptive" as a way of introducing a more inductive approach but then seems to reject this view on "ethical" reasons. This is somewhat surprising, since the ethical arguments mentioned are more a matter of praticalities (ensuring future transfers) than they are a genuine consideration of moral obligations (e.g., stewardship).

Of central concern is whether or not the chapter conveys to policy makers what they need to know to make informed choices regarding the discount rate for policy analysis in GCC. I think there are several serious problems here:

I. The chapter fails to consider the more fundamental issue of the nature of the problem. As one reviewer points out, the authors proceed as if all the consequences can be framed as a gradual process of incremental damage. Under these conditions, the problem collapses to a debate over rates that may be of great interest to economists, but I believe will be regarded by policy makers as missing the point. In contrast, another reviewer faults the chapter for treating GCC as a special case. While I am inclined to believe it is, for a number of natural and social scientific reasons, I agree that the authors have not made the case here. The chapter should begin with a clear essay on why GCC is or is not different from any other policy concern. For example, the chapter states that future generations can be compensated for "some" environmental/natural resource effects, but what about the "and not for others" case? This should be followed by a discussion of the significant views of "better off" that would be at the core of alternative normative perspectives for this problem if we were to treat it as a special case. The relationships between Chapter 3 and this chapter should be clarified.

II. The economic perspective should receive special attention, but the authors should carefully delineate normative and positive results. Policy makers will want to know when prescriptions are based on normative models (some of questionable empirical validity), and when they are based on credible scientific evidence. The chapter's distinction between "prescriptive" and "descriptive" approaches is misleading. In fact, both approaches are

prescriptive; however, one is based on a largely deductive methodology while the other is more inductive. Both approaches are often at odds with empirical results in decision making and market behavior in the case of unfamiliar or poorly defined goods (and these major results should be made clear for policy makers). What the authors present as an "emerging consensus" regarding discounting is clearly not one, given the reactions of the reviewers.

III. Very little discussion is devoted to the implications for policy analysis in the real world. As examples, the chapter does not offer insights for sensitivity analysis, scenario development, or alternative treatments of the problem as might follow from specific stabilization policies. Contrary to the tone in the SUMMARY which endorses cost-effectiveness analysis (but not cost-benefit analysis) and a variety of ethical principles for addressing equity, the tone in this chapter emphasizes finding the "correct" rate of discount to decide about alternative policies. The chapter seems determined to make a single recommendation, rather than explicating reasonable alternatives that reflect different normative commitments and preferences. In addition, the chapter should more carefully distinguish the interesting cases of this problem: policy choice, project choice given a policy goal, catastrophic risks, and cooperative and non-cooperative policy strategies.

IV. Key concepts and examples need clarification and editing. Some examples are confusing, key concepts are introduced with little definition, abstract methodological concerns are raised but not explained, and, as currently written, the annex does little to resolve concerns about the normative perspective or its empirical grounding.

To help the authors think about revisions, I have organized all of the general comments under the four categories discussed above. In some cases, I have appended to a comment from a reviewer some additional concerns of my own. The specific comments are ordered by page and line number, but the category concerns are noted there as well.

General Comments on Chapter from Reviewers:

I. Intertemporal Equity

1. The Inappropriateness of Discounting

A. Assuring Climate Change. Since the costs of averting change occur in the present, and the benefits in the perhaps distant future, discounting dramatically devalues the future values associated with it. Ironically, if we assume a smooth warming path with slowly

accumulating net damage (as these authors do for the most part) then the adoption of this framework alone constitutes the decision to do nothing. There is no need for any analysis within it. This assures that the goal stated in the "Summary for Policy Makers" of "stabilization of greenhouse gas concentrations" will never be met. The conclusion is such a short inference away from, and so completely determined by, the (unjustified) assumptions of the method that the whole thing seems silly.

B. Immortal Agents. The authors are quite mistaken to brush aside Tom Schelling's criticism that long term discounting assumes an immortal agent. Surely Schelling is right that there is a world of difference in thinking about my own future consumption and that of others. This difference causes the whole framework used by this chapter to collapse. The authors have conflated issues of allocation with those of distribution. This is completely illegitimate.

C. Time and its Correlates. Further still, the idea of discounting is far more problematical than normally assumed by these authors. As Derek Parfit has argued, discounting typically confuses things that are correlated with time, with time itself. A variety of arguments are offered in support of discounting: risk, opportunity costs, the supposition that future generations will be better off than we are, etc. But in none of these cases, is it time itself that is the key issue. These authors exhibit these confusions in numerous places including pages 9,11 and 17.

D. Time Preference. We would think much more clearly about the future if we used a disaggregated vocabulary rather than starting with the assumption the there is a social discount rate. I think that there are also reasons to doubt that individuals have a rate of time preference; or at least, that it functions in the broad way that economists assume. For example, why must present and future time value be related by an exponential function? Why not some other relationship? What is referred to as time preference needs to be disaggregated in much the same way as "the" social discount rate. See, for example, Rawls' discussion of this subject in A Theory of Justice.

2. Problems with the Point of Departure

A. Distributing Utility. The authors are quite mistaken in thinking that the issue is the distribution of utility. Utilitarianism has been virtually universally rejected by philosophers, but the authors seem

unaware of this literature. Their statement (page four) that their approach derives from a "persuasive axiomatic structure" hovers somewhere between irrelevant and outrageous. They seem uninterested in the questions of whether the system is true or not. Who cares if it is axiomatic or not. The utilitarian project has failed utterly to offer a satisfactory account of moral obligation.

- Utilitarians have been unable to show how to get from the (I believe false) proposition that everyone seeks to maximize their own utility, to the idea that we have a moral duty to maximize the utility of everyone.

- In offering no place for the language of rights (Bentham referred to rights as "nonsense, nonsense on stilts") it authorizes the ruthless exploitation of the minority if we can show a net gain of utility.

- It is infeasible from a motivational point of view in the classical version (greatest happiness of the greatest number) because it requires more altruism than we can reasonably expect people to muster. (Further, it is mathematically impossible to maximize two variables.) The self-interested motivational assumption of the neoclassical school fails for the opposite reason in that it fails to offer any account whatsoever of what we owe one another.

The attempts on the part of modern economics to distance itself from the failure by dropping the language of utility in favor of that of preferences backfires. If preferences are not connected to utility then it is completly mysterious why one should care about them. Incidentally, a utilitarian should consider the preferences of at least some nonhuman animals since many of them can also experience pleasure and pain.

B. Finding a Foundation. Not all goods are, or should be, tradable at the margin. Coase type transactions cannot go all the way down--otherwise we would have to bribe people not to assault us. The way all societies actually function is to block a set of exchanges and then allow Pareto transfers above those constraints. In our society, for example, votes cannot be legally marketed, nor can certain fiduciary goods like national battlefields. C/B analysis sheds no light on which exchanges should be blocked. One might reasonably assume that exchanges that impair the earth's life support systems should be blocked as we have done in the case of ozone depleting chemicals.

3. An alternative point of departure: Trusteeship

The authors seem to misunderstand the trust model (p. 3) in that they imply that it allows for perfect substitution. Here they conflate technical with moral substitutability. The conventional efficiency/equity distinction is dysfunctional because it misunderstands the nature of goods.

A. Problems with the Efficiency/Equity Distinction. In the standard view there are two objectives for policy: efficiency, to be achieved by corrected markets; and equity which is usually not very robust- but is either a constraint on efficiency or is some ways to be traded off against it. There are a number of problems which go way beyond the one normally recognized: that economics doesn't have much to say about equity.

First, the basic distinction does not parse at the joints. The idea is that there are goods traded in corrected markets that yield efficiency makes it sound as if there is only one or two kinds of goods. But Walzer is certainly correct in Spheres of Justice in his observation that goods move in accordance with their meanings as much as with their prices. There are at least four different classes of goods in all societies: 1) those traded in markets; 2)those distributed according to merit--public office, licenses to practice medicine and the like; 3) those distributed according to need--e.g. food stamps; and 4) fiduciary goods which one generation preserves for those who follow. (My argument is that because of its role in the preservation of species and cultures that climate is a good of this kind.) Seen from this perspective the role of public policy is the proper maintenance of these various spheres--not the maximization of utility or consumption in one of them--the market.

Market Preconditions. Once we distinguish between markets and their preconditions the question arises of how should we think about those preconditions. In Restoring the Public Trust I argue that a fiduciary model captures what is at stake with respect to climate change. This grounds, I believe, an obligation to leave the world at least as good as we found it--meaning leaving its productivity and diversity intact.

Because of the role of climate change in species extinction, and as a possible threat to some of world agriculture, I argue that there is an obligation to stabilize climate. Seen from this point of view the role of economic analysis is to be concerned with discovering the most cost effective means of reaching the goal of having GHG emissions and sinks in rough equilibrium.

A. Tractable Morality. There is no obligation to maximize utility or preference satisfaction or anything in that family of ideas. We have a much more

tractable account of our moral obligations. Rather, we can follow Locke in stating our obligations in terms of the preservation of persons: understanding this to mean preserving their lives from external threats, preserving and enhancing their moral and religious choices, and assuring the means to subsistence.

In the trustee conception the fundamental job of the nation states is not to create opulence or to correct for market failures--but to preserve the persons of their citizens now and in the future. An element in this overall obligation is to keep the various kinds of goods discussed above in proper balance.

Other Problems. This chapter also fails to draw on the large literature on intergenerational justice. An excellent compendium by Bayard Catron entitled Ethical Dimensions of Environmental Policy and Decision Making: Risk Management, Intergenerational Equity, and Discounting(Washington, D.C.: NAPA, 1993) would have helped a lot. Beyond this the authors seems unaware of the literature on the nature and unpredictability of ecological change. See, for instance, C.S. Hollings, "A Cross-Scale Morphology, Geometry, and Dynamics of Ecosystems in Ecological Monographs 62(4) 1992, pp. 447-502, esp. pp. 478-485 for a discussion of the inherent unpredictability of the future.

4. Social welfare functions are generally assumed to be an summary of the preferences revealed by a political process, and are used as a convenience in theoretical explorations of the necessary conditions for maximizing some concept of social welfare in which both efficiency and equity matter. When a policy that satisfies the efficiency conditions results in a redistribution of income that is judged to be undesirable (based on some idea of a social welfare function) the consensus approach is to design compensatory programs or transfers that make it possible to achieve both efficiency and equity. This is the Birdsall and Steer recommendation. The "prescriptive" approach abandons any efforts to reconcile efficiency and equity, and recommends policies that leave all generations worse off compared to the welfare they could achieve if efficient climate policies were adopted and intergenerational transfers dealt with through policies affecting savings and investment. Birdsall, N. and Steer, A. Act Now on Global Warming - But Don't Cook the Books, Finance and Development 30 (1), pp. 6-8.

5. The discussion of the chapter on the problem of earmarking revenues for future generations in a Fund for Greenhouse Victims (Page 16, lines 33-35) is both erroneous and irrelevant if the possibility of providing for future generations through capital investment is admitted (Stiglitz). Today's

investment in physical capital increases future productive capacity; no other funding is required to make future generations better off.

Stiglitz, J. E. The Rate of Discount for Cost-Benefit Analysis and the Theory of the Second Best in R. Lind ed. Discounting for Time and Risk in Energy Policy. Resources for the Future, 1982.

6. I have a serious interest in this issue, and found Chapter 4 to be helpful to my own thinking. However, I feel the chapter overstates the merits of the prescriptive approach relative to the merits of the descriptive approach. My comments below elaborate on this point, and suggest some textual changes that would help to redress the balance.

The primary criticism leveled at the descriptive approach is that there is no guarantee that investments we make now will ultimately benefit individuals in future generations who may be harmed by climate change. However, this exaggerates the difficulties of transferring non-environmental capital to those harmed by climate change, and it fails to recognize the difficulties inherent in transferring environmental capital.

Barring an event like the "dark ages," investments which expand the stock of technological knowledge cannot easily be squandered by future generations. Moreover, since the benefits of advancing technology are significantly a public good, it is not plausible that these benefits will somehow fail to help the particular individuals in future generations who may be most harmed by climate change. Likewise, investments in education, particularly of women, seem to produce self-sustaining social change which lowers population pressure, and this too has spillover benefits to all members of future generations. Thus some very important classes of non-environmental investments are likely to have enduring payoffs in future generations, and those payoffs are likely to be available to those who are ultimately harmed by climate change.

Moreover, it should be acknowledged that environmental investments we make to reduce CO2 emissions can be subverted in the future, as long as oil, gas, and coal resources remain available to be used at some future date. Thus today's investment in CO2 emissions reduction may be equally or more at risk of being squandered or "misappropriated" than investment in other kinds of non-environmental capital, particularly education and research.

7. As Chapter 4 acknowledges, the prescriptive approach is fundamentally an ethical position, shared (more or less) by many social scientists who are highly educated and wealthy, at least relative to the people likely to bear

the cost of controlling CO2. If the observed income redistribution policies of the world's governments are grossly inconsistent with the ethical norms of these individuals, it seems to me that the common sense explanation is that most of humanity does not share these ethical norms. The chapter acknowledges that this is possible, but the point is "soft-pedaled," particularly in the summary section where it is not mentioned (even though the critique of the descriptive approach is prominently featured there.)

According to Aaron et al. (1994), these values are affected by affluence. Our future generations, if wealthier and better educated, can be expected to place more value on "respecting and preserving nature and the natural." Will this be handled in the estimates of avoided damages?

Aaron, H.J., Mann, T.E., and Taylor, T (eds), 1994, Values and Public Policy, The Brookings Institution.

8. It seems to me much more work needs to be done on telling the modelers how to design their models so as to answer the questions that are imbedded in the discount rate issue. To the extent that the present is transferring substantial resources to the future, we ought to be able to tell people how much. To the extent that under reasonable assumptions per capita consumption will be greater in the future, again, we should know much greater. In other words we shouldn't bury major ethical decisions in the discount rate.

   In part, this is a result of the lack of connection between Chapter 3 and 4. If the authors want to set aside the major ethical issues then they should explain how decision rules from Chapter 3 will interact with the approaches in Chapter 4.

9. One reason for this is that the preferences of today as expressed by democratic governments, as Chapter 4 notes, differs drastically from the consensus of economists as moral philosophers. We need to give the democratically elected decision makers the information needed to make these decisions, not bury the decision in the choice of a discount rate which reflects our moral judgments which are not those of the public. If we don't do this, our work will become more and more irrelevant.

II. Economic Efficiency and Discounting

1. The chapter is unbalanced in its presentation of the economic theory relevant to choice of discount rates. It is not the consensus of professional economists that the social discount rate should be based on the kind of ethical judgments used in the "prescriptive approach" to justify a discount

rate of 3% or less. What the chapter labels the "descriptive approach" is in fact the mainstream approach to the subject. The chapter should concentrate on the descriptive approach, and give the prescriptive approach only brief mention as a perspective that suggests climate policy should be treated as a special case and based on ethical judgments that have not been embodied in any other economic policy.

2. The chapter fails to provide a justification for choice of a discount rate lower than the before tax return to capital. What Stiglitz, Dreze and Sandmo, Arrow and Kurz and others demonstrate is that when governments cannot use either optimal taxes or make lump-sum intergenerational transfers, the correct discount rate for evaluating public investments may not equal the before-tax return to capital. There are necessary conditions for welfare maximization that must hold among the return to capital, before and after tax rates of return, and the social discount rate. The chapter states correctly (Page 13, Line 2) that with nondistorting taxes and optimal intergenerational transfers, the social discount rate will equal the before tax return to capital. The chapter is incorrect in dismissing this as a special case. These assumptions are the normal starting point for applied welfare economics. The burden of proof should be on those who argue for different assumptions. Moreover, as will be discussed below, alternative assumptions do not lead to any simple characterization of the social discount rate.

3. If existing taxes create significant distortions between the before and after tax returns to investment, a case can be made for choosing a discount rate between the two (as Nordhaus and others suggest) or for converting foregone investment to consumption at the before-tax return to capital. These are necessary conditions for intertemporal efficiency, and hold regardless of the choice of a social welfare function. Choosing the weights to be applied to before- and after-tax rates of return in computing the average requires an explicit analysis of how climate policy affects investment and consumption. The chapter includes no such analysis and therefore has no basis for concluding that the correct discount rate is not the before tax return to capital, as it would be if the costs of climate policy all come from investment.
Nordhaus, W. D. Managing the Global Commons: the Economics of Climate Change. MIT Press, 1994.

4. It is only if governments cannot make intergenerational transfers that choosing a social discount rate different from some weighted average of before and after tax rates of return to capital can be desirable (Stiglitz). But this does not justify an analysis that constructs a social rate of discount from ethical principles, as the prescriptive approach recommends. Instead, the correct theoretical approach (Stiglitz, Arrow and Kurz) is to model

explicitly the constraints presumed to exist on intergenerational transfers, the characteristics of the investment in question, and the relation between climate policy, consumption and investment. As Stiglitz shows, the conclusions that follow about the relation between the social rate of discount and returns to capital (before or after tax) will depend on all these factors, and the social rate of discount may be higher or lower than the before tax return to capital. The conclusions that the chapter reaches on the range of discount rates is not based on any such analysis, and therefore has no foundation.

Stiglitz, J. E. The Rate of Discount for Cost-Benefit Analysis and the Theory of the Second Best in R. Lind ed. Discounting for Time and Risk in Energy Policy. Resources for the Future, 1982.
Arrow, K. J. and M. Kurz. Public Investment, the Rate of Return and Optimum Fiscal Policy. Johns Hopkins University Press, 1970.

5. All of the theory of social discount rates assumes that governments attempt to maximize a social welfare function, but face constraints on tax and transfer policy that make it necessary to choose a social discount rate different from the private return to capital. None of the economic theory of discount rates is based on the assumption that governments are maximizing the wrong social welfare function. This is the assumption on which the prescriptive approach adopts (Page 12, line 32). The prescriptive approach posits a social welfare function different from that which governments are assumed to be maximizing in making economic policy, and then uses it to argue for a low discount rate for climate policies. That entire line of reasoning is illegitimate, and certainly does not represent the consensus view of mainstream economists.

6. The "descriptive" approach, which assumes that the preferences revealed by current policies reflect the social welfare function of the nation in question, is the mainstream approach and should be presented as such. The complexities involved in choosing a discount rate for public investment with constraints on tax policy and distribution can then be discussed in that context.

7. The prescriptive approach is relatively well-explained. However, the descriptive view is not presented very coherently. It points to the relevance of alternative investment opportunities, but does not specify exactly what the discount rate should be.

8. The main area of omission in this chapter is the psychological work on intertemporal choice. This research shows a number of decision biases that

may have policy implications. Below is a reference list of some potentially relevant papers.

Benzion, U., Rapoport, A., and Yagil, J. (1989). Discount rates inferred from decisions: An experimental study. Management Science, 35, 270-284.
Cairns, J.A. (1992). Health, wealth and time preference. Project Appraisal, 7, 31-40.
Cropper, M.L., Ayded, S.K., Portney, P.R. (1994). Preferences for life saving programs: How the public discounts time and age. Journal of Risk and Uncertainty, 8, 243-265.
Ganiats, T.G. (1994). Discounting in cost-effectiveness research. Medical Decision Making, 14, 298-300.
Keeler, E.G. & Cretin, S. (1983). Discounting of life-saving and other non-monetary effects. Management Science, 29, 300-306.
Lipscomb, J. (1989). Time preferences for health in cost-effectiveness analysis. Medical Care, 27, s233-s253.
Loewenstein, G. (1987). Anticipation and the valuation of delayed consumption. Economic Journal, 97, 666-684.
Loewenstein, G. (1988). Frames of mind in intertemporal choice. Management Science, 34, 200-214.
Loewenstein, G. & Prelec, D. (1992). Anomalies in intertemporal choice: Evidence and interpretation. Quarterly Journal of Economics, 107, 573-597.
Loewenstein, G. & Thaler, R.H. (1989). Anomalies: Intertemporal choice. Journal of Economic Perspectives, 3, 181-193.
Olsen, J.A. (1993). On what basis should health be discounted? Journal of Health Economics, 12, 39-53.
Prelec, D. & Loewenstein, G. (1991). Decision making over time and under uncertainty: A common approach. Management Science, 37, 770-786.
Redelmeier, D.A. & Heller, D.N. (1993). Time preferences in medical decision making and cost-effectiveness analysis. Medical Decision Making, 13, 212-217.
Redelmeier, D.A., Heller, D.N., & Weinstein, M.C. (1994). Time preference in medical economics: Science or religion? Medical Decision Making, 14, 301-303.
Shelley, M.K. (1993). Outcome signs, question frames, and discount rates. Management Science, 39, 806-815.
Shelley, M.K. (1994). Gain/loss asymmetry in risky intertemporal choice. Organizational Behavior and Human Decision Processes, 59, 124-159.
Thaler, R.H. (1981). Some empirical evidence on dynamic inconsistency. Economic Letters, 8, 201-207.
An important issue to resolve for policy makers: How is it we can seriously challenge decision making for unfamiliar goods and not "choices?" In addition, what do these studies indicate about framing the "time horizon?"

9. This seems to me to be the next step in the process of creating the models and analysis that will help us perform a systematic economic analysis of climate change policies.

10. The chapter exhibits two strong biases of the authors: (1) the "proper" discount rate is the social rate of time preference (SRTP) and (2) the component of the SRTP corresponding to the pure rate of time preference should be set equal to zero. These positions do not represent the consensus of the economics profession and the chapter should be revised to provide greater balance in the treatment of different approaches to discounting.

11. The formulation of the SRTP as the sum of the pure rate of time preference and an adjustment for changes in the marginal utility of consumption due to per capita consumption growth is presented as if this is a general result that is value free. It is described as "the fundamental equation for the discount rate of consumption," (page 6, line 44).

    This treatment obscures normative assumptions that underlie the derivation of the SRTP. For example, the derivation is dependent upon acceptance of assumptions about "welfarism," (the concept that social welfare is a function of only the welfare of individuals), the comparability of welfare across individuals, and a specific class of social welfare functions. The underlying social welfare function assumes that social welfare in time t is reducible to per capita consumption in time t and is independent of the distribution of consumption among individuals in time t. Individuals living in different periods enter the social welfare function identically with the exception of a discount factor for pure time preference that varies as a function of distance from the present. These normative assumptions yield a SRTP that varies with per capita consumption growth, adjusted by the marginal utility of consumption, but not, for example, changes in the variation of consumption across individuals.

    The assumptions may be reasonable approaches to simplifying the problem intertemporal optimization and discussion of them may not be necessary when writing for professional economists. But the audience of the WGIII report will include non-economists. For these readers, it is important to make the normative underpinnings of the SRTP explicit and discuss what they imply about intergenerational and intragenerational equity.

12. This chapter has improved over earlier versions, but still could use some work. One general suggestion would be to have the chapter consider efficiency on a level more comparable to the current emphasis on equity. For example, shouldn't efficiency be in the chapter title and receive more attention in the summary? Also, there could be some additional explicit

discussion of what efficiency means in the intergenerational context; the standard view that efficiency is a less controversial criterion than equity has some merit for this application.

III. Implications for Policy Analysis

1. I believe that the Chapter is an excellent survey of the issues and literature on discounting and intergenerational equity. It falls short of giving the modelers who are trying to evaluate alternative policies any specific guidance. I suggest an approach to this shortcoming. I also feel too little has been said about sequential analysis of options and particularly the option of waiting.

2. However, if I were one of the two or three dozen researchers developing integrated assessment models, I probably would feel let down that I wasn't told which rate I should use in my model, or more importantly, how I might modify my model or use it to answer the questions regarding efficiency and intergenerational equity that are addressed in Chapter 4.

3. Let me suggest an approach, although time and space preclude a complete analysis of this issue which should be the next project for research on discounting and global climate change. I believe the key to the answer lies on the discussion on pp. 13-14. There are two key rates: (1) the rate at which we discount consumption and (2) the marginal rate of return on investments that are alternatives to investments in climate change abatement. I suggest that we keep these two rates separate in our models for the purpose of clarity. For example, in integrated models that explicitly model economic growth, one would use the rate of return on alternative investment in determining the growth path and consumption path if the proposed investment in climate change were instead invested in the economy. Consumption over time would then be discounted to its present value using a rate reflecting the SRTP. This would then become the baseline against which global climate policies would be compared.

   This seems to be what the chapter is suggesting, but it is somewhat hidden by all the other arguments.

4. This approach is very similar to the shadow price of capital approach, however, by disaggregating the analysis, it forces us to specify and debate what the alternatives to investment in climate control are and what rates of return could be earned. It forces us to look at consumption rather than GNP. We can debate and vary the SRTP of discount separately. In short, it helps us keep straight the myriad of issues that are involved and doesn't bury them in a single discount rate.

For example, Cline gets a discount rate of 2% - 3% (p. 14) by assuming that 80% of cost comes at the expense of consumption and 20% at the expense of investment. Such an assumption might have followed from the assumption that the money was raised by taxation and the marginal propensity to consume was .8. The problem with this analysis is that the government could have invested it in other public projects. The problem with most second-best lines of analysis is that we don't properly account for the opportunity cost and the approach suggested above would force us to do that.

5. Finally, we need to look more carefully at sequential approaches to this problem. The sequence we should follow is not necessarily act, learn, act. The optimal sequence, given the uncertainty we act may be to wait, learn, wait, learn, maybe act. Given the feasible size of budgets that will be devoted to this problem, gathering information and developing the technologies for the future may be our best option.

6. Economists know something about how individuals and companies trade off current and future cash or consumption. We know much less about how people trade off their consumption for the consumption of their descendants -- or don't like the answer we observe in such behaviors as national finances. We have even less to say about how people trade off their consumption relative to the consumption of future generations in other countries -- or don't like the answer at all, as demonstrated by the abhorrence of the American electorate for foreign aid. Can this meaningfully be expressed as a discounting problem at all? Schelling's argument that after a certain point future generations run together has some real common sense to it. Furthermore, much of the benefit that takes place far in the future cannot reasonably be estimated anyway, because it involves health and eco-system effects which are not well-defined and whose valuation is uncertain and controversial. This suggests that a multi-criteria approach to the problem is more suitable. However, this risks painting the problem as one of fundamental values of current generations about their stewardship responsibility over the planet and its future inhabitants, and thus losing the sense that these are small benefits far in the future.

7. These are topics of greater than average difficulty. Consideration should be given to organizing the chapter along the following lines:

   - Economics provides no clear answers to many of the issues raised by discounting in this situation. There are strongly held opinions on all sides of the question.

- The use of multi-criteria analysis provides an alternative to trying to discount the future benefits of current climate change mitigation strategies, although multi-criteria analysis is not without its own drawbacks.

- There is a strong philosophical following for the use of low social discount rates for discounting future consumption, and a strong practical following for the use of rates nearer market levels. Trying to value the effects of foregone investment on future consumption is complex and possibly subject to manipulation. It is hard to justify lower discount rates for this particular type of social investment than for the many other types of investment that are currently made. Faced with this dilemma, some analysts have chosen compromise rates between these positions. An alternative is the use of multiple discount rates by analysts. The implications of this approach, with all results provided to other analysts and policy makers, might usefully be addressed in this chapter.

8. Firms and Planets. The authors conflate the use of a perfectly usable framework about decisions within a firm or public agency with a program of planetary management. We need to distinguish between the means to achieve efficiency through markets or their surrogates, and the things that make markets possible--their preconditions. In "The Cultural Contradictions of Capitalism" Daniel Bell argues convincingly, to me at least, that capitalism depends on certain virtues (e.g. thrift, hard work etc.) that it tends to erode. Surely the earth's basic systems such as climate are candidates for being among market preconditions, and are being disequilibrated by unconstrained markets.

9. GNP a Mismeasure of Man. The problems with the GNP (p. 21) measure are far more extensive than even the literature on its defects (e.g., corrections for capital depletion, defensive expenditures and the like) recognizes. None of these revisions deals with the underlying problem that it embodies far too narrow a conception of human well-being to begin with, because it focuses too much on consumption. A much more promising way of thinking is being developed by Nussbaum and Sen entitled the capability approach. see, for instance, The Quality of Life. They argue that there a generic set of capabilities that define the good life, and that consumption is instrumental to only some of them. This grounds Sen's claim that development as normally understood is a result of conceptual and moral failures.

IV. Editing and Clarification

All but one of these points are noted in the specific comments on the chapter.

1. My comments will likely point out which parts of this chapter are unclear to a non-economist. This chapter sometimes provided clear explanations of relevant concepts and other times used cryptic economics shorthand that I was not able to follow. In my specific comments below, I try to point out which sections were which.

Specific Comments on Chapter

Page ii, Summary, Lines 3-7.
The recognition that this is a philosophical and ethical question as well as an economic one is appropriate and important. However, this also means that there can be no one right answer to the discount rate question; rather there is a range of advice based on different prescriptive and descriptive considerations. To communicate to policy makers the necessary absence of a definitive answer to this question is important in an assessment of economic knowledge as applied to the climate change question.

Page ii, line 20.
How accepted in Brown-Weiss's argument? My sense is that it is not supported by any treaty. Rather it is more an ethical norm. Does terming it an international legal principle give it more weight than other philosophical criteria (e.g., Rawls's difference principle or Nozick's theory of rights)?

Page ii, Summary, Lines 31-32.
"Identifying the proper discount rate is probably the single most important analytical step in economic analysis of climate change."
Consistent with the comment above, the phrasing should be changed to, "The choice of discount rate ..." to avoid the implication of a single "proper" answer.

Page ii, line 32.
The chapter does not explicitly recommend sensitivity analysis, despite the wide range of rates that can be justified. Shouldn't sensitivity analysis be recommended? If so, what would the recommendation be -- perhaps use of social rates of time preference of 2 to 4 percent with commensurate shadow prices of capital? If so, the shadow price of capital (SPC) -- or a range for this measure -- should be suggested. Higher discount rates should be considered in the case where no adjustment is made for the SPC (e.g., 2 to 8 percent).

Page ii, lines 32-34.
The intragenerational equity questions are no less profound than the intergenerational equity questions. Greenhouse gas stabilization objectives may require substantial abatement by some of the poorest countries in the world. Some of the benefits of this abatement will accrue to the wealthy. Vulnerability to climate change may be greatest in the poorer countries. Questions about how to share the costs of abatement and distribute climate change damages are no easier to resolve than those regarding the intertemporal questions.

This should be handled by a clearer sense of the relationship between Chapters 3 and 4.

Page iii, lines 28-32.
The authors argue that the proceeds of market investments are not likely to be set aside to compensate those adversely affected by climate change. The implication is that market rates of interest, or opportunity cost of capital, are inappropriate for discounting future benefits of climate investments. The argument is not convincing.
While investment proceeds are unlikely to be set aside directly for the exclusive use of future climate change victims, market investments will benefit individuals in the future, even the distant future. The opportunity cost of climate investments include foregone investments that would augment human and physical capital. Augmentations to the stock of human and physical capital will expand capacity to produce consumption goods in the future, thereby benefiting future generations. In fact, the industrial age has witnessed an extraordinary increase in wealth and living standards as one generation inherits capital from the previous generation and leaves a larger stock of capital to the following generation. Also note that, although little physical capital from the dawn of the industrial age has survived to the present, no one can doubt that investments made at that time yielded benefits that still enrich us today, two centuries later. These benefits accrue to us today even though no one thought to earmark and reserve them for the end of the 20th century.

Given the history of the creation of wealth over the past 200 years, it is puzzling that the authors cavalierly dismiss the possibility of adding to the wealth of future generations through investment in any projects but those that mitigate climate change. If this hypothesized inability to benefit the future by current investment is the sole argument against use of the opportunity cost of capital as the discount rate, then this criticism does not seem to be fatal. Use of the opportunity cost of capital as the discount rate would seem to be a defensible position. The chapter, which gives far to little attention to the opportunity cost of capital approach, should be revised to correct this deficiency.
However, we should be carefully to think about our assumptions regarding the motives of past generations and their sense of moral obligation to us.

Page iii, Summary.
Drop this sentence. Since the critique of the prescriptive approach is not mentioned here, and that of the descriptive approach is not well thought out, the easiest way to achieve balance in the summary is to drop the critique of the descriptive approach here.

Page iii, Summary, Lines 30-32.
"... society is not likely to be able to set aside investments over the next three centuries and earmark the proceeds [to] the eventual compensation of those adversely affected."

The authors of this chapter should be complemented for their effort to include views of the discount rate, such as those held by Schelling and Nordhaus, which are different than their own. However, this summary gives rather short shrift to the "descriptive" approach. In particular, the implication that society needs to set funds aside, as in a trust fund, earmarked for eventual compensation of greenhouse victims seems extreme. So long as funds are invested productively, they will be available to future generations. Incremental economic growth provides the resources for future compensation of any victims. Compensation is really a redistribution problem for future generations, which cannot and should not be solved now.

Page 1, line 14.
Why is the alternative chapter title posited? If efficiency is an important consideration in discounting -- and it surely is -- then it should be mentioned in the actual title and should get adequate treatment in the chapter.

Page 2, line 11.
The flip side of the collapse of future values due to discounting is that very small displaced investments can lead to very large future shortfalls in output.

Page 2, Lines 28-34.
This generalized egalitarianism seems to have to do with transferring wealth from the rich to the poor (utilitarianism) and seems logically unrelated to intertemporal or inter-generational trade-offs. It just so happens that future generations are expected to be wealthier than the present generation.

Doesn't this assumption need to be considered in constructing our scenarios of the future?

Page 2, line 38.
The implication that markets do not effectively allocate goods over time (and particularly over generations) is controversial. It affects more than global warming policy, and raises significant questions about national savings policy and

use of exhaustible resources. I do not think that there is, in fact, a consensus among economists that market interest rates are generally incorrect guides to behaviors in those settings.

Page 2, Lines 40-44.
How, exactly, are inter-generational trade-offs for environmental goods different from those for private consumption goods? Converting environmental goods to their equivalent in private consumption goods would seem to ensure that these two types are trade-offs are treated equivalently, not differently.

Page 3, Line 8.
What is the "incremental component" of the discount rate? Is this the idea that risks compound over time? If so, why would we not want this aspect incorporated into the discount rate?

Page 3, Line 13.
How can certainty equivalents be used to treat issues of equity?

Page 3, line 21.
The compensation problem deserves some discussion; it is relevant for any discount rate.

Page 3, line 33.
See comment for p. ii, line 20. p. 3, last line. Why "must" discussions of intergenerational equity go beyond sustainability? Brown-Weiss, for example, implies that sustainability is a "legal" (though perhaps more accurately, "a plausible ethical") obligation that generations face. What evidence is there of a consensus that governments should be allowed to make poorer generations suffer so long as richer generations gain sufficiently? Arguably this view is controversial, yet it is implicit in the utilitarian framework that drives the equity analysis in this chapter. While this framework is important and merits exploring, it should be made clear that this is not the only possible framework. It should also be explained to policy makers that despite the technical content of this discussion, the material covered is quite normative, and that while economists have expertise in analyzing these norms, they are not in a position to determine them for society.

Page 4, Lines 10-19.
Contrast between utilitarianism and min-max is well summarized.

Page 4, Lines 21-35.
Re Schelling's dissenting opinion. Distributional considerations can be incorporated into utilitarianism. Distributions affect individual utility by way of perceptions of fairness and emotions such as envy. (see also page 5, lines 9-18).

Page 4, box.
The discussion of Schelling's view is too abstract to be useful to policy makers. Regarding the conclusion in the box, it is not obvious that the analysis presented in the chapter --which, in effect, suggests consumption transfers across generations to help equate marginal utility -- is appropriate in a world where richer nations make only modest transfers to poorer ones.

Page 5, line 12.
The sentence on Thurow's paper should probably be moved later in the paragraph.

Page 5, Lines 20-26.
If environmental outcomes are not discounted, but other outcomes (e.g., financial ones) are, certain inconsistencies will result, such as preference reversals (see Keeler & Cretin, 1983).

This is certainly a consequence of "special treatment" that should be pointed out to policy makers.

Page 5, line 30.
The discussion in the prior section is also prescriptive.

Page 5, Lines 37-44.
(See above comment.) Would not the answer to these three questions be the same, because of the inconsistencies that result from using different discount rates for different outcomes?

Page 6.
The five points put forward on this page are clearly stated and well-argued.

Page 6, Lines 7-10.
Why is this argument limited to benefits accruing to the same generation? The whole idea of utilitarianism is that utility can be traded-off across people.

Page 6, line 38.
Should add the following sentence to this paragraph: "However, given appropriate estimates of relative prices, there is no reason to explicitly modify the discount rate."

Page 7, line 3.
The social welfare function and related relationships used to derive this equation should be stated explicitly. This is the most important equation in the chapter, but it is not clearly derived for readers. A reference to the annex and a full presentation there would be useful.

Page 7, Lines 8-14.
Throughout the chapter I was unclear about the relationship between the SRTP and the market interest rate. Is SRTP meant to express discounting above and beyond discounting because of investment opportunities? Investment opportunities (leading to a particular market interest rate) presumably exist because of economic growth, g. So why is g so much smaller than current interest rates? (see also page 12, line 38- page 13 line 8).

Page 7, Lines 20-24.
"If the project displaces private investment that has a high marginal productivity... The prescriptive view takes into account opportunity costs in calculating changes in consumption, but in valuing the changes in consumption, uses the SRTP."

I believe that what is being said is that, where mitigation projects displace other investment, future consumption must be reduced by the consumption that the displaced investment projects would have generated. It is net consumption that is to be discounted with the social rate of time preference. This appears to be a compromise between using low social discount rates throughout the analysis and using the opportunity cost of capital throughout the analysis. However, I am not clear what one does in practice, and I am concerned that the discounting method suggested will be both confusing and subject to manipulation. Any investment can be argued to displace some other investment that would generate (at least) the opportunity cost of capital. And that investment will yield returns, some of which will then be re-invested. The suggested procedure may be better in concept than in practice. If this procedure is to be proposed, I suggest that specific examples are required to clarify the method.

Page 7, Line 44.
This is the only reference to the work by Loewenstein and others on decision biases in intertemporal choice. In addition to the common difference effect cited here (lower discount rates for longer delays), descriptively, discount rates are lower for large magnitudes, for losses compared to gains, and for sequences of outcomes, compared to individual outcomes. Finally, temporal discount rates expressed in decision expressed in decision-making experiments are typically 50% annually or more, much higher than those discussed in this chapter. What implications to these findings have for potential climate change policies and the success of their implementation? One implication might be that because many people have personal discount rates much higher than those suggested in this chapter, they would be uncooperative with the resulting policies (e.g., unwilling to make present sacrifices for future benefits). I do not know of psychological work looking at inter-generational decisions, however (but see Lipscomb, 1989).

Page 8.
As stated elsewhere in this chapter, shouldn't risks, such as the small change of human extinction, be incorporated into a certainty equivalent, which would then be discounted?

Page 9, line 19.
The finding that the optimization problem is not well defined should be explained somewhat more.

Page 9, Lines 24-35.
I don't understand why these knife-edge results occur.

Page 10, Line 9.
I don't view this as a "problem" with utilitarianism. The normative status of utilitarianism is independent of descriptive behavior (such as the unwillingness of people to make large sacrifices to benefit future generations.)

Page 10, Lines 38-41.
I think this idea is a bias. If I discount outcomes from generation 1 to generation 2 much more than from generation 101 to generation 102, I am not exhibiting constant discounting. Although someone in generation 1 may view a benefit delivered to generation 101 as equivalent to the same benefit delivered to generation 102, someone in generation 101 would not have the same view. This example illustrates the preference reversals that result from non-constant discounting.

This comment about the empathetic distance suggests the need to clarify how the discounting is grounded in a particular time period. Also, other social science research shows that there are markedly different cultural views on concepts of time that affect behavior.

Page 11, line 22.
Insert "absolute value of" before "elasticity".

Page 11, line 26.
Are the low rates of productivity a U.S. phenomenon or a world phenomenon?

Page 11, line 38.
See comment for p. 11, line 22.

Page 12, Lines 11-12.
This statement does not seem right. A very high theta (say 50) would imply that I require an incredibly high rise in the next generation's per capita consumption before I would agree to a small decrease in my own generation's consumption--not

very equitable. Instead, higher values of theta seem to imply more selfishness, lower values imply altruism, and some intermediate values imply equity.

Page 12, line 11.
What is meant by "The more weight the society gives to intergenerational equity"? There are all kinds of equity criteria, each with different values of Q. One view of equity would be very protective of worse-off generations; another might be less so.

Page 12, line 27.
While there are a number of equity reasons to intervene to help the very poor, the idea that government should generally fine-tune the income distribution is less clear. At some point government intervention can cause inefficiencies and can run into other equity problems, such as those associated with confiscation.

Page 12, line 40.
Should "even" be "particularly"?

Page 13, Lines 12-17.
Where do these specific discount rate values come from?

Page 14, line 13.
Shouldn't one state that based on "certain" ethical grounds, it is tough to support the higher time preference rate?

Page 14, Line 15.
What is OECD?

Page 15, line 30.
Replace "most plausible discount rates" with "discount rates below 10 percent".

The presentation of the example does not follow the methods advocated by the chapter. The authors should carefully construct an example that demostrates the various discounting approaches discussed in the chapter, including all of their steps. For example, when $1M is removed to pay for the project, you have argued that the displaced investment is accounted for in the stream of consumption benefits, but this is not demonstrated in the example.

Page 16, line 9.
The estimate of a 15.1 percent real return to nonresidential capital over the period 1975-90 seems very high. The estimates should be properly attributed to their respective authors.

Page 16, line 33.
Wouldn't general economic growth address a large share of the damages from warming? Moreover, compensation of future parties that lose from particular policy choices is difficult regardless of the discount rate chosen.

Page 16, Lines 33-35.
Replace the last two sentences with the following:
"Society may not be willing to make other investments, for example in education and research, which could reasonably be expected to benefit those adversely affected by climate change, even hundreds of years in the future. Even if society were willing to make such investments, there is no guarantee that their rate of return would remain where it is today over this entire time period."

Page 17, line 1.
The existence of multiple market failures is a classic problem of the second best. It is not obvious whether piecemeal fixes would make things better or worse.

Page 17, line 19.
Footnote 3 is unclear. Risk aversion (declining marginal utility) is supported by data, for example.

I agree it's not clear what the authors are saying about data. Also, what about the data that shows risk loving over losses? Is GCC a problem of losses or gains? I also found footnote 2 unclear. Does "G" refer to the public good? If so, it's not defined until 7 pages after the endnote shows up.

Page 18, line 17.
If there is no intertemporal welfare maximization by the government, then how can one assert that market rates are necessarily wrong? Couldn't the lack of intervention be viewed as an endorsement of market rates?

Page 18, Lines 21-30.
I don't follow this explanation of what a shadow price is.

Page 18, line 29.
The work presented by Lyon at the IPCC meetings shows that a shadow price of capital of 1.5 to 2 may be quite low, given the rates of time preference assumed by Cline and others. For example, with no reinvestment of capital income (except for coverage of depreciation), a rate of time preference of 2 percent, and a return to capital of 8 percent, the SPC will be 4.0. If 10 percent of net returns to capital are reinvested, the SPC rises to 6; and if 20 percent of net returns are reinvested, the SPC rises to 16. Moreover, if the rate of time preference is 1.5 percent -- as is argued at times in chapter 4 -- then the SPC under the last set of assumptions would be infinite. (Note that the total weight on costs will be below

these values, as only the portion of costs coming from investment gets weighted by the SPC.)

Page 19, line 1.
The relationship of the discussion in this paragraph to the shadow price of capital approach is unclear.

Page 23, line 24.
This derivation of the discount rate could be explained a bit more. Equation 4A.1 should be maximized, and the relationship of the interest rate to this equation should be explained.

Page 24, line 4.
Again, intergenerational equity can be far more complex than determination of Q. See comment for p. 12, line 11.

Page 25, line 20.
Again, the discount rate would not be negative if prices are appropriately adjusted. See comment for p. 6, line 38.

Page 25, line 23.
The relationship of the Sandmo-Dreze approach to the SPC approach is unclear.

Page 27, line 17.
Should the statement refer to G=U or G not equal to U?

Items to Be Included in Chapter 5 Summary:

- An analysis of costs and benefits offers a useful framework for organizing information about the consequences of alternative actions for addressing the climate change problem.

- Traditional cost-benefit analysis developed originally for project-level decision making with 20-30 year planning horizons is being used in a more broadly defined context to deal with climate change.

- Cost-benefit analysis employs a variety of techniques to address issues important to climate, such as:

    --risk, uncertainty, and irreversibility;
    -- valuation of non-market benefits and costs; and
    -- discounting, particularly over long time horizons.

- In addition to cost-benefit analysis, other techniques have been developed to respond to limitations in analyzing certain resource problems. These techniques include cost-effectiveness and multi-criteria analysis. Another class of frameworks includes decision analysis.

- However, in the application of cost-benefit analysis to the problem of climate change, there are important difficulties because of the global, regional and intergenerational nature of the problem.

    -- Information on the consequences of climate change and actions to address climate change is limited.

    -- Valuation of consequences is a central feature of cost-benefit analysis, but confidence in valuation estimates for many important consequences is low.

    -- For some categories of ecological, cultural and human health impacts, economic concepts of value may not be widely accepted as appropriate.

    -- Actions to address climate change will likely result in net benefits for some individuals, regions, nations, and generations while generating net costs for others. There is no widely accepted decision criterion for selecting a course of action based upon the costs and benefits of alternative actions in such a case.

US GOVERNMENT COMMENTS
CHAPTER 6: THE SOCIAL COSTS OF CLIMATE CHANGE

General Comments

1. The chapter provides a competent and extensive coverage of much of the literature on the social costs of climate change. We are disturbed, however, by the lack of balance in the assessment of the literature. The chapter draws the conclusion that an equivalent doubling of carbon dioxide will result in global net damages of 1.5% to 2.5% of gross world product. It is stated that damages are uncertain, but it is asserted that the uncertainty implies that the above estimates are likely to underestimate damages. The chapter also draws the conclusion that a central estimate of regional damages range from 2% to 9% and that damages for individual countries could be even higher.

   These conclusions are not representative of the full range of results found in the published literature. Some of the research on the social costs of climate change have estimated that the effects of an equivalent doubling of carbon dioxide may result in slight damages or even net benefits for important categories of impacts. The methods and results of these studies are credible and reflect a valid scientific viewpoint. The chapter authors give insufficient weight to results that are consistent with this viewpoint. In doing so, the chapter authors' assessment of the literature gives the erroneous impression that there is general agreement that an equivalent doubling of carbon dioxide is highly likely to result in substantial damages at global and regional scales.

   We believe that a more accurate and balanced assessment of the literature would indicate that economists and social scientists just don't know how severe the impacts of climate change are likely to be from the perspective of human welfare. Part of this uncertainty derives from uncertainty regarding how the climate may change and how changes in climate may affect physical and biological systems. Part of the uncertainty derives from uncertainty about how the changes may influence the production and consumption of market and non-market goods and services of value to humans, how individuals and societies may adapt in response to these changes, and how the combined effects of changes in the physical world and adaptation may influence human welfare.

   We urge that the chapter authors revise the chapter so as to provide a more balanced treatment that emphasizes the limitations of economic science for providing credible estimates of climate change damages and the wide range of results that have been obtained. Within this context, we think it appropriate that the chapter indicate that the range of results indicates that substantial damages are plausible outcomes of an equivalent doubling of carbon dioxide in the atmosphere. It is also appropriate to reiterate in the chapter that uncertainty about the severity of effects of climate change on human welfare is not sufficient by itself to justify a conclusion that measures to constrain greenhouse gas emissions are unwarranted. Reducing the risk of possibly

severe damages is a compelling motivation that should be integral to the process of forming strategies to address the climate change problem. This is an important message of the entire Working Group III report that is raised in a number of chapters. We are concerned that an imbalanced treatment of the literature on social costs of climate change that draws stronger conclusions than can be supported by the literature will detract from this important message.

2. The chapter attempts to summarize the literature on climate change damages by providing best guesses of global and regional damages. Because of the lack of consensus discussed in the comment above, we urge that the IPCC Working Group III report not endorse any estimates as representing best estimates of climate change damages. Damage estimates are highly sensitive to a host of highly uncertain assumptions and researchers have widely varying views on the likelihood or plausibility of different sets of assumptions. The current state of knowledge makes it difficult to assess the validity of these assumptions. Given these limitations, identifying any estimates of damages as best estimates will give a false sense that we know more than we do about climate change damages.

   We suggest that the authors characterize reported damages as illustrative of the approximate magnitude of damages that are consistent with particular sets of assumptions, assumptions whose validity may be controversial and difficult to evaluate. At this time, none of the published estimates of damages should be interpreted as the expected value of damages, nor as lower or upper bounds of the range of potential damages.

3. The chapter does not provide a systematic explanation of what factors are thought to be most responsible for differences in damage estimates. Given the wide range of results obtained by different studies and within studies for different scenarios, it would be valuable to provide greater discussion of the factors that are thought to account for the differences. For example, damage estimates may differ due to differences in the climate scenarios analyzed, differences in scenarios of physical and biological system impacts, and differences in the modeling of adaptation behavior. The chapter includes comments addressing these issues, but the lack of a systematic discussion makes it difficult for the reader to understand what are the critical differences across and within studies that shape the results.

4. The treatment of damages that might arise from climate change impacts on natural ecosystems, species abundance, and species survival is relatively weak. The discussion is overly focused on the few monetary damage estimates that have been made for narrow aspects of this category of damages. This orientation fails to adequately emphasize the view that these damages are possibly the most important unknown in the equation of climate change damages.

   We suggest that the chapter be revised to incorporate an overview discussion of the

potential character and magnitude of ecosystem changes, drawing upon the draft assessment of Working Group II, and a qualitative discussion of the ways in which these changes could influence human welfare. The discussion should emphasize the difficulties and controversies about estimating the value of changes in ecosystems, species abundance, and species diversity in monetary terms. The discussion should also discuss the opportunities, or lack of, for adaptations that might limit ecological damages.

5. Many of the studies of damages from an equivalent doubling of carbon dioxide in the atmosphere are dated and are based upon climate scenarios that project substantially greater warming than current best estimates. In addition, the studies are based upon scenarios of physical and biological system impacts of climate change that do not include the most recent evidence. In some cases, the assumptions incorporated into analyses of damages are inconsistent with the draft assessment of Working Group II.

The problem regarding changes in climate science is specifically addressed in section 6.1.8. It should be highlighted in the chapter summary. It should also be highlighted in the text when specific damage estimates are discussed. This is done to some extent, but needs to be done consistently. The discussion in section 6.1.8 draws the conclusion that recent changes in climate science have only minor implications for estimates of damages, but this conclusion is not supported by citations of published research that have addressed this question. We suggest that the discussion be revised to remove such conclusions unless the authors can offer stronger support than is present in the document. We also suggest that the section include a discussion of the difficulties inherent in interpolating damage estimates from scenarios of 4 to 5 degrees mean warming to derive estimates of damages for lesser warming. Research for some damage categories suggest very non-linear relations between damages and mean warming. For example, agriculture may benefit from modest warming but suffer after some unknown threshold is surpassed.

The problem regarding evolving evidence of potential climate change impacts on physical and biological systems is not addressed in the chapter and needs to be. An important example is new evidence that suggests forests in many parts of the world may benefit from climate change and elevated carbon dioxide levels. The new evidence is not conclusive, but chapter 6 provides no indication that there is uncertainty about the direction of forest impacts. The authors face a difficult task in attempting to provide the most current assessment of the literature possible. The chapter authors clearly cannot incorporate all the recent literature relevant to the chapter. But it would be useful to incorporate a brief treatment of important new evidence on physical and biological system impacts, similar to what is done in section 6.1.8 regarding changes in climate science. In addition, where specific damage estimates are discussed, mention should be made of new evidence that conflicts with assumptions made regarding physical and biological evidence.

6. The distinction made between estimates of the damages of an equivalent doubling of carbon dioxide and the benefits of greenhouse mitigation policies that would not avoid all damages needs to be stated earlier in the chapter and more prominently. The distinction should also be made in the chapter summary. The distinction is an important one that needs to be highlighted for the reader. Note also that the chapter title is misleading and suggests that the benefits of control are the topic of the chapter.

7. The chapter strays into a number of areas that are peripheral to the topic of the chapter and which are covered, or should be covered, by other chapters. In a number of instances the discussions tend to prescribe normative values or policy positions (e.g. sustainability and equity). Discussion of the topics should be limited to a brief statement of their relevance to the chapter and a reference to other parts of the report where more detailed treatment can be found. The peripheral topics include:

   Sustainability approach: The discussion of different frameworks or approaches for considering the climate change problem is the topic of Chapter 2.

   Equity: Equity is the topic of Chapter 3. The discussion in Chapter 6 of how damage estimates might be adjusted to reflect equity concerns is overly long and detailed. Chapter 6 should limit discussion of equity to comments indicating that measuring and aggregating welfare changes raise important equity issues, that methods exist for incorporating equity concerns in damage estimates, but that equity adjustments are controversial.

   Marginal damages and optimal emissions: These topics are the subject of Chapter 10 on integrated assessment. As noted in the chapter 6, there is no direct relation between damages from 2xCO2 and the marginal benefit curve for abatement. To make the connection requires a framework that integrates modeling of economic activity and emissions, the carbon cycle and other trace gases, the climate system, and climate change damages. The short treatment in Chapter 6 does not do justice to these complex issues and is redundant with Chapter 10. The discussion should be deleted from Chapter 6.

   Secondary benefits: Because the topic of Chapter 6 is the damages from 2xCO2 and not the benefits of mitigation, the discussion of secondary benefits from mitigation is peripheral to the chapter and potentially confusing. The framework laid out in other chapters for measuring the costs of mitigation treats secondary benefits as negative costs of mitigation that should be factored into the assessment of costs. The appropriate place for discussion of estimates of secondary benefits is in Chapter 9 on the costs of mitigation.

8. Citations in the chapter include references that have not been peer reviewed. It is appropriate to include such citations, but the text should indicate what results are supported by peer reviewed publications and what results are not.

9. Numbers of tables and figures should be made consistent with the order in which they are referenced in the text.

Summary of Key Messages of the Chapter

The following points are what we believe to be the key messages to be derived from the literature on the social costs of climate change. We recommend that the chapter authors incorporate these points into the summary of the chapter and recommend that these messages also be incorporated into the Summary for Policymakers for the entire Working Group III report.

- Monetary estimates of climate change damages are based upon economic concepts of individual welfare. Methods exist to estimate damages in monetary terms for both market and non-market effects, but much less confidence is placed in estimates for non-market damages than for market damages. For some categories of ecological, cultural and human health effects, economic concepts of value may not be widely accepted as appropriate.
  - Examples of market effects include changes in the production and consumption of foodstuffs, forest products, energy and other commodities.
  - Examples of non-market effects include changes in human health, flood protection, outdoor recreation, and preservation values for species and natural places.

- Estimates of damages are dependent upon a host of assumptions regarding highly uncertain inputs to the analysis. Damage estimates for a number of categories of damages range from net benefits to slight damages to substantial damages depending upon the assumptions adopted. Researchers have widely varying views on the probabilities that should be associated with different sets of assumptions. Because of this lack of consensus, damage estimates reported in the chapter should not be interpreted as best estimates, nor as providing upper or lower bounds on likely damages.

  - A small number of studies estimate global damages for an equivalent doubling of carbon dioxide in the atmosphere and obtain a range of damages from 1.5% to 2.5% of gross world product.
  - Damages are expected to vary by region and there is limited evidence that developing countries may experience greater damages as a percentage of gross domestic product than will developed countries.
  - None of the damage estimates reviewed in the assessment represents damages for catastrophic scenarios of climate change and climate change impacts.

- Comparisons of monetary damage estimates from different studies suggest that damage categories of particular concern include agriculture, coastal zones, water resources and

human health. However, there is little agreement across studies about the magnitude of damages for these and other categories of damages and little agreement in the relative ranking of damage categories. For example, research results are inconclusive about the severity of agricultural damages with some studies indicating the potential for agriculture to benefit.

- Also of concern are damages that may arise from the disruption of natural ecosystems by climate change. These potential damages are of concern because there is a high degree of uncertainty about how these systems will respond to climate change and a low level of confidence in available valuation methods to adequately account for the importance of these systems to human welfare. A few researchers have made monetary estimates of damages to natural ecosystems from climate change, but the estimates are speculative and not comprehensive.

Comments on Specific Portions of the Text

Page 1, lines 23-31.

The discussion of judgmental and monetized benefit-cost frameworks is not needed in this chapter. Benefit-cost and related decision making frameworks are discussed in Chapters 2 and 5. The discussion here is redundant and uses terminology that is inconsistent with terminology in those chapters, which makes for confusion. We recommend that the discussion be deleted from Chapter 6.

Page 2, lines 1-8.

The discussion of value estimates based upon created markets should indicate that confidence in these estimates are generally lower than value estimates that are based upon observations of behavior in actual markets. The discussion of contingent valuation methods should reference Hausman and Arrow and Solow.

Page 2, lines 22-26.

The paragraph is cryptic. The point should be clarified by stating it in plain language that avoids technical terms such as pure rate of time preference. Care should be taken that the wording avoids advocating a particular view as to how problems of intergenerational equity should be resolved. The statement that the discount rate may be endogenous is not made relevant to the problem and should be deleted.

Page 2, lines 36-40.

The statement that aggregation of damages can mask variations in impacts is an important one to make and should be retained in the text. It is not evident, however, that aggregation masks

dislocation costs. Dislocation costs are absent from most studies because they have not been estimated, not because they have been lost in aggregation.

Page 2, lines 42-43.

This item is not a characteristic of a benefit-cost framework and so does not fit in the list.

Page 3, line 1 to Page 5, line 12.

Different approaches or frameworks for considering the climate change problem are the topic of chapters 2 and 5. The discussion of the sustainability approach is misplaced in Chapter 6. Note that the discussion of sustainability is not needed to support any of the analysis of climate change damages presented in the chapter and the concept of sustainability is not referenced again after page 5. We recommend that the discussion be deleted from Chapter 6.

Page 4, line 30 to Page 5, line 12.

The authors claim that there is a consensus between the sustainability and benefit-cost approaches that is not supported. There are also some problems with the points identified as forming the consensus. Regarding point (a), "doing nothing" needs to be defined carefully to make the statement valid. In particular, the current course of action based upon current commitments is not equivalent to "doing nothing." Regarding point (b), the statement that actions are likely to yield benefits and costs that are of similar magnitude is imprecise and therefore subject to erroneous conclusions. Point (c) advocates blending sustainability and benefit-cost frameworks for addressing the climate problem. This advocacy is policy prescriptive and has no place in an IPCC report.

Page 5, lines 32-37.

The statement that non-market costs can be 30% to 80% of total damages needs citations to support. Assertions made in points (a), (b) and (c) need to be explained and supported.

Page 5, line 42.

The statement ". . . the appreciation of . . . decreases rapidly . . ." is needlessly confusing. Suggest revision to clarify the point.

Page 6, line 8.

Should 0.03X percent be 3X percent?

Page 6, lines 13-22.

The paragraph relies too heavily upon technical terms such as: transient and equilibrium warming, ocean thermal lag, steady state increase in ghg concentrations, and radiative forcing. The ideas should be explained in plain language. If technical terms are indispensable, they should be defined. The implications of the inherent asymmetry discussed in lines 19 to 22 should be stated.

Page 6, lines 35-37.

We agree with the propositions and recommend that they be retained.

Page 6, line 39 to Page 7, line 8.

We agree with the proposition that damages will be greater the more rapid the rate of warming and recommend that it be retained.

Page 7, lines 15-29.

The topic of time horizon and discounting is covered in Chapter 4 and the discussion here is redundant. It is also incomplete and not representative of mainstream views of discounting. The damages of climate change discussed in this chapter are not discounted but are simply presented as corresponding to a time in the future when the effects of a doubling of carbon dioxide would be experienced. Therefore, the discounting discussion is not essential to the chapter and should be deleted from the chapter.

If the authors choose to retain a discussion of discounting, the discussion should be revised to present a more balanced discussion of discounting and to be understandable to a non-technical reader. Any readers familiar with terminology such as pure and social rates of time preference, elasticity of marginal utility, shadow-pricing of capital, and logarithmic utility functions are unlikely to need a tutorial on discounting. For readers not familiar with the terminology and discounting issues, the discussion is likely to be incomprehensible.

Page 7, line 33 to Page 8, line 2.

The paragraph should be revised to stress that benefits and costs may be highly sensitive to technological change, that over the long time horizon relevant to the climate problem there are tremendous uncertainties about technology, and that these imply substantial uncertainty for benefits and costs. Studies have adopted various assumptions about technological change to arrive at estimates of benefits and/or costs, but much work needs to be done to evaluate the sensitivity of results to different assumptions and their implications for decision making. To state that a set of assumptions adopted in one study obviate dealing with technological change is potentially very misleading.

Page 8, line 6.

The statement should include specific reference to non-carbon energy technologies.

Page 8, line 11 to Page 9, line 29.

The Introduction and Overview chapters of Rosenberg, ed., 1993, "Towards an Integrated Impact Assessment of Climate Change: The MINK Study," Climatic Change provide a systematic discussion of adaptation in agriculture, forestry, water resource management and energy that may be useful to this section.

Page 8, line 26.

The phrase "optimal coastal protection levels of 50 to 100%" is vague. Clarify.

Page 9, lines 4-6.

The definition of damages as the sum of adaptation costs plus the costs of remaining, unmitigated damage should be incorporated into the first paragraph on adaptation on page 8.

Page 9, lines 15-21.

These are important points that should be retained.

Page 10, lines 41-42.

The central estimate of cumulative warming from IPCC (1990) uses a preindustrial base as the reference point for measuring warming. The estimate from SAR of Working Group I uses the year 1990 as the reference point. This is confusing. Estimates from both sources should use the same point of reference for ease of comparison.

Page 10, lines 3-7.

Estimates of warming should be given for the Southern Hemisphere as well as the Northern. It is not clear from the paragraph whether or not estimates of warming for the Northern or Southern Hemispheres have changed since the IPCC (1990) report.

Page 10, lines 12-13.

The meaning of the statement ". . . intensify the role of variability and surprises at the regional level" is not clear. Clarify and support with references to published literature.

Page 10, lines 15-16.

Explain in plain language the meaning of increasing ocean-land differentials. Provide citations

to support statements that increasing ocean-land differentials may result in greater precipitation changes and higher storm damages. Also include citation to Lighthill et. al. (1994), which offers evidence that tropical storms and cyclones may not get worse in a warmer world, and note that the issue is a controversial one.

Page 10, lines 21-24.

The statement is not supported by citations to published literature and it does not recognize that other conclusions could be drawn. If it cannot be supported by citations, it should be deleted.

Page 10, lines 26-29.

The assertion that recent changes in the climate science give little reason to alter the broad magnitudes of damage estimates is not supported by citations to the published literature. If it cannot be supported by citations, it should be deleted.

Page 10, lines 34-44.

This section should clarify that the damage estimates presented in this chapter are not equivalent to the benefits of a mitigation policy that reduces but does not fully prevent global climate change. The discussion should clarify that the baseline against which damages are being measured is one that assumes that there is no change in global climate. It should also make clear that the analysis is partial in the sense that the damages are not net of costs for preventing climate change.

Page 11, line 6.

Reference to current damages should be explained and supported or deleted.

Page 11, line 22 to Page 14, line 16.

The section on agriculture covers a large number of studies but does not give a sense of why results vary substantially across the various studies. The section would be much more informative if it provided an assessment of the major factors contributing to the differences. For example, damage estimates seem to be highly sensitive to differences in the climate scenarios evaluated, assumptions about the opportunities for adaptation (including international trade), and assumptions about the concentration of carbon dioxide and the responses of crop yields to carbon dioxide. Results may vary in systematic ways across regions. Results may also be sensitive to the methods applied to estimate damages. Some of these issues are touched upon but they are not treated in a systematic way that makes it clear to the reader what are the major sources of differences in damage estimates.

The section should place greater emphasis on the potential for climate change to result in benefits at regional and global scales for warming that is roughly consistent with the current

best estimate of the effects of a doubling of carbon dioxide. The tone of the chapter leaves the impression that damages are much more likely than benefits. But there is no consensus on this point.

Some important articles on agriculture and climate change that are not discussed include: Reilly, Hohman and Kane (1994, Global Environmental Change) and Kaiser et. al. (1993, American Journal of Agricultural Economics).

Page 11, line 22.

The sentence seems to imply that damages will result in more areas than will experience benefits. There is no basis for this position and the sentence should be revised.

Page 11, line 23-25.

Whether or not warming will increase or decrease the growing period will vary by region and by crop. The sentence should be revised to reflect this expectation.

Page 11, line 25.

The implication of drier Continental interiors for agriculture should be stated explicitly.

Page 11, line 39 to Page 12, line 7.

The treatment of the CO2 fertilization effect is not sufficiently comprehensive. The authors should refer to the agriculture and forestry chapters of the Working Group II report which provide a good review of the issue. See also Kimball, Rosenberg and Allen, eds. (1990).

Page 12, lines 6-7.

Many would argue that evaluating agricultural impacts at a CO2 concentration of 440 ppm is also the wrong experiment. By the time warming reaches the level corresponding to an equilibrium change for an equivalent doubling of CO2, the concentration of CO2 will very likely be substantially greater than 440 ppm, perhaps even greater than 660 ppm. The correspondence of 440 ppm with an equivalent doubling of CO2 is not persuasive reasoning that it is the appropriate level to use. For example, if the damage estimate is to be used as a benchmark for parameterizing a damage function in an integrated assessment model, as is suggested later in the chapter, the estimate should correspond to transient warming, not equilibrium warming. For the transient case, warming of 2.5 degrees should be matched with a CO2 concentration substantially greater than 440 ppm.

The discussion here and later at the bottom of page 12 should be revised to remove the implication that 440 is the correct concentration to use in evaluating agricultural damages. The discussion should simply indicate the sensitivity of results to different assumptions about

concentration.

Page 12, lines 9-26.

Information on the full range of results from Kane et. al. (1992) should be provided. Reporting only results from a very adverse scenario and an average of all scenarios masks information on the sensitivity of agricultural impacts to scenario assumptions.

Page 13, lines 22-23.

The statement "Substantial economic losses are predicted in all scenarios once temperatures rise by 4 degrees C" is misleading. Sensitivity scenarios which assume 4 degree warming result in losses. But, for a number of GCM scenarios which project warming of more than 4 degrees, agriculture benefits. The discussion should also state explicitly that Adams et. al. estimate benefits for scenarios that assume 2 degree warming.

Page 13, lines 28-38.

Rosenberg, ed., 1993, Towards an Integrated Impact Assessment of Climate Change: The MINK Study, Climatic Change is a better reference to direct readers to regarding the MINK study. For a discussion of adaptation in developing countries see Jodha, 1988, in Rosenberg et. al. eds., Greenhouse Warming: Abatement and Adaptation.

Page 14, line 22.

On page 10 the latest IPCC estimate of mean sea level rise is given as 45 cm. Why not repeat that estimate here instead of giving an estimate from Wigley and Raper of 48 cm?

Page 14, lines 24-31.

The rationale presented for using damages for 1 meter sea level rise as the damages that should be associated with benchmark warming damages is not convincing. Basing benchmark warming damages on a 1 meter rise introduces a strong positive bias in the sea level rise damages. Estimates of damages for 50 cm sea level rise are available in the literature and these estimates should be presented in the chapter.

Page 14, line 44.

The statement that sea level rise damages for the US reported in Cline (1992a) may be an underestimate is controversial and should be deleted. As argued above, damages for 1 meter rise will overstate the costs of warming. Further, estimates of damages from the US Army Corps of Engineers (see OTA, Preparing for an Uncertain Climate, 1993) are substantially lower than estimates from EPA. Recent work by Gary Yohe suggest even lower costs and that EPA cost estimates may be high by an order of magnitude. The Yohe work is not yet published

and so should not be cited in the chapter. However, it and the above arguments suggest that the authors should refrain from stating that the earlier EPA estimates are underestimates.

Page 15, lines 7-11.

What is the source of prices per acre for wetlands and drylands that have been adopted by the various studies? Of particular concern are the wetland prices, for which no market observations are available.

Page 15, lines 19-32.

The discussion of sea surges may double count some damages. The coastal protection measures included in the costs of sea level rise would provide protection against flooding from sea surges. The estimates from FEMA do not take into account any protective measures. If the discussion of sea surges is retained, it should be made clear that the protection costs discussed above would largely eliminate damages from sea surges.

Page 15, line 37-40.

The analysis attributed to Sedjo and Solomon (1989) was actually done by Emanuel et. al.

Page 15, lines 36-41.

The discussion of climate change impacts on forest productivity and distribution is far too limited. There is a substantial literature on forest impacts of climate change that should be discussed in addition to the two dated studies referenced. Some of this literature would imply very different economic damages than is estimated based upon the Holdridge Life zone classification analysis. Some results suggest that forests in many regions could benefit from climate change. Even if it is not possible to incorporate monetized damages/benefits based upon some of these newer studies, there should at least be a discussion of them and an indication that benefits to forests are possible. The discussion should also include mention of the potential beneficial effects of CO2 fertilization for forests. See the forestry chapter of Working Group II for a discussion of the forest impacts literature.

Page 16, line 27 to page 17, line 7.

The discussion of water supply impacts is very misleading by the heavy emphasis on results that project decreases in runoff for a few regions and the almost complete omission of references to results that project increases. Extrapolating runoff decreases from a handful of sites for a few scenarios to estimate damages at national and global scales is arbitrary and implies an implausible scenario in which runoff declines everywhere. The lack of any discussion of the adaptability of water management practices to weather variability is also problematic. The discussion should be revised to highlight three key points: (1) confidence in projections of water runoff is very low, (2) some areas will likely benefit from increases in

runoff while other areas will suffer from loses, and (3) water management practices can adapt to variations is streamflows. The discussion could also be improved by citation of a broader range of studies, e.g. Gleick (1989) Review of Geophysics, Nash and Gleick (1991) Journal of Hydrology, Lattenmaier and Gan (1990) Water Resources Research, Leavesley (1994) Climatic Change, and Frederick (1993) Climatic Change. See also the hydrology chapter of Working Group II for a more balanced treatment of water resource impacts.

Page 16, line 43 to Page 17, line 44.

The sentence summarizing the estimates for the central valley of California should be revised. As currently written it could be misinterpreted to imply that water deliveries would decrease 7% to 16% by the year 2010 and that demand is projected to increase 50% as a result of climate change. The demand projection, which is for the year 2010, has nothing to do with climate change. The reduction in water deliveries, which is a projected consequence for selected scenarios of 2xCO2, would not occur for many decades. It should also be noted that the 2xCO2 scenarios incorporate substantially more than 2.5 degree warming.

Page 17, lines 6-7.

The attribution of an 18% decrease in reliable water yield for Boston as a result of a mean model estimate is incorrect. This is the result of a scenario of 4 degree warming and 0% change in precipitation.

Page 17, lines 22-29.

Discussions of disproportionate water resource impacts on developing countries in the context of international security can be found in Gleick (1989) Ambio and Gleick (1989) Climatic Change.

Page 17, line 33 to Page 18, line 31.

The discussion of cooling and heating costs is imbalanced by its heavy emphasis of studies that estimate that the net effect of warming will be an increase in energy costs. The Rosenthal et. al. study is a credible study and deserves more than the passing mention it receives. The discussion should be revised to emphasize that there are few studies on the issue, there is no consensus on the net effect, that effects will be highly variable across regions, and that the effect could plausibly be beneficial in aggregate for modest warming.

Page 17, lines 33-37.

The result that cooling costs increase in Japan with higher temperatures up to 30 degrees but are not changed by warming beyond 30 degrees seems odd. The authors should verify that this result is reported correctly.

Page 18, line 35 to Page 19, line 29.

Inclusion of the discussion of insurance as a distinct category of damages is potentially confusing. Some readers may interpret the payments for insured losses as damages that should be aggregated with other damages, potentially doubling counting damages from storms etc. The discussion should be deleted or moved to the section on extreme weather events and the information on insured losses for specific events used to illustrate the destructive potential of these phenomena. Alternatively, it could be moved into an expanded section on adaptation. Insurance serves to spread risks and represents a form of adaptation.

Insurance would be a separate category of damages only if climate change were to affect the efficiency of risk spreading in insurance markets. Losses due to changes in the efficiency of insurance markets are only peripherally discussed in the section. Changes in insured losses would not provide any easily interpreted evidence regarding changes in the efficiency of these markets.

Page 20, lines 22-28.

Additional information on urban infrastructure can be found in Schwartz and Dillard in Waggoner, ed., 1990 and NAS/NRC/IOM, Policy Implications of Greenhouse Warming, 1992.

Page 20, line 32 to Page 22, line 8.

The discussion of health effects needs an introduction that discusses the broad range of possible health impacts. The discussion places too much emphasis on mortality from heat stress. Note that the authors of the Working Group II health chapter take the view that heat stress mortality is unlikely to be the most important health impact. The authors should see the summary of the health chapter for the Working Group II report for a more comprehensive treatment. Another source of information is the NAS/NCR/IOM report.

The discussion in this chapter should state explicitly that the monetized health damages reflect only mortality due to heat stress and that other health effects of climate change are excluded.

Page 21, lines 39-41.

Clarify that the estimated deaths are additional deaths per year.

Page 23, lines 3-5.

The discussion of Fankhauser's analysis of air pollution damages lacks sufficient details to understand. Why does Fankhauser assume that NOx and SO2 will increase 5.5% and 2% respectively?

Page 23, lines 15-16.

The discharge of pollutants would not change in proportion to river flow. Likely the pollutant load would remain unchanged and the streamflow would carry a more concentrated flow of pollutants. Check the Titus (1992) study to see if the sentence misstates the assumptions of that analysis.

Page 23, line 29 to Page 24, line 7.

The discussion of migration costs is highly speculative and includes no reference to research that finds that international migration is a likely response to climate change. The discussion is also weak for its failure to note that estimates of illegal migration and the costs of migration are controversial. The section should be revised to make it explicitly clear that there is no empirical basis to any existing estimates of migration costs due to climate change.

Page 24, lines 33-34.

The climate amenity values from Leary (1994) are present value per household; they are not annual values. This should be made clear.

Page 25, line 15 to Page 26, line 19.

Available estimates of ecosystem damages have serious limitations. Because of the limitations, the discussion should emphasize a qualitative discussion of ecosystem impacts, drawing upon relevant draft chapters of the WGII report. The qualitative impacts could be discussed from an economic perspective to provide the reader with a sense of what types of benefits from ecosystems might be at stake. The discussion should reiterate the difficulties and controversies about estimating the value of ecosystems and biodiversity in monetary terms. It might also include the assessments of the opportunities (or lack of) for adaptation to limit ecosystem damages. This would be more informative than the current discussion of monetary damage estimates for species loss. These estimates are pure speculation and address only a narrow aspect of the problem of ecosystem damages.

Page 25, line 22.

The discussion of barriers to migration should not be limited to animal migration. Barriers to migration are likely to be more formidable for plants than for animals.

Page 25, line 27.

The example of forests providing watershed protection does not fit well into a discussion of species value. Watershed protection is a service provided by a wide spectrum of ecosystem types that have very different species compositions. It is a joint product whose value cannot be ascribed to individual species or even groups of species as there is great potential for substitution among species in the production of watershed protection.

Page 25, line 29.

A rare work of art can have all three types of value. Provide a more precise definition or example of existence value.

Page 25, line 30-34.

The reader should be warned that summing estimates of wtp to preserve various species is inappropriate because of the embedding problem.

Page 26, lines 23-33.

The section on extreme weather events should be introduced by a summary of the assessment of Working Group II regarding potential changes in extreme events. This summary should make it clear that the consequences of global warming for the frequency and intensity of extreme climatic events is highly uncertain.

Page 26, lines 32-33.

The last two sentences, beginning "However, adaptation is costly . . ." are vague and need clarification.

Page 27, lines 19-25.

See paper by Lighthill et. al. (1994) for a different view on tropical cyclones.

Page 27, line 44 to Page 28, line 1.

The statement "Considering that the IPCC did not indicate any likelihood that tropical cyclones might decrease, the expected direction is an increase" is faulty logic. It should be deleted.

Page 28, lines 37-43.

The discussion of droughts should include losses of hydropower production as a potential damage. Estimates of such losses for parts of the US are reported in Gleick and Nash, 1991, "The Societal and Environmental Costs of the Continuing California Drought", Pacific Institute for Studies in Development, Environment, and Security; Nash and Gleick, 1993, "The Colorado River and Climatic Change," US EPA; and Dracup et. al., 1993, "Integrated Modeling of Drought and Global Warming, Impacts on Selected California Resources," US EPA.

Page 29, line 9.

The statement "It is unclear which fraction of casualties can be attributed to global warming"

carries the implication that some fraction is attributable to global warming. While this is possible, there is no consensus that this is the case and the IPCC remains agnostic on the question. It should be revised to state that it is unknown whether or not global climate change has contributed to the death toll.

Page 29, lines 38-44.

The statement that the damage estimates are likely to understate true impacts is not adequately supported and should be deleted. The three reasons given for an underestimate are not convincing. First, it is not at all obvious that excluded impacts are predominantly harmful. For example, the effects of climate change on non-tropical storms and drought are ambiguous and thus could be harmful, neutral or beneficial. Research on ecosystem impacts indicates that some ecosystems could potentially benefit from climate change and elevated carbon dioxide levels. Morbidity effects are an important source of concern, but the possible effects of climate change on health are complex and poorly understood. There is little evidence at this time to assert that the effects are most likely to be negative.

Second, as stated on line 42, adaptation is not fully taken into account. The most likely effect of more careful consideration of adaptation is to reduce damage estimates, not increase them.

Third, the statement that estimates are far from exact does not imply that damages have been underestimated. Not all would agree with the claim that many damage estimates are deliberately kept conservative. For a number of damage categories, research results indicate the potential for either gains or losses. The estimates included in tables 6.4 to 6.6 invariable assume damages for these categories. For example, some studies suggest that agriculture could benefit in many regions and possibly even in aggregate for the world. Recent studies on forestry suggest the same. Energy could very plausibly be a net gain for many regions. In the case of water resources, global damage estimates presented in the chapter make the implausible assumption that water runoff declines globally. In sum, many researchers would disagree with the assertion that the damage estimates presented in this chapter are conservative and therefore underestimate total damages.

Page 30, lines 30-31.

The observation that estimates are probably biased toward convergence is an important one and should be included in the chapter summary.

Page 31, lines 8-21.

The results of the opinion survey are inappropriately used to support the argument that damages are understated. Economists who gave the lowest damage estimates are misleadingly described as never having done research on global warming. Nordhaus indicates that all participants in the survey have done work in the area of global warming. The eight economists in question are described as not having specialized in natural resource and environmental

economics, but all are familiar with global warming issues and have written on the topic.

The sample is non-random and exceedingly small and should not be used to draw strong conclusions about the views of different groups of specialists. Characterizing the views of natural scientists based on the responses of only three scientists, who were selected because of their research on climate change, is particularly dangerous. The patterns of responses from this small sample is very weak evidence to use to support the position that existing damage estimates are underestimates. Note that this view also seems to give greater credence to the views of natural scientists than to other disciplines. While natural scientists generally have a comparative advantage in evaluating the potential physical effects, economists and social scientists have a comparative advantage in evaluating the economic and social consequences.

The paragraph should either be extensively revised to remove the biased treatment, or it should be deleted. If discussion of the survey is retained, it should add median responses to highlight how skewed the responses are.

Page 33, line 5.

The statement that precipitation rises linearly with temperature should be verified and supported. The exponential relation between temperature and evapotranspiration suggests that precipitation should also have an exponential relation to temperature.

Page 34, lines 3-4.

The sentence "Also, the impact of, . . ." is vague. Revise to clarify.

Page 35, line 13.

The reference should be to Dowlatabadi and Morgan, not Dowlatabadi and Granger.

Page 35, line 40.

The section on regional damage estimates should reiterate the low confidence in projections of regional changes in climate and the implication that regional damage estimates are also of low confidence. The discussion should also highlight that the GCM projections used in many of the analyses project warming considerably higher than the 2.5 degrees suggested as a benchmark for 2xCO2.

Page 40, line 15.

A $9 million increase in health expenditures per 10,000 persons implies a per capita increase of $900. This seems like a very large increase in health expenditures for a low income country. The estimates should be verified.

Page 42, line 28.

Meaning of "increases in altitudinal vegetation zones" is not clear.

Page 43, line 18 to Page 45, line 31.

This section usefully draws a distinction between the damages that are estimated for a doubling of CO2 and the benefits of mitigation policies. However, the discussion of marginal benefit estimates per ton of carbon mitigation is redundant with chapter 10. Chapter 10 is the appropriate place for this material. Estimating marginal benefits, or marginal damages, per ton of carbon requires a dynamic, integrated modeling of emissions paths, the accumulation of greenhouse gases, the climate system, and damages. That is the topic of Chapter 10. The discussion in chapter 6 should be deleted and the reader directed to chapter 10 for information on marginal damage estimates and their implications for policy.

Page 45, lines 38-42.

The discussion should be revised to indicate that what is done with the tax revenue can influence the cost of the policy. The example given of lowering a distortionary tax with beneficial secondary effects is but one possibility. It is also possible that the revenue could be used in ways that increases distortions and efficiency losses. See chapter 8.

Page 48, line 19.

The assertion that the damage estimates in the preceding paragraph are best guess estimates cannot be supported and should be deleted. Damage estimates are highly sensitive to a host of highly uncertain assumptions. Researchers have widely varying views on the likelihood or plausibility of different sets of assumptions and it is difficult to assess the validity of different sets of assumptions. Because of this lack of consensus, the IPCC should not endorse any estimates as representing best estimates of climate change damages. The best that can be said of any damage estimate is that it is illustrative of the magnitude of damage that is consistent with a set of plausible assumptions.

Page 48, lines 25-28.

The statement that "Global warming will not stop at this level of concentrations if it is unconstrained" is stated as if this is certain. The statement should be deleted and replaced with a brief discussion of the IS92 scenarios and the CO2 concentrations that would result from these emission profiles. Of the six scenarios, four pass 2xCO2 by the year 2070, and two do not reach 2xCO2 by 2100. See the report of Working Group I, Radiative Forcing of Climate Change, Executive Summary, page 12.

Pages 49-54, Boxes 6.1 and 6.2

The discussion of the value of a statistical life and damage aggregation include lengthy commentary on equity issues. Equity is dealt with in detail in Chapter 3. The boxes in chapter 6, which are much too long to fit into boxes, could be shortened by deleting the discussions of how different notions of equity might be incorporated into estimates of the value of a statistical life and in aggregating welfare change measures across individuals or nations. The boxes could simply note that there are serious equity issues involved, that valuation measures can be adjusted to reflect equity concerns, but that there is no consensus about how or if such adjustments should be made. The reader could be directed to Chapter 3 for a general discussion of equity issues.

Page 55, Box 6.3.

It is stated in a number of places in the box that damages are expected to be greater in LDCs than in DCs for categories of impacts that are ambiguous. For example, agriculture may either benefit or suffer damages. Consequently, human health may either improve or diminish due to nutrition changes. The consequences of climate change for tropical cyclones are very uncertain. Because it is uncertain whether or not damages will result for the above categories as a consequence of climate change, it is misleading to state that greater damages are expected in LDCs. We suggest changing the wording to state that for these categories LDCs are expected to be more vulnerable than are DCs.

Page 55, lines 38-42.

The influence of income as a determinant of wtp is not limited to the value of a statistical life and is applicable to all damage categories. The influence of income in damage estimates should be identified as a separate point and not incorporated into the point on human life.

Page ??, Figure 6.1. (Note: the figure is inserted between pages 56 and 57 and does not have a page number)

Figure 6.1 should be deleted. The figure is intended to illustrate the difference between the benefit-cost framework and the sustainability framework. We recommended in an earlier comment that the sustainability discussion is more appropriate for Chapter 2 or 5 and should be deleted from Chapter 6.

Also note that neither the text nor figure provide sufficient explanation to interpret the diagrams. If the figure, or some portion of it, is retained, the text should provide an explanation of what is illustrated in the diagrams.

Page 57, Figure 6.2

The labeling of the diagrams is insufficient. In the upper diagram, do the damage curves illustrate marginal damages or total? Annual or cumulative? In the lower diagram, do the emissions curves illustrate annual emissions or cumulative?

Page 58, Table 6.1

The table is insufficiently discussed in the text.

The footnote applied to agriculture ("widespread disagreement") would seem to apply to just about every category of damage. Applying this footnote solely to agriculture gives the erroneous impression that there is agreement or only minor disagreements about other categories of damages.

Page 59, Table 6.2

The table is not essential to the chapter and could be deleted.

Page 61, Table 6.4.

The table should indicate that damage estimates refer to annual damages in some future year and are not the present discounted value of those damages.

Page 62, Table 6.5

It would be helpful to have the monetary damages by category from Fankhauser (1995).

Page 66, Table 6.10

More explanation of the information in the table of vulnerability indexes would be helpful. The information in the note is cryptic and not very helpful. What categories of impacts are included? Can an example be given of how one of the numbers in the table is calculated?

The table is referenced on page 42 in the section on small island states, yet the table reports vulnerability indexes for all countries, developed countries and developing countries. Perhaps the table should be discussed in section 6.5.1 on page 35.

Page 75, Reference to Gleick (1992).

The reference is incorrect. The correct reference is:
Gleick, P.H. (1992), Water and Conflict, Project on Environmental Change and Acute Conflict, University of Toronto and the American Academy of Arts and Science, Cambridge, Massachusetts.

Chapter 7: Major Points

- The conceptual basis for establishing the cost of options is well-established but there are wide differences in estimates among empirical studies. These include:

  - differences in the technical description of the inputs and outputs of the technology or response options

  - differences in the prices used to cost inputs (e.g. labor, capital, materials)

  - whether or not estimates consider how market prices may change as the scale of the industry changes; learning and demonstration effects may reduce costs as scale increases (from p. 3, line 15) but competition for resources (e.g. competition for land from agriculture) may cause costs to increase with scale

  - dependence of costs on varying quality grades of the resource (e.g. solar insolation, regularity of wind, the rate at which forests/biomass will grow or where the resources is limited in quantity may lead to increases in the cost of the response option as scale increases.

  - whether and how market prices of traditional inputs and outputs have been adjusted to reflect the full social cost (and benefits) of the option; such adjustments may reflect other labor, capital, and other market distortions.

  - whether the cost includes other socially beneficial or detrimental effects such as effects on the environment or the distribution of income/employment.

  - finally, the full cost of the option must be compared with the full cost of the current practice that will be replaced by the option; the full environmental costs of current practices are not uniformly incorporated in current market prices or these altenatives may be subsidized. The current practice being replaced can vary (e.g. oil or gas-fired power plants substituting for coal would provide CO_2 benefits but if they replace hydroelectric power they would increase CO_2 emissions).

(Most of these points are raised on p.3, lines 9-20 with respect to mitigation options, page 7, lines 17-27 with respect to energy efficiency, and again on p. 16, l. 34 with respect to renewable fuels. Under the suggested changes this would replace material on p. 1 line 9, recognizing that these issues generally apply all options)

The generic set of responses to climate change that have been identified in the literature are:

- mitigation including

- reducing or changing the activities that lead to trace gas emissions

- scrubbing (removal of trace gases from combustion by-products)

- sequestration (enhancing the uptake of greenhouse gases)

- adaptation (acting to limit the impacts of changing climate)

- geoengineering (large scale interventions in the earth system in an attempt to counter-balance the atmospheric changes and radiative forcing caused by greenhouse gases)

(Mitigation, Adaptation are identified on p1, line ; geoengineering, scrubbing and sequestration on p. 3, lines 26-36)

- Estimates of the potential of "no regrets" energy efficiency improvements and low cost alternatives to fossil fuels vary widely. To achieve this potential will require policy intervention.

  (from the current summary, p. i)

- While there may be considerable unexploited technical potential for fossil fuel alternatives, there is little consensus on the full cost of various options compared with current practices (for more detail on the technical options see WG-II).

  (from current summary, p. i and e.g. Table 6)

- The failure of "no regrets" options to succeed under current economic, political, and social conditions has many possible explanations; specifically identifying why these options fail is a necessary precondition to devising remedies that would encourage their broader application. The reasons vary widely across technological options and across countries ranging from tax systems that provide favorable treatment to fossil-fuel using activities, direct fossil fuel subsidies, and lack of reliable and concise information that allow purchasers of energy-using durables to accurately estimate their operating costs to the lack of incentives for households and firms to take into account the full social costs (and benefits) of current fuels and their alternatives.

  (This pulls together various points made at different points. In general, current policy failures are identified in various places as reasons why "no regrets" options have not been yet adopted. One current example is footnote 2; also it is asserted that policy changes will be required on p. 11, line 17)

- While a full assessment is not possible at this time, existing evidence makes clear that both the technical potential and the cost (or cost-savings) of various non-carbon fuel alternatives and of energy efficiency improvements vary substantially by geographic region and across different social, political, and economic systems. Among the reasons for these differences are:

  (This is an argument made at various places in the current chapter, e.g. most directly, on p. 3, lines 18-20 with respect to mitigation; some specific points are made on p.5, line 14-17 for n developed countries; p 7, line 11-12 identify some specific issues in developing countries)

- There are wide differences in energy-using characteristics among countries with similar economic and social conditions; while recognizing this significant within group variation, 1990 energy use per capita in the developed and eastern Europe and countries of the former Soviet Union was over seven times higher than in countries of Africa, Latin America, the Middle East, and Asia. At the same time, the developed west used less than one-half the energy per unit GNP than eastern Europe and the countries of the former Soviet Union and one-third the energy per unit of GNP of developing countries. While suggestive of opportunities for efficiency gains and low or no-cost opportunities for energy-savings, this aggregate evidence is insufficient to conclude that the economic, political, and social costs (or benefits) of options are greater or lesser for different groups of countries.

  (From table 14 and p. 10, lines 34 to p. 11 line 5).

- Relatively fewer studies have assessed the costs of adaptation to changes in climate. The potentially affected activities span a broad range from agriculture and energy use, to health, coastal communities, and recreation and ecosystem preservation. Among each of these broad sets of activities there are many possible adaptive responses. (For identification and discussion of such options see WG-II).

(p.25, line 25)

- Still less evidence on the costs and technical feasibility of geoengineering and scrubbing exist. These options have not been technically proven at an operational scale; moreover, these options pose substantial potential environmental risks of there own.

(geoengineering is only mentioned on p. 1.; the discussion on p. 18, l. 13-14, l., 45 make these points more or less)

General Comments on Chapter 7

First, with respect to reasoning, this chapter is filled with logical errors and inconsistencies. These are, most often, not errors of economic analysis, but simply errors in logic. Conclusions are stated that simply do not follow from the arguments provided. There are frequent self-contradictions, as if the authors had not read their own previous comments. Assertions are made without reference, cited references are of dubious scientific merit as there is no evidence of scientific peer review, citations are made to unrefereed papers that have manipulated the results of peer reviewed literature in illegitimate ways when the original work could be cited directly, and material is miscited.

Second, with respect to judgment, the authors show an evident bias in favor of reporting relatively easy response options for mitigation. This often takes the form of such statements that, "costs may be" in some apparently reasonable range, when it would be just as true that cost may not be in that range.

Third, with respect to expertise exhibited, the authors make any number of mistakes. As a recurring example, they frequently ascribe the reason for a range in economic cost estimates to differences in the discount rate. That is only one possible source of such differences. Moreover, the authors have not exercised critical analysis of estimates in which discount rates appear to be decisive, not recognizing that the economic decision procedures used are often incomplete.

Fourth, the role of this chapter in the WG-III document is unclear; the chapter has focussed in such a way that it is redundant or in conflict with other chapters in WG-III (chapters 8, 9, and 11). The focus on specific response options from an engineering perspective also leads to redundancy with WG-II. For example, WG-II already has a strong section on agricultural adaptation; the limited discussion in this chapter is naive and misleading. All energy technology options are addressed at length in WG-II and possible future scenarios have been developed as part of the IPCC process that take into account estimated resource availabilities and costs (WG-II, and WG-III, Chapter 12). Forestry and biomass options are discussed in chapters 8 and 9 in working group III and to considerable extent in WG-II. Section 4.6 frequently references the work done in WGII, ChIII.F to support various points. A first priority ought to be to relate this work to discussions in WGIII, Ch.8 and 9. A reference to the WGIII Ch. 8/9 be inserted at: 19:43, 22:21, 38:24.

The overall recommendation is that this chapter should be eliminated; there is very little in this chapter that is not covered better somewhere else within the IPCC and for the most part within WG-III. The material could be offered to the authors of chapters 8, 9, and 11 to be included if useful. Elimination of the chapter would greatly improve the WG-III effort by avoiding redundancy and inconsistency. Correcting the specific concerns reported below are unlikely to produce an acceptable chapter as the inherent structure and basic content of the chapter is fatally flawed. The one possible role for this chapter that does not appear to be covered elsewhere in WG-III is to focus on adaptation and response to climate change but this is covered in WG-II. Unfortunately, this is currently a very weak part of the chapter (some references that the authors might find particularly useful in this regard are:

CAST (Council for Agricultural Science and Technology), 1992. *Preparing U.S. Agriculture for Global Climate Change*. Report No. 119 (June), Ames, Iowa, CAST, 96 pp.

Kates, R., J. Ausubel, and M. Berberian, 1985. *Climate Impact Assessment*, John Wiley & Sons, New York

Reilly, J., N. Hohmann, and S. Kane, 1994: Climate change and agricultural trade: who benefits, who loses? *Global Environmental Change*, **4(1)**, pp. 24-36.

Reilly, J. and C. Thomas, 1993. *Toward Economic Evaluation of Climate Change Impacts: A Review and Evaluation of Studies of the Impact of Climate Change.* MIT-CEEPR 93-009WP, Boston, Massachusetts Institute for Technology, Center for Energy and Environmental Policy Research, 54 pp.

Ruttan, V.W., D.E. Bell, and W.C. Clark, 1994. Climate change and food secuirty: agriculture, health and

environmental research. *Global Environmental Change*, **4(1)**, pp. 63-77.

Smit, B. (ed.), 1993: *Adaptation to Climatic Variability and Change*. Occasional Paper No. 19, Guelph, Canada, University of Guelph, 53 pp.

USA Congress, Office of Technology Assessment (OTA), 1993: *Preparing for an Uncertain Climate, Vol. 1*. OTA-O-567, Washington, DC, USA Government Printing Office.

Specific Comments on Chapter 7

Page 1, line 3-5

The indirect policy options are never conceptually well-defined in the text. As noted later, it may be possible to introduce this distinction but it seems like a subcategory of mitigation. In addition, while discussed only briefly, the chapter does mention geoengineering which does not fit neatly into mitigation or adaptation. Further it would be useful for the reader to identify early in the text the important distinctions under mitigation already later in the text.

The following statement more clearly identifies the distinct options discussed in the chapter.
The generic set of responses to climate change that have been identified in the literature are:

- mitigation including
    - reducing or changing the activities that lead to trace gas emissions
    - scrubbing (removal of trace gases from combustion by-products)
    - sequestration (enhancing the uptake of greenhouse gases)
- adaptation (acting to limit the impacts of changing climate)
- geoengineering (large scale interventions in the earth system in an attempt to counter-balance the atmospheric changes and radiative forcing caused by greenhouse gases)

Page 1, Lines 9, footnote #1

The authors distinction here between engineering efficiency and welfare economics approaches is so confused as to be useless as first defined on page 1, Lines 9, footnote #1. This distinction between engineering and welfare economics does not follow conventional terminology and in fact redefines terminology used in economics to mean something very different. This distinction is of concern further in the text as well (i.e. p. 6, lines 16-40). These and other passages provide further evidence that the authors do not understand what is conventionally meant by the term 'welfare economics'. Part of the confusion appears to be an inability of the authors to distinguish between technical options (such as energy conservation, renewables, nuclear energy, etc.) and the policy instruments that one would use to bring these options into broader use should that be desirable (e.g. reforming utility markets, energy efficiency labeling, taxes, creation of property rights that would allow the formation of markets that would create incentives for adoption of the technology, education and information, demonstration, standards and regulation, R&D, etc.).

The recommendation is that the authors should get rid of the distinction between engineering and welfare economics throughout the text and instead open the discussion by indicating that: Full evaluation of possible responses requires an accurate technical description of the inputs and outputs of the technology or response options. Evaluation of the cost of the option (relative to the current technology) requires that prices for the inputs and outputs be established. A narrow evaluation would use current market prices. Estimation of the market potential also requires an assessment of how market prices may change as the scale of the industry changes and an evaluation of the size of the market for the current technology for which the alternative would be economically competitive. Economies of

scale and learning associated with broader use may reduce the costs of the technology as scale is increased; dependence on resources of varying quality grades or where the resources is limited in quantity may lead to increases in the cost of the response option as scale increases. For public policy purposes, an estimate of the full social cost (and benefits) of the option compared against the full social costs (and benefits) of alternatives is frequently recommended. For a variety of reasons, labor, capital, and materials market prices may not reflect the social costs of these resources (e.g. Dasgupta, Sen, and Marglin, Guidelines for Project Evaluation, United Nations, New York, 1972). Additionally, the option (or current alternatives) may have other socially beneficial or detrimental effects. A few examples may illustrate some of these points. Particulate emissions from coal-powered electric plants have detrimental health effects that may (as in the United States where controls on particulate emission exist) or may not (e.g. many developing countries) be controlled. In the United States, coal generated electricity prices already reflect the higher cost of controlling these emissions but in countries where these are uncontrolled, it may be useful to adjust the market price of coal generated electricity to obtain an accurate social cost comparison with alternatives. Similarly, harvesting of biomass energy may create soil erosion or involve disruption of wildlife habitat and thus these costs should be added if the full social cost of the technology is required. For options like biomass, carbon sequestration in forests (Moulton and Richards, 1990), and solar energy (e.g. see Edmonds and Reilly, 1985 chapter 13, Solar and Wind, pp. 192-215 in *Global Energy: Assessing the Future*, Oxford University Press, New York), the quality of the resource may change (some areas have mostly sunny days while other areas are more frequently cloudy, and in some areas biomass crops grow rapidly over a long growing season whereas in others the annual flow of biomass is much lower). And, options that require extensive land (biomass and carbon sequestration) in particular, must compete with other uses of land (most importantly with agriculture, forestry, and preservation of habitat and ecosystems); at a small scale, these options would have little effect on land prices but at a large scale competition with these other sectors for the most productive land would lead to higher land prices and higher cost of the option (see, Adams. et. al., 1993). Similarly, conservation opportunities may be subject to increasing cost as for some consumers and in some applications perfomance differences of the alternative technology may not be important while for other consumers or applications this difference may be more important.

Page 2, Lines 1-25

Figure 1 has a number of deficiencies. Under "Impacts" the distinction between, "1st order," "2nd order," and, "3rd order," has no content. All of the types of impacts can happen simultaneously. All have economic effects, not just the, "3rd order," impacts and there is interaction among all the impacts, which is not shown. In addition, the Figure shows no feedback from, "Policy Response," to "Global Trends," except through, "Reduce Emissions," whereas policy responses can affect global trends which affect emissions. Part of the problem with the current figure is that policy response does not reduce emissions directly but only as it affects economic activities and global trends (that is, emissions are a result of human activities, thus a change in emissions must result from a change in the human activities contributing to the emissions). It is these types of logical failures that make this chapter particularly problematical.

Recommend deleting the figure as it creates more confusion than illumination. Attempts to diagram in a simple manner the interrelationships of climate, economy, and society is fraught with problems. More detail tends to create more controversy because it is fairly easy to find 2-way interaction between any pairs of boxes that can be developed. A possible substitution for Figure 1 here is Figure 1 from Commitee on Earth and Environmental Sciences (CEES), Economics and Global Change: The FY-1993 Research program on the Economics of Global Change, Washington, D.C. This figure avoids the 1st, 2nd, 3rd order distinction and includes direct arrows from government policies to economic activities.

Page 2, Lines 39

Again, I think the authors have created an odd distinction between direct and indirect policy options without being

very clear about what they mean. The chapter itself admits this distinction is not very clear in line 43 "obviously, the various types of options are not mutually exclusive, nor can they be fully separated." In one sense no option is direct, as these options require some public policy instrument to change the activities that are contributing to emissions. It seems what the authors are trying to get at here is that lower population growth or changing urban design so that the need for automobiles is reduced are less direct than, for example, a regulation that would allow no coal-fired power plants or that required fossil-fuel power plants to create some type of carbon sequestration offset. The examples currently given (p.3, lines 1-6) do not help and are themselves rather confusing. Something approaching a comprehensive list of the types of options that have been identified would be useful. If the authors wished to group these in some way (direct or indirect) this would be less objectionable because the reader could regroup them in other ways. Rather than worry about conceptual groupings, it is probably more important to identify in a more or less comprehensive manner, the policies that have been put forward. Again, it would be useful to have a couple of lists; one dealing with technologies or physical changes (solar power instead of coal, denser residential development to reduce transportation requirements, or slower population growth) and the policy instruments by which these would be accomplished (e.g. fossil fuel taxes, zoning, distribution of birth control). Note these do not need to match one-to-one; fossil fuel taxes or some type of permit scheme could be expected to create incentives for new technology, denser development, etc. In this regard, it would be useful to review the economics of second-best policies.

Page 3, Lines 17

The sentence "All of these factors ... in the course of time." should be eliminated. This seems to restate the obvious. The term "(suddenly)" is particularly troublesome because without a context of the size of the change, the degree to which the change was or was not anticipated, and the time period defined as sudden this is not a very meaningful statement. Better to provide specific evidence of learning curves or cost changes than to make general, unsupported statements.

Page 3, Lines 23

The distinction proposed, that CO2 is energy related and other greenhouse gases are not, is obviously incorrect and contradicted by the later discussion in this chapter of the emissions of methane.

Again, eliminate this distinction as it is clearly wrong (though the authors use of the term 'largely' may let them off). More to the point, given the possibility of sequestration, just because the source is largely fossil fuel, it does not logically follow that the response options need necessarily be largely related to energy (it is logically possible that forestation, carbon sequestration in soils and in the ocean, etc. may provide the best mitigation response options). It would be one thing to say that based on consideration of the relative costs and potentials, the most of the least cost opportunities are in the energy sector but quite different to suggest that conceptually this need be the case. The authors may simply indicate that the chapter considers, in order, mitigation options of the major greenhouse gases, carbon dioxide, methane, HFCs, nitrous oxide, and other greenhouse gases. Both options to limit emissions (reduce the size of the source) and to increase the rate of removal from the atmosphere (increase the rate of uptake by sinks) are considered.

Page 3, Lines 24-45

The list of measures does not take into account possible changes in the composition of output, or lumps those into energy conservation, when the latter should imply technological changes. For example, a shift from dependence on private cars to public transport in urban areas may not require any technological change, but it is a change in the "output mix" that would reduce energy use and emissions.

This list could be made more logically concise and could better relate to the statement on line 43-44 (it assets the list begins with primary energy and goes through end-use--in fact it is the other way around). A better list would be:

1. Changes in source of primary energy from more to less carbon intensive (e.g. switiching from coal to oil or gas or from fossil fuels to biomass, nuclear, solar, wind, tidal, ocean thermal, geothermal or other non-carbon energy sources).

2. Improving the efficiency of energy conversion and distribution from primary sources to secondary energy. (e.g. of electricity generation, petroleum refining, or natural gas distribution).

3. Improving the efficiency of secondary energy in specific applications (e.g. reduced energy use in iron ore smelting or increased efficiency of lighting, appliances, automobiles, and heating and air conditioning)

4. Changing the composition of activities in the economy by reducing the use the material, service, or appliance or substituting other less carbon intensive materials, services, or appliances. (e.g. switching from private automobiles to public transportation, bicycles or walking, lowering thermostats or using heating and air conditioning less, or substitution among materials in production. (Side note--there is a lot of evidence that as much or more of the difference in energy use per unit of GNP across countries and over time within countries is due to differences in the compostion of output as to the efficiency with which activities are conducted (e.g. see McDonald, S. 1990. A Comparison of Energy Intensity in the United States and Japan, PNL-7288, UC-400, Pacific Northwest Laboratory, Richland Washington.) This is, of course, why economics argues for prefer broader policy instruments targeted directly at the problem of interest such as carbon taxes as opposed to narrower instruments such as sector by sector standards-- taxes create incentives to improve efficiency but where efficiency improvements are costly will create incentives to switch to other materials. E.g. depending on whether glass, plastic, or aluminum can become more efficient as fossil fuel prices rise, bottlers and canners can quite easily switch among containers depending on which are cheapest.

Page 4, Lines 4-5

The sentence implies that consumer demands are the major factor in determining the potential for energy conservation. That is not true. All the demands for output, investment demands, government demands, export demands as well as consumer demands, are relevant for energy conservation. This unsupported statement appears only as an attempt by the authors to explain why fewer studies have been done with regard to conservation and as such seems unnecessary. If the authors believe it is relevant, they might simply state their objective finding that fewer analyses of the opportunities, costs, and potentials for changing the composition of activities in the economy have been conducted. As noted above, there are more aggregate analyses that indicate that this is a major mechanism of response to higher prices. Also, footnote 2 is interesting but a typographical error has rendered the sentence incomplete and grammatically incorrect. As this and other examples highlight, the authors frequently focus on costless or negative cost opportunities for carbon reductions. The summary highlights their findings with regard to this potential and importantly and correctly points out that schieving this potential will require policy intervention. The authors do not, however, provide much evidence of the type of intervention. The true no-regrets options are those where the intervention is to remove existing policy distortions (in footnote 2, it is creating equal treatment for earnings and in-kind remuneration (free parking) that would eliminate a tax code generated subsidy for private/solo automobile commuting to work.

Page 4, Lines 10

There is no reason to believe, as the sentence states, that, "renewable energy is characterized by a practically unlimited natural supply." There are limits to hydro power, wind power sites and forest cover. The last are recognized explicitly later in the chapter, so the statement is not consistent with the later discussion. Reviewer:

The sentence should be deleted. Moreover, as, in other places in the text, a broad generalization with value-laden terminology is applied to a general class of technologies and options. Without a definition of "severe local environmental impacts" as in what is the measure of impact, what is the quantitative cutoff between severe and moderate, and what area is covered by the term local, we are left with enough degrees of freedom to make this statement true for every technology or false for every technology. A reasonable definition, would no doubt find that some renewable technologies fall on each side of the cut-offs.

Page 4, Lines 42

Th sentence creates confusion through the use of imprecise language and language by the authors that suggest universal generality of their statements. I.e. "climate change is expected to take on the order of a human lifespan," Climate change is a continuous phenomena not an event. A more accurate statement here would be that "Based on current understanding of the possible transient path of climate change as described by WG-1, the global mean temperature is expected to increase by .25°C and 4°C over the next 50 to 100 years which covers the average expected lifespan for most people." Following on with this sentence, what does it mean that "the economic, social, and political systems change several times within a human lifespan and, as it seems, increasingly so as time progresses." What type of change is meant here. Yes, the former USSR and Eastern Europe has seen recent change but even so, it does not thus far seem to average more than about one change per lifetime. Western Europe and Japan had the disruption of World War II and World War I so maybe 2 changes per lifetime but growing more stable in the last half century. India and Latin America have been fairly stable. China had its share of disruption through the Mao period even though the government did not change. In general, p 4 line 35-p5 line 36 is an unstructured, interpretative description of events and history with (only one) selective citation to support the discussion. The exact purpose of this section is unclear. This would be a good place for the authors to list those options authors consider to be indirect options.

Page 5, Lines 32
The attention to the Reijntes work gives it credibility that may or may not be warranted. The authors do not cite any reviews that would warrant its credibility. While the authors may say that they do not certify the argument, neither do they criticize it. The authors should set up a consistent approach to their subject and follow it by reviewing and comparing the literature that relates each point rather then spread selective citations through the text where they seem to support the arguement that the authors happen to be making at the time.

Page 5, Lines 36
The suggestion that wave energy is, "particularly interesting if applied at a small scale in developing countries," implies that it can be applied at a small scale at costs competitive with other sources, in spite of the fact studies of wave energy are quite speculative.

This is a haphazard selection of a reference that supports a particular viewpoint rather than an attempt to provide a comprehensive review of scientific understanding of an area as is the intent of the IPCC assessment. This should be moved into a structured discussion of wave energy in later parts of the chapter if it remains. Again, to say that something is "particularly interesting" is nearly without content because we do not know what the standards are by which "interesting" is being judged. Do the authors mean that the system is particularly cost competitive where energy demands are small relative to the scale of central generation facilities? If so they should state it thusly and provide the data to support it. If it is interesting by some other standards, then they should state it precisely.

Page 6, Lines 16-40
The authors imply that an, "engineering efficiency" study would be an adequate basis on which to "proceed" to implement a program. This is not consistent with earlier statements, apparently less committed to this approach. See again, the response to comment 1. This distinction should be eliminated and issues of evaluating response options treated as discussed in comment 1.

Page 7, Lines 5-12
This paragraph is hopeless confused about developing countries and what is required for a welfare economics study. The ability to do such a study does not depend on its uses, i.e. the, "policy priorities," of line 7. Information about externalities is seldom, if ever, quantified in developed or developing countries. A, "lack of institutional capacity," is true of some developing countries, but not others. Mexico and Chile have as good an establishment for dealing with such issues as the U.S. and better than many other developed countries, such as Austria.

Page 7, Lines 14-15
There is no bias in welfare economics, as the authors state, against absorbing and applying new technologies. If

they make such a statement, they should provide a rationale for it. Again, this is a problem of the authors redefining a commonly accepted term in economics (welfare economics) to mean something completely different than how it is used in the discipline--the equivalent of using the term Greenhouse Warming Potential (GWP) when one is actually referring to instantaneous radiative forcing. A solid welfare economic analysis of a project or response option will consider points a-c as well as d-e. Unfortunately the authors miss in this list some of the reasons why costs may be higher (they refer to them elsewhere) in the text and they are listed under comment 1. In this discussion, it appears that the authors have confused part of the debate about top down and bottom up studies with their novel distinction of engineering versus welfare economic analysis. It is true that most aggregated econometric analyses generally assume that an economy is in some type of equilibrium where actors have chosen an optimal combination of inputs. In such a representation, the potential for the economy to be part way through a dynamic transition, hence the possibility for reductions (or increases) in carbon use in the absence of any further forcing (eg. price or policy change), are not directly represented other than as a trend phenomenon. Moreover, simplifications of constant returns to scale within an industry are made and with a constrained resource (labor, savings, natural resources), there will generally be increasing costs if any activity expands within the economy. The cost increase will be minimal if the sector/activity is small with respect to the size of the resource base. These constraints are not inherent in these types of analyses but reflect a convention largely determined by empirical practicality. Never-the-less, the problems of top-down analysis are largely irrelevant to this chapter. The authors should concern themselves with calculating the internal rate of return on projects, and can recognize that some of the analyses that have been conducted follow a narrow (current market prices without externalities) costing approach and others attempt to more broadly include other considerations. Actual valuing of all environmental externalities and other social considerations such as distributional effects is rarely done anywhere, developed or developing countries. The authors, may want to state the difficulty of valuing some of these external effects and allow that it may not be practical to value all external effects (positive or negative) to thereby calculate a full social cost-benefit or an internal rate of return to a project that prices all inputs and outputs (market and non-market) at their social value. On the issue of project costing, the authors should clearly familarize themselves with the UN, Guidelines for Project Evaluation referenced above, which while quite old (1972) remains, a fairly definitive statement, albeit somewhat optimistic on the ability to actually adjust prices for their full social cost. For a recent discussion of the issues of environmental valuation of external effects for inclusion in public decisions, the authors should consider three papers in vol. 8, no. 4, The Journal of Economic Perspectives. The authors are Portney, Hanemann, and Diamond and Hausman.

Page 8, Lines 1-24

This is another example of giving prominence to results from a study for which there is no evidence of a peer review.

Page 8, Lines 43-45

There is no evidence for the sentence on this page. It is true that there have been fewer studies of greenhouse related modeling for developing countries, but, there is no special intellectual obstacle to doing these studies. The authors should focus on the simple fact that there are fewer studies for developing and economy-in-transition countries and that where the potential for political, social, and economic change is great, future predictions are probably more uncertain.

Page 9, Lines 16

The authors put the KAYA identity to a use that is not warranted. It is an identity, which means that it is always and everywhere true. There are no behavioral relations in it. If there were, there would be interactions among the various terms. The authors completely ignore such interactions in using the identity as if it were a behavioral relation, itself. This error pervades the subsequent discussion. This discussion should be eliminated, i.e. at least from p. 9 line 13 to page 7 line 21. Other references to the KAYA identity should be eliminated. The chapter could reasonably be reorganized to include a discussion presentation of historical evidence with regard to energy-GNP relationships. The authors should take care not to confuse an identity with a behavioral explanation or as providing insight into prescriptive recommendations.

Page 10, Lines 10-12

This section is illustrative of the problem of using identities as if they are behavioral relationships. Using different conventions to measure either energy or GDP does not change the historical facts of what actually occurred nor whether the result was good or bad. Without a reasonable behavioral structure, this type of analysis suggests behavioral interpretation while the supporting evidence is insufficient to make any prescriptive judgement.

Page 10, Lines 23

This line contains the first recognition of the importance of structural change in determining energy efficiency. It is not reflected previously in the chapter.

Correction for this problem is provided in earlier comments. In general, this is another example of the haphazard presentation of material. I.e. earlier we were told that there were four categories of energy savings; now, suddenly the authors have discovered a fifth. This undermines the chapters credibility.

Page 10, Lines 37-45

The discussion is confusing. After carefull examining this section, the numbers presented in the text are consistent with the identity final/primary*useful/final = useful/final. At first reading, the various ratios presented appear to suggest at one point that efficiency is lowest in the developing countries but later that it is highest. More importantly, this is again a discusson that suggests behavioral and policy implications from exploration of the identity above. The different ratios for different groups of countries are almost certainly due largely to differences in the shares of different primary fuels and how they are used in the economy and secondarily to the efficiency with which individual fuels are used. For example, fuelwood and bagasse are a large share of energy use in many developing countries. There is little or no loss of energy in conversion from primary to final energy (the harvested fuelwood is used directly as a final fuel--though this is partly convention as one could count the energy content of the roots, stumps, and leaves that are not harvested as part of primary energy if there were data to do so). Yet, these fuels obtain very low efficiencies compared with electricity or natural gas in conversion from final to useful energy. The overall result is a low useful to primary energy ratio. In developed countries very little solid fuel (coal) is used as a final energy form but rather is converted to electricity. There are very large losses in this conversion. Thus, the ratio of final to primary energy is low in developed countries. But, this very conversion produces a final energy form that can be converted very efficiently into useful energy, so the useful to final energy ration is high. Note that for transition economies (and China and India), the greater direct use of coal as a heating fuel for example, creates the same biases (not much loss in primary to secondary, but large loss in secondary to final). The result is that the comparison of economies with different useful to primary energy ratios provides potentially seriously misguided information on the opportunity for efficiency improvement. As the above example, illustrates another interpretation of this data is that developing countries could obtain the efficiencies of developed countries by switching from fuelwood to electricity and natural gas; this may or may not be desirable from a carbon perspective or from an economic perspective. The point is there is no foundation for arriving at any particular conclusion from this identity. Suggest that this be deleted.

Page 11, Lines 6

A "back of the envelope calculation" can be given no credence unless explained and this seems hardly the place for casual empiricism. This section should be deleted.

Page 12, Lines 3

It is simply not true that a, "substantial part of the demand for energy is met from renewable energy sources like biomass," in industrialized countries. What could the authors be thinking of: firewood for fireplaces, solar or wind energy? These are not significant. Only hydro power, in some countries, provides an example.

Again, the authors use terms like substantial without indicating what is there standard for substantial. Should this be seen as a necessary statement, they should provide quantitative estimates of the contribution and allow the reader to judge whether this is substantial or not. The focus throughout the text on renewable versus non-renewable is peculiar as the effectiveness of an energy technology mitigation strategy depends on how little carbon it emits and its supply (cost and quantity). It renewability or nonrenewability has little to do with these factors.

Page 12, Lines 16

The non-standard and conceptually indistinct distinction between 'conservation' and 'efficiency' creates confusion. The conclusion in this line is unsupported by data or citation. The authors do not identify what "indicators...point in this direction." If there is evidence for this statement, the authors should present it. There is much controversey on this point and many definitional differences. For example, are the authors referring to energy savings through conservation against a projected growth path (that might include increasing energy use due to structural change) or from current levels.

Page 13, Lines 8

The statement shows that the authors do not understand the significance of a high discount rate. The idea that policy can change such a rate suggests that it is simply a matter of monetary policy, which is quite wrong. The reference to the, "host of studies...suggesting a considerable scope for no-regrets options," is not balanced by reference to studies that show limited scope for such options.

Part of lack of balance is a structural defect of the WG-III report and a good reason for eliminating this chapter. As this chapter focuses primarily on the bottom-up type of study, it probably correctly represents the bulk of literature conducted in this manner. The more balanced approach is to present the evidence of top-down and bottom-up studies together as is done in other chapters in WG-III. But having done this elsewhere there is no need to do it again here. There is not an inherent reason that bottom-up type studies cannot provide a more balanced picture as pointed out elsewhere again relating to misguided distinction between engineering and welfare economic studies. The authors should provide discussion and citations of studies that analyze what barriers exist that have led firms and households not to adopt technologies that cost studies suggest would be economically advantageous to adopt.

Page 14, Lines 32

The authors state that estimates of reserves of natural gas are likely to be revised upward in the near future. But only a few sentences earlier state that fossil fuel reserves will last for only 130 years, as if there is no chance that coal and oil reserve estimates will also be revised upward.

In addition, the authors appear to misuse or mix terminology. They consider fossil "reserves" which normally do include estimates of unproven resources, but refer to natural gas "resources" which includes proven reserves as well as estimates of undiscovered resources that might be economically recoverable. Mixing these terms without explanation (or without awareness of there specific meanings) leads to confusion. Speculation on the possible transition to other fuels in the long term (lines 30-36) is not supported by data or citation. As in other places, the authors frequently refer to engineering potential or measure of resource absent any economic dimension which is not very useful and potentially misleading. For example, while the amount of hydrogen that could be obtained from water is massive in relation to conceivable future energy use, the technology for obtaining hydrogen from water is electrolysis which requires large amounts of electricity. The economic desirability of hydrogen thus depends on the cost of electricity generation. The amount of electricity required is so large per unit of hydrogen energy produced, that there would have to be an extremely high premium on gaseous fuels over electricity to make it pay to ever use hydrogen instead of using the electricity directly. Note here that hydrogen offers a good example of why the renewable, non-renewable dichotomy is fairly meaningless. Technically, hydrogen is a non-renewable energy source because there is a fixed (but very large) quantity (basically all the hydrogen in water). If it could actually be utilized cost-effectively, there would be no reason to favor "renewable" energy over this non-renewable form.

Page 15, Lines 9

The GWP measure for methan should be checked against WG-I. It may be better to provide the radiative forcing or to provide a range of GWP given the various ways this can be calculated. (see, eg. Reilly and Richards, "Climate Change Damage and The Trace Gas Index Issue," Environmental and Resource Econmics, 3: 41-61, 1993.

Page 15, Lines 41

It is not true that biomass, wind and solar energy can always be produced, "near the spot of consumption," at least at economically relevant costs.

The wording is poor and should be changed to indicate that where remote sites have favorable conditions, these technologies are relatively more cost competitive with fossil sources because there are significant economies of scale for fossil electricity generation at scales up to ?? megawatts. I.e being more specific here would be beneficial, including citations.

Page 15, Lines 44-45

The authors are generally correct that these are well-developed relative to ocean technologies. One may argue whether the current share of these technologies in the market place (in many cases only with substantial subsidy) can be called "well-developed." Again, the problem is that the basis for distinguishing "well-developed" from a non-well-developed technology is not specified. The most useful (but among the more difficult to empirically assess) basis would be the some measure of the potential for future reductions in the cost of the technology. A well-developed technology would have little cost-reduction potential. From the learning curve type of analysis, well developed technologies would be those where the learning curve slope has leveled off. But, a technology could be well-developed by this standard and far from economically competitive.

Page 16, Lines 21

The estimation of "practicable potentials" in energy technology is of no use at all unless there are cost estimates associated with it. There are many ways of producing energy, nearly all of which are terribly inefficent and not economically feasible. There are, relatively, only a few ways of producing energy that are economically feasible. A "practicable potential" may be technically feasible, but that tells us nothing about its economic feasibility.

Practicable potentials should be eliminated without evidence of the economic dimension. In particular, these number should not be carried into the summary.

Page 16, Lines 28

This statement is not very informative nor does there appear to be analysis supporting the statement that the differences are "mainly" due to these factors. The table is fairly confusing in identifying what the convention is for adjusting for inflation. The current and future costs appear to refer to costs if the technology were applied today and costs after further development but in constant dollar terms. The IEA estimates are reported as in 1984 British pounds (presumeably converted to US dollars using the 1984 exchange rate?). The footnote 2 after Johansson et al. includes "1984." Is this to be taken as in 1984 dollars? There is no indication for the other 2 sources of estimates. This is not very useful unless the dollars are adjusted to a comparable year for all studies and potentially misleading if left in 1984 dollars because the economy-wide implicit price deflator increased 37.3 % between 1984 and the end of 1993 (as in the 1994, USA, Economic Report of the President). Thus, to compare these costs with current prices of energy, they should be multiplied by 1.37 (or 1.4 or so to get to 1995). The unalert reader might well compare these costs to the current price of energy which would bias these the interpretation toward making these more cost-competitive than they are.

Page 16, Lines 40

The statement that, "current prices of hydro, wind and some solar and biomass technologies...are already competitive with conventional sources," is highly suspect, except for hydro. The wind and solar power applications are nearly all subsidized or legislated into existence via requirements that utilities purchase electricity from these sources as in California. The calculations with respect to their competitiveness usually assume cost reductions that have yet to be demonstrated.

Page 17, Lines 12

The statement is true; but its converse, which is not presented, is also true. This reflects the bias of the authors. If this passage is retained it should list the barriers as well as the positives. Most of this discussion lacks rigor.

Page 17, Lines 35 Comment: Nuclear plants, for example, in France, do not have unduly long design/construction times. The authors clearly do not understand the sources of the long times in the U.S.

The authors accept the long lead time barrier for nuclear power as insurmountable yet are willing to see the barriers

that have prevented renewables from penetrating as opportunities for policy intervention that can provide a free lunch. A more factual presentation and less subjective judgement would enhance the scientific credibility of this discussion.

Page 17, Lines 43
The authors use a welfare economics argument with respect to nuclear power, but have not used such an argument with regard to other non-conventional power sources. This again suggests a bias.

Page 18, Lines 15-16
What is the basis for the statement that "significant intermediate potential," for carbon capture and disposal in China exists. If the statement is true, it would be true for many other countries as well.
The authors must present data and/or authoritative citations.

Page 18, Lines 44
The basis for the statement that there is, "almost unlimited potential to store," CO2 in aquifers, is not provided and it is quite implausible, again, if there is an economic constraint.

Page 19, Lines 8
Storing of carbon in forests is not likely to have modest costs, if the cost of land is taken into account correctly. Deforestation in Latin America is most often the result of land having greater value in other uses than in forests.

This is a serious issue and consistency needs to be established among the chapters in WG-II and WG-III that deal with this issue. It is unacceptable to report carbon storage costs in forests as if there is no alternative use for the land. The fact that deforestation occurs is clear and incontrovertible evidence that both the land and a standing stock of trees have alternative value.

Page 19 Line 21
The list of forestry measures is very narrow; suggest rephrasing as follows:"...commonly distinguished: halting or slowing deforestation; reforestation and afforestation; adoption of agroforestry practices; establishment of short rotation woody biomass plantations; lengthening forest rotation cycles, adoption of low impact harvesting methods and otherwise adopting management methods that maintain and increase carbon stored in forest lands; and sustainable forest exploitation..."

Page 19, Lines 29-32
This contradicts the statement in line 8.
The authors should resolve this apparent conflict between statements of costly competition with estimates that do not include land costs and the statement of large potential and modest costs. Again, not only do the authors use subjective terminology such as substantial, modest, large, small, they appear to shift their frame of reference without giving the reader much indication of how there frame of reference has shifted. Thus, a forestry potential that is referred to as large is later referred to as limited. By disciplining themselves through quantification the authors would be less likely to repeat this mistake and the reader could use their own frame of reference to determine whether the amount was small or large. This sloppy language is unacceptable in a scientific assessment.

Page 20, Lines 11
There are no citations or evidence presented to support this statement. There is a body of agricultural economic literature that argues for the importance of market failures as a source of many of these problems. Part of the problem is drawing a line between technical and economic. Correcting market failures will encourage adoption of technical solutions. These statements should be referenced and the logic clarified.

Page 20, Lines 32
Land use does not depend on "perceptions" in a market economy, but on market forces. Market forces can be quite ruthless to people who operate with perceptions too far from reality.

Page 20, Line 36

Centeno 1992 is not included in the references at the back.

Page 21, Line 13
The statement that Nordhaus (1990) did not account for "the rapid growth that could be achieved in young forests" is very misleading. Nordhaus' cost estimates were dramatically higher than everyone else's because he used very low estimates of the carrying capacity and length of productivity of forest plantations. One of the few things he did right, in fact, and was way ahead of the rest of us, was to try to account for the growth pattern of forests with a logarithmic growth function. Some forests do grow quickly when they are young, but they tend to be in tropical areas that have a host of social stability/forest protection problems. Even in the Southeast U.S., where we have our highest productivity, it takes loblolly pine 15 to 25 years to hit peak carbon uptake rates. One of the reasons tree planting doesn't figure prominently in the U.S. CCAP is that you get almost nothing in the first decade after planting. Chapters 8 and 9 contain a figure that illustrates the fact that peak uptake rates in the U.S. do not occur until the 2nd to 5th decade after planting, the exact timing of the peak depending upon the species and region of the country.

Page 21, Line 13
The reference should be to: Richards, Rosenthal, Edmonds and Wise 1993. "The Carbon Dioxide Emissions Game: Playing the Net" Presented at Western Economic Association Annual Meeting, Lake Tahoe, NV. Reviewer:

Page 21, Lines 21-22 Comment: Perhaps there are places where land is free, but there cannot be many of those which can grow forests. Forests are valuable and would make land valuable. The authors trip up again on simple logic. See earlier comments. This should be resolved.

Page 22, Lines 15
The authors finally recognize that point estimates of costs are much less useful than cost functions. However, if they believe what they say here, they should qualify many of their previous statements about costs.
This section is a great improvement over all the previous material but is probably redundant with other chapters.

Page 23, Line 27
Rephrase to read: "c. rising opportunity costs as fallow land is used up and plantations move on to land suitable for alternative uses."

Page 23, Line 31
This is confusingly and awkwardly worded. Suggest, "Together these factors generally mean that marginal costs will rise as the area being forested increases. Exceptions..."

Page 24, Line 21
Comment: Should include cite to Richards, Moulton and Birdsey (1993), already included in the references.

Page 24, Line 26
Comment: Sentence should end with cite to Richards 1993, already included in the references but not cited anywhere.

Page 24, Lines 28-30
The conclusion that newer research tends to find steeper increases in costs, and that the costs per tC range from $30 to 60/tC is not a justified generalization. It is inconsistent with the data reported in both the WGII and WGIII discussion of forestry mitigation costs. It may be true that the marginal costs of carbon sequestration in large national programs would be 30 to 60 $/tC, but it is certainly not the case that the average social costs fall in that range. This statement is not even consistent with Table 10 on the same page where Adams et al. suggest that the marginal cost (i.e. the cost of the last, most expensive ton of carbon) in a 420 MTC/year program, would only be $37. The average cost in that program looks to be something more like $25.
The chapter should make itself consistent or explain this apparent inconsistency. Coordinatin with other IPCC chapters is needed.

Page 24, Table 10
The carbon cost listed for Parks and Hardie is incorrect. They have mistakenly labeled their costs as being in units of $/tC. In fact, their costs are in units of $/tC/year. That is, they develop costs for flows of carbon not for a one time, one ton capture of carbon. Comparing their results to those of Moulton/Richards and Adams et al. is like comparing apples and oranges - or more precisely, like comparing oranges and crates of oranges. Check with Ken Richards (Pacific Northwest Laboratory) or Roger Sedjo for clarification if needed.

Page 24, Line 26
The next version of WGIII Ch.8 will include a discussion of the lack of consistent definition of the term $/tC among cost studies. The term is used five different ways in the literature, at least three of which are defensible. The choice of definition makes as much as an order of magnitude difference in cost estimates. A correlation between regional analysis and choice of definition is at least partially responsible for the misperception that carbon sequestration is much more expensive in the temperate regions than in the tropics. The confusion has led to misuse of cost figures, and to the extent that 4.6 compares the figures in Tables 8 and 9 with the figures in 10 it perpetuates that misuse. We may want to coordinate our respective chapters once the new section is added to Chapter 8.

This is more evidence for eliminating this chapter which appears to have taken a very casual approach to reviewing the evidence and studies whereas the material is reviewed far more rigorously in other places. The non-expert is likely to come away confused by multiple presentations of material where some of it is incorrect or misleading.

Page 25, Lines 35 Comment:

The statement that developing drought resistant cultivars and techniques is a no-regrets option fails to take into account the costs of such development. The options of allowing droughts or providing irrigation also have costs, but those may or may not be lower than the costs of developing drought resistant cultivars.

There are far better discussions of agricultural adaptation in WG-II. This material offers no references.

Page 26, Lines 16
The authors give short shrift to the effects of climate change on agriculture, as compared to their more extended discussion of other effects. Table 11 appears somewhat confusing. Averaging different scenarios as in the last three columns has doubtful scientific merit. The source of this table is a non peer reviewed document. The basic material has been published in peer reviewed form and, while the same result format is not presented, offers the same insights with other tables. The Reilly(1994) citation is not listed in the text. I suspect this should be:
Reilly, J., N. Hohmann,and S. Kane, 1994: Climate change and agricultural trade: who benefits, who loses? *Global Environmental Change*, **4(1)**, pp. 24-36.

Also peer reviewed versions of the Rosenzweig and Parry work are:
Rosenzweig, C. and M.L. Parry, 1994: Potential impact of climate change on world food supply. *Nature*, **367**, pp. 133-138.
Fischer, G., K. Frohberg, M.L. Parry, and C. Rosenzweig, 1994: Climate change and world food supply, demand and trade. *Global Environmental Change*, **4(1)**, pp. 7-23.

Detailed results in:
Rosenzweig, C., M.L. Parry, and G. Fischer, in press: Climate change and world food supply. In: *As Climate Changes: International Impacts and Implications* [K.M. Strzepek and J.B. Smith (eds)]. Cambridge, Cambridge University Press.

Page 27, Lines 23-24
One can agree that dynamiting coral reefs should be stopped, but the logic of the relation to accommodation to sea level rise is obscure.

Page 27, Lines 38-39

Comment: The statement is not likely to be true and is inconsistent with other statements by the authors. What about health, heating/cooling, etc. The authors appear to use this statement to justify their failure to cover other sectors. They should simply indicate that they only cover these sectors, others that may be affected include.

Page 28, Lines 5-24
None of these adaptation options are referenced nor is there any evidence that literature evaluating these options was reviewed. Where does the 'ballpark' figure for 'controlled environment agriculture' come from and what is controlled environment agriculture--greenhouses or farm buildings? Of course greenhouses are currently used extensively but there are no studies that suggest that climate change will increase the need for greenhouses--a few suggest that greenhouse costs will fall because of reduced heating costs. And, some studies have identifed modification to farm buildings as likely adaptive responses. The authors need to be far more specific with regard to what they are referring to if they propose cost estimates or judgements about the scope for improvement. This appears to be a very selective list, with little evidence as to why these options deserve 'special attention' (line 3) References should be supplied for this section and it should be made more complete, or it should be deleted entirely.

Page 28, Lines 25-26
The reasoning is incomplete and unconvincing as stated. The authors need to provide a clearer exposition of their chain of reasoning that goes from unequal distribution of land to marginal groups being at greater risk of loss.

Page 29, Lines 42
This statement is undoubtedly true, but the authors have not taken it to heart in their previous discussions, where, in spite of lacking an integrating framework, they have presented assessments with only narrow bases as if they were believable.

Page 30, Lines 4 Comment: The authors have previously argued that economies of scale in forestry were negligible. Which is true? Also, figure 2 provides evidence that on a broader scale, marginal costs are increasing as these total costs curves bend upward. The authors have not provided much evidence here on the range over which economies of scale are observed. Is this over the range of, for example, 1 to 100 units when the likely level of application is 1,000,000 units or is it over the entire range. More specificity would greatly reduce the apparent inconsistencies.

Page 30, Lines 25
The sentence is grammatically incorrect and substantively incorrect. The so-called "top down" studies will often pick a single best option. The authors are over-generalizing, apparently based on knowledge of a limited and not universally representative efforts.

Page 38, Line 38
The cites are mistaken as they stand. Moulton and Richards (1990) did not include consideration of increasing marginal costs. That cite should be stricken and replaced with Richards, Moulton and Birdsey (1993) and Richards, Rosenthal, Edmonds and Wise (1993).

Page 44
The cite to Richards, K.M. should be corrected to Richards, K.R.

U.S. Government's Comments of the
IPCC Working Group III Draft Assessment
Chapter 8: Estimating the Costs of Mitigating Greenhouse Gases

General Comments: Review Coordinator

The chapter presents a reasonably thorough overview of the issues involved in estimating the costs of GHG gas mitigation, and includes most of the useful information on the subject. However, in its present form the chapter is somewhat disorganized and confusing and would, in our opinion, greatly benefit from the following recommended reorganization.

Current form of the Chapter. In its present form, Section 1 of the chapter begins with a taxonomy of cost concepts, then discusses the distinction between gross and net costs, and then discusses factors affecting costs, particularly the efficiency of the baseline and the nature of the mitigation policies. The main problem with this section as it stands is that it does not compare the cost concepts to an ideal, so that the relative utility of the different concepts can be compared.

Section 2, titled "patterns of development and technological change," has three separate sub-sections, only one of which is directly related to the title. The first sub-section focuses on factors that affect emissions and adaptive behavior (technology, consumption patterns, geography, trade, etc.). The next sub-section discusses "current and future development patterns"; however, this sub-section is simply a restatement of the first, and the two would read better if they were integrated. The final sub-section discusses the concept of multiple baselines.

Section 3 discusses differences among models and their results, focusing on the differences between models and the key assumptions affecting their results. (Carbon sequestration is given a cursory treatment, while non-carbon emissions are not treated at all.)

Recommend Revision of Chapter. We recommend a four-section structure as follows.

1. Costs. Rather than begin with a taxonomy of cost concepts, this section should begin with a discussion of the components of an ideal cost assessment, focusing on the need to characterize the response of all markets to policy options and to account for externalities, information costs, distributional effects, and so on. The section should also discuss the major difficulties involved in meeting this ideal cost assessment, mentioning particularly the lack of market institutions in many countries, the absence of markets for many goods (pollution, etc.), the difficulty of characterizing information costs, and the growing uncertainty that arises in forecasting further and further out into the future. (This discussion could touch on the concept of multiple baselines.) Finally, the section should close by characterizing the different cost concepts found in the literature and comparing them to the ideal.

2. Factors Affecting Costs. This section should incorporate the discussion currently in sections 2.1.1 and 2.1.2, preferably integrating the sections together. It should bring together in one section the factors that most strongly affect emissions and behavioral responses to mitigation options, including population growth, technological patterns, consumption patterns, resource availability, geographical distribution of activities, economic structure, land use, transportation, trade, and so on.

3. Modeling Approaches. This section should begin by noting that there are a number of different methodological approaches that generate different types of cost estimates, and that none of them has been used to generate an estimate of full costs as defined in Section 1. It should then describe in some detail the "bottom-up" and "top-down" approaches, taking care to describe the "top-down" approaches as a range from simple macroeconometric models to highly detailed CGE models. It should then make four important points: first, the approaches are being integrated only gradually; second, different models will remain suited to answer different issues; third, none of the models are suited to address issues of long-term development because of uncertainty over technology, etc.; and fourth, the models present a wide range of cost estimates. The section should then discuss the controversy over the reasons for the wide difference between the "bottom-up" and "top-down" cost estimates (i.e. whether the high cost estimates involve market failures, intangible costs, or some combination of the two), and should then discuss the related issue of the extent of "no regrets" potential. Alternatively, the discussion of these controversies could be placed in the next section.

4. Most Important Insights. This section should present important basic findings, such as the importance of baseline assumptions in determining cost estimates, the importance of economic instruments, the possibility of multiple baselines and the importance of infrastructure decisions, the nature of "double dividends" and how to account for them in costs assessments, the areas of greatest short-term mitigation potential, and so on.

In addition to the major structural revision recommended above, a few omissions, discussed in

the specific details below, should be corrected, including 1) a more extended explanation of gross vs net costs, and the economics of the "double dividend" from tax recycling, 2) the estimation of mitigation costs for GHG's other than carbon, 3) the potential importance of, and interaction between, sequestration and biomass energy, and 4) the potential role of CO2 recovery (even though it is not generally deemed cost-effective, it should at least be discussed).

Finally, we recommend that the following chapter summary bullets be included at the beginning of the chapter and in the conclusion.

Recommended Chapter Summary

1) A complete evaluation of the costs of greenhouse gas mitigation would require an accurate technical description and pricing of all of the inputs and outputs in all markets affected by mitigation policy options, and would describe how output and prices in all markets are affected by policy options over time. This is a very difficult task because the economy will respond in many ways to changes in policy that, for example, raise fossil fuel prices or promote new technologies. Economies of scale and learning associated with broader use may reduce the costs of new technologies as their scale of production grows. On the other hand, dependence on limited resources of varying levels of quality may increase costs as scale grows. Moreover, markets for existing technologies may also respond: introducing more efficient energy technology or non-fossil energy supplies may drive down the prices of fossil fuels.

2) An evaluation of full social costs and benefits of a policy will be particularly difficult where market institutions do not exist; where market prices fail to reflect external costs such as pollution; where information costs play a significant role (as is the case with new technologies); or where costs are estimated well into the future. In each of these cases, it is very difficult to quantify costs, either because they are not fully captured in prices that reflect buyers' and sellers' evaluation of goods and services and hence are not readily observable and measurable, or because of the great uncertainty about future developments.

3) Mitigation costs will be affected by a wide range of factors, including population growth, consumption patterns, resource and technology availability, geographical distribution of activities, land use and transportation patterns, and trade. Ideally, all of these factor should be taken into account in estimating mitigation costs.

4) Existing studies use a variety of methodological approaches and definitions of cost to assess the costs of mitigating GHG emissions. No existing study yields a complete evaluation of full social costs and benefits. Instead, studies present a range of cost estimates: some provide estimates of direct financial costs of specific technological options; others provide estimates of the effects of broad policies on aggregate economic activity; still others attempt to estimate welfare costs. It is important to be clear about which type of cost is being estimated in any specific study.

5) The range of methodologies can be grouped into two generic classes: "bottom-up" studies focus on detailed technology assessment; while "top-down" focus on aggregate responses of the entire economy.

- "Bottom-up" studies begin with detailed assessments of engineering costs of a wide range of available or forecasted technologies. The studies calculate the financial costs of these options, generally at current market prices, and compare the options to each other and to current technologies in the market. They do not quantify the aggregate impact of technology adoption on related markets or on the overall economy. "Bottom-up" studies generally show that the best existing technologies yield very high energy cost savings relative to the cost of continuing to use installed equipment and not adopting the best technology, so that it appears financially profitable to replace a large quantity of existing equipment. As a consequence, these studies generally conclude that a significant quantity of emissions reductions – well beyond stabilization at 1990 levels for the next two decades or so – can be achieved at net savings, where costs are calculated as the sum of the equipment and energy costs to individual equipment users.

- "Top-down" studies use a wide range of methodologies to try to calculate the response of the entire national, regional or global economy to a policy option, typically to an emission tax such as a carbon tax. These studies typically evaluate costs as the difference between gross domestic product (GDP) in a no-policy "business-as-usual" base scenario and GDP in a policy scenario. Some models attempt to quantify the change in overall economic welfare as defined by economists. Because the models represent markets in a fairly aggregate way, they do not provide for detailed assessments of particular technologies. Instead, they attempt to quantify in a more general way the response of the aggregate economy and the slow adjustment of all markets, thus trying to account for components of full social cost not quantified in the "bottom-up" studies. The processes are modeled on the basis of statistical analysis of historical behavior. "Top-down" studies yield a range of cost estimates, and the results depend critically on the choice of modeling framework. On one end of the spectrum, general equilibrium studies, which provide for rapid adjustment of markets, yield relatively low cost estimates (e.g. $5/ton to $20/ton for stabilization of emissions at 1990 levels over the next decade or two); on the other end, macroeconometric studies, which try to represent the more gradual adjustment that is typically found in real economies, yield medium to high cost estimates (e.g. $40/ton to over $100/ton for stabilization of emissions at 1990 levels over the next decade or two).

6) The different cost assessment methodologies are gradually being integrated. The most detailed models currently being developed provide for highly detailed representation of the energy sector and also for representation of the rest of the economy. This convergence means that differences in results from integrated models will be driven increasingly by differences in input assumptions – particularly assumptions about the rate of penetration of new technologies – rather than

differences in model structure. Peer-reviewed results from these models are not yet generally available.

7) Despite convergence of methodologies, different types of models will remain best suited to answer different kinds of questions. Models with more detailed representation of technology are more suited to identifying technical potentials and financial costs and savings; models with more detailed representation of broader economic activity – consumption, investment, international trade, and so on – are more suited to identifying costs in terms of higher or lower economic growth. However, none of the existing approaches is very effective at quantifying long-term costs because there are likely to be a range of very different long-term socio-economic and technological development paths that would give rise to quite different emissions scenarios and costs of mitigation.

8) There is substantial disagreement over the reasons for the wide difference between the low mitigation cost estimates found in "bottom-up" studies and the higher cost estimates found in most "top-down" studies.

- Proponents of the low-cost view tend to view the high costs found in the "top-down" studies as evidence of a range of market failures, such as lack of information, capital constraints and inadequate investment in research, development and commercialization of new technologies. They point to the low adoption rate of profitable technologies as *a priori* evidence that there must be a range of market failures; they tend to conclude that the economy is operating well below its potential, and that its performance can be substantially improved at relatively low cost.

- Proponents of the high-cost view regard the low market penetration of what appear to be profitable technologies as a priori evidence that there must be a range of adjustment costs, information costs, and other intangible costs that are not measured in detail in any studies but that are nevertheless captured in the aggregate in the "top-down" studies. While they may consider these costs as evidence of market imperfections, proponents of the high-cost view generally do not see them as evidence of market failures that can be corrected at low cost. As a consequence, they tend to conclude that the economy is operating near its maximum potential.

9) As a consequence on the controversy described above, there is substantial disagreement over the extent of "no regrets" potential for GHG emissions reduction (i.e. reductions that can be undertaken at net savings). The extent of "no regrets" potential depends on how efficiently the economy is operating. The conclusion of some researchers that significant "no regrets" potential exists is based on their view that significant market imperfections or market failures exist which give rise to increased GHG emissions (i.e. society is below its production possibility frontier), and that policies can be designed and implemented at low cost that eliminate these market imperfections or correct these market failures.

10) Although researchers attempt to incorporate their best understanding of development processes into the studies, neither the baseline nor the intervention scenarios should be interpreted as representing likely future conditions, especially more than two decades into the future. Policymakers should place more confidence in the insights generated by modeling analyses than in the specific numerical results of any one analysis. Here are some of the important insights that have been generated.

- The magnitude of mitigation costs depends critically upon the assumptions built into the baseline of the model. Models with high assumed economic growth rates tend to show high rates of energy use and therefore greater costs of mitigation. Likewise, the greater the assumed efficiency in the economy, the greater the costs of mitigation; and the more emissions reduction built into the baseline, the greater the costs of further reduction.

- Economic instruments such as taxes and tradeable permits are likely to be more efficient than regulatory approaches.

- Decisions about provision of infrastructure are critical because they have long-lasting effects that can allow or restrict future options, and different decisions can lead to very different cost outcomes. The issues include transportation infrastructure, electricity generation, and land use regulation. These issues are of particular importance to developing countries, where major infrastructure decisions will be made over the next 25 years.

- Mitigation policies may have beneficial or harmful side effects. Two potential benefits may be very important in determining the net cost of mitigation.

    - Emission taxes, such as carbon taxes, will raise substantial revenues, and how the revenues are redistributed can dramatically affect the cost of mitigation. If the revenues are redistributed by reducing rates on the most distortionary taxes in the existing system, they will help reduce the "excess burden" of the existing tax system, yielding an additional economic benefit. On the other hand, if the emission tax revenues are used to fund wasteful activity, the tax could be even more burdensome.

    - GHG emission taxes would be likely to reduce emissions of other pollutants, with additional benefits.

  To the extent that such side-effects provide benefits, the emission taxes would yield "double dividends," and would entail lower net costs than if there were no beneficial side-effects. It is important to distinguish between the gross costs of mitigation measures and net costs. From a policy point of view, decision-makers will be served best by being provided with information on both gross costs and net costs.

- The areas of greatest short-term potential for cost-effective emission reduction include energy and non-energy conservation and forestry.

- Encouraging energy supply or conservation lowers overall energy prices, resulting in some increased energy demand and emissions. This is called the "bounce-back effect."

Specific Comments on Chapter

Page 1, Line 8-18. This section overstates the "strong tradition in long-term energy modeling and energy forecasting". We suggest modifying the text to ". . . the existence of an established tradition of long-term energy modeling . . .", and adding a footnote: "However, before the climate change, "long-term" energy modeling generally meant 10-20 year time horizons, not the 100 plus year horizons used in climate change scenarios."

Page 1, Line 42-49. The gap between what policy makers expect and what "information economics models can supply" needs to be acknowledged - this observation should be kept in the report.

Page 2, Line 25-34. Presumably this WGIII document makes some reference to adaptation in addition to mitigation and damages. It would be useful to refer to sections in Chapters 2 (Decision-Making Framework), 5 (Cost-Benefit) and 6 (Social Costs) that discuss adaptation.

Page 3, Line 19. Add "s" to "economic".

Page 3, Line 20. Add the following text noted in italics: "an additional ton of carbon *(or its equivalent)*"

Page 3, Line 20. Spelling of "marginal".

Page 3, Line 39. It would be helpful to the reader to refer to the first type of costs as "direct engineering and financial costs".

Page 3, Line 39-51. Figure 8.1 presumes that there are energy savings from some efficiency investment, so that it has negative net cost. However, the paragraph only mentions positive expenditures for energy. If avoided energy is considered in evaluating a specific technical measure, it must be mentioned. It would be helpful to add a sentence on line 45: "Technical measures can show negative costs because a given technology may yield enough energy cost savings to completely offset the cost of the technology, relative to the cost of continuing to use installed equipment and not adopting the technology."

Page 3, Line 47-49. This caveat, that "they do not provide an economically meaningful cost assessment unless they are fed into coherent technical... frameworks", is accurate and important,

and should remain in the document

Page 4, Line 14-15. It would be helpful to distinguish between 1) macroeconomic cost comparisons between equilibriums, and 2) macroeconomic costs that occur in the transition between macroeconomic equilibria.

Page 5, Line 11. Change "Second, human welfare does not ..." to "Second, human welfare may not ..."

Page 5, Line 13-14. Add to sentence: "Third, changes in the level of GDP do not account for the relationship between distribution of income and overall welfare, and the measurement of overall social welfare is extremely problematic."

Page 5, Line 21. Change "direct financial costs" to "direct engineering and financial costs".

Page 6, Line 31-54. The extent of the "negative cost potential" issue is controversial, and the acknowledgment on line 33 should remain in this section. Similarly, acknowledgment of the controversy (lines 51-52) about the existence and magnitude of positive side-effects also is accurate and should remain in the report.

Page 6, Line 44. Modify text: "land and natural resource degradation, such ..."

Page 7, Line 16. Modify text as follows for clarification (see also accompanying revised figures).

"Fig 8.2 illustrates the various components of the net costs of reducing carbon emissions. The first column, labeled "direct control costs", represents the direct costs of reducing emissions through fuel substitution and price induced energy conservation. Figures 8.2a and 8.2b also illustrate the same concept of control costs, in the diagram form familiar from analysis of the excess burden of taxation. In Figure 8.2a, the triangle labeled A is the cost of an emission tax that reduces emissions from Q' to Q", and corresponds exactly to the control costs illustrated in Figure 8.2.

"The column labeled "added tax burden" in Figure 8.2 corresponds to the rectangle labeled B in Figure 8.2b. This rectangle represents the additional costs of an emission tax when it is levied on top of existing distorting taxes. As Goulder and others have noted, emission taxes are taxes on intermediate goods that will be shifted back onto other factors of production, labor and capital, that are already taxed. Emission taxes are like increases in already burdensome taxes, and therefore have costs greater than would be estimated by examining their control costs alone.

"The column labeled "Uses of Revenues" can be either positive or negative. If the revenues from emission taxes are used to fund new government programs with a return less than would be earned if the same resources were invested privately, there will be an added positive cost. If taxes

are recycled in lump sum fashion, there will be neither added costs nor offsetting benefits. If taxes are recycled to reduce distorting taxes, there will be a benefit (or negative cost) which may be larger or smaller than the added tax burden. Whether the benefits of recycling are large enough to offset the added tax burden depends on whether the taxes that are reduced are highly distorting, and whether the taxes that are reduced are on the same factors of production that carbon taxes are shifted to or on other factors. These issues are discussed in the recycling section of Chapter 9.

"The last two columns represent the environmental benefits, outside of climate, that may accrue from reducing energy use and associate emissions, and the possible reductions in cost that could come from removing energy market imperfections to exploit a "negative cost potential." The result of all these adjustments to the direct costs of reducing emissions is to produce net costs of emission reduction that may be greater or smaller than the direct costs, and that may be negative if the revenue recycling benefits, environmental dividend and negative cost potential outweigh the direct control costs and added tax burden. These net costs than must be compared to the benefits of delaying or reducing climate change."

Page 8, Line 22-24. Not a sentence. Delete "then".

Pages 8-13. This section provides a very useful characterization of different views of economic and emission reduction trade-offs. The section needs to remain but could be clarified.

Page 10, Line 10-11. Please retain this important point. Indeed, Fig 8.3 shows this point. At point O, an economy committed to emission reduction has a 50-50 chance of moving in a southeasterly (less economic activity) as in a northeasterly direction.

Page 10, Line 10-11. The discussion seems to distinguish between market failures and institutional failures without ever explicitly doing so. If the authors intend such a distinction, it would be helpful to the reader to have a short elaboration on the difference between the two (e.g. market failures such as externalities or natural monopoly vs. institutional failures such as inadequate delineation of property rights, inadequate regulation or over-regulation).

Page 10, Lines 16-21. Item (ii) should be edited to read: "that it is possible to identify policies that have the ability to correct these market and institutional failures and whose cost of implementation does not off-set benefits of correcting the market / institutional failures."

Page 10, Line 28. Expand sentence: "Few costing studies address these complexities; however, some bottom-up studies examine the additional environmental benefits of GHG mitigation policies, while some top-down studies examine the benefits of using carbon taxes to reduce other tax distortions in the economy."

Page 10, Lines 30-44. Replace paragraph with following text (See also accompanying graphic.)

"Figure 8.4 illustrates different views about the relation between cost and emission reduction in the case of a carbon tax. Each curve in Figure 8.4 shows how marginal costs would increase for higher levels of emission reduction, given different views about the nature and effectiveness of offsetting policies. These are marginal costs, and therefore represent the cost of achieving an additional ton of emission reduction, once the emission reduction indicated in the horizontal axis has been achieved.

"Curves A, B, C and D assume that there are no reducible market imperfections in energy markets, so that there are no negative cost potentials. Curve A assumes that all revenues from an emission tax are recycled through lump sum transfers, rather than removing existing distortionary taxes. In this case, even a small emission tax imposes positive marginal costs, as illustrated by Curve A starting at a point above 0 on the vertical axis, because it increases the excess burden of existing taxes. Curve B illustrates the least favorable case for recycling, where revenues are used in wasteful ways that actually increase the burden of the tax. Curve C assumes that emission tax revenues are optimally recycled by reducing highly distorting taxes. Curve D includes an environmental dividend represented by the other environmental benefits induced by GHG emission reduction, as well as the optimistic assumptions about recycling included in Curve C. Curve E includes all offsetting policies in Curve D, plus the "negative cost potential" described in section 1.2.1 above.

"Areas under each curve and above the horizontal axis represent positive costs. Areas between each curve and the horizontal axis, under the horizontal axis, represent negative costs. All these curves are theoretically possible. Sufficient empirical evidence is not available to determine which of the influences affecting the location of the marginal cost curve is most important. Therefore the marginal costs of small emission taxes could be positive or negative, and there may or may not be a range of emission reductions that could be achieved at zero or negative cost."

Page 12, Lines 11-21. The text accurately reports that the turnover of capital stock is a critical component of costs during a transition period. This conclusion needs to remain in the report.

Page 12, Line 12. Replace "carbon free techniques" by "less carbon-intensive or carbon-free techniques"

Page 12, Line 27. Modify sentence: "The types of policy instruments that have been studied in detail are energy taxes and quotas on the one hand and a collection of regulatory programs, efficiency standards, incentives, and information programs, including voluntary programs, on the other."

Pages 14-21. This brief discussion provides a very useful discussion of different national circumstances and potential impacts if GHG limitations would be required. The mention of different urban development is particularly useful (page 16 lines 22-34) and should remain in the report. It might be useful to add a short paragraph references differences in development

associated with different natural resource endowments (e.g. hydroelectric power versus coal resources).

Page 15, Line 12. Modify sentence: " ... some form of protectionism was considered necessary ..."

Page 18, Line 13. Add the following statement: "- reductions in the material intensity of specific products (Worrell, forthcoming);"

Material intensity of the products to fulfill the product function (or service). Like energy intensity can be decreased to fulfill a energy service, likewise can be done with the material intensity. References:
E. Worrell, B. Meuleman and K. Blok, Energy Savings by Efficient Application of Fertilizer, Resources, Conservation & Recycling (forthcoming)
E. Worrell, A.P.C. Faaij, G.J.M. Phylipsen and K. Blok, An Approach for Analysing the Potential for Material Efficiency Improvement, Resources, Conservation & Recycling (forthcoming)
Also published in: E. Worrell, "Potentials for Improved Use of Industrial Energy and Materials", Ph.D. Thesis, Utrecht University, Utrecht, The Netherlands, June 1994.

Pages 21-26. This discussion on the need for multiple baselines is vital in characterizing the limitations of long-term economic modeling and must remain in the WGIII report.

Page 23, Line 23. Many top-down models are not econometric nor macroeconomic in the sense that monetary and tax policies are represented. Suggest alternative phrase: "Many top-down models of the aggregate economy . . ."

Page 23, Lines 23-33. This section needs a new paragraph to distinguish between: 1) econometric macroeconomic models that can identify transition costs of GHG limitation policies; and 2) general equilibrium macroeconomic models that attempt to characterize new equilibrium conditions in the future but which say nothing about the costs of transition to that equilibrium from current conditions. If the paragraph is not added here, a statement should be added that refers to similar discussion recommended on page 32.

Page 23, Lines 30-33. Modify sentence: "Such analysis provides very useful "counterfactual" information on, say, the aggregate impact of a carbon tax relative to some assumed base case, but they are unlikely to be of strong prediction value for the very long term."

Page 28, Line 27. Modify sentence: "Many models are used to try to ..."

Page 28, Lines 31-35. Modify sentence: "This type of predictive exercise attempts to extrapolate the interaction of historical trends into the future, with a minimum of exogenous parameters."

Page 28, Line 41. Modify sentence: "... the Jorgenson-Wilcoxen, McKibbin-Wilcoxen and Goulder models are the only such ..."

Page 28, Line 46. Modify sentence: "... "explore" the future rather than "predict" it, and in so doing ..."

Page 29, Line 13. Suggest another phrase for "backcasting". In economic modeling, "backcasting" refers to the process of simulating a model over history with the correct inputs and comparing the historical "projection" with actual historical data.

Page 29-32. This section provides a useful discussion of existing models. The paragraph on page 32 on prescriptive and descriptive models should be edited as follows: Line 8: "capital constraints, attitude to risk (via higher discount rates for some agents) and uncertainty (actual performance of new technologies), or nay kind of...." The observation on lines 11-12 about "considerable disagreement" is quite accurate and needs to remain in the report.

Page 32, Lines 18-38. Description of macroeconomic and general equilibrium models is somewhat confusing. Modify these two paragraphs as follows:

"Neo-Keynesian macroeconomic incorporate econometrically estimated structural sets of equations that forecast the national economic accounts aggregates and related components of economic activity, using lag equations to model slow adjustment processes. They allow for unemployment and disequilibrium response to shocks in the short run and structural unemployment due to inadequate demand for labor in the long run. They usually incorporate long-run growth models that simulate aggregate potential output as a function of aggregate inputs of capital, labor, energy and materials. The most comprehensive macro models also 1) incorporate submodels of specific sectors of the economy, such as the energy, housing, or manufacturing sectors, or 2) include various types of input-output frameworks that detail the intermediate transactions between sectors of the economy. These models provide fairly realistic predictions of short- to medium-term economic activity because aggregate behavior is relatively stable over the medium term, and adjustments that are particular to specific detailed goods and factor markets generally do not greatly affect the general movements of aggregate volumes and prices. In general, however, macro models fail to account for the effects of agents' intertemporal preferences or expectations; nor do they adequately account for the complex processes by which technological advancement leads to increased efficiency in production.

"Computable General Equilibrium (CGE) models use the economic concepts of utility maximization and cost minimization to derive sets of consistent supply and demand equations for the entire economy. In the most sophisticated of these models, the equations are derived econometrically from historical data. This type of model, given an exogenous shock such as a change in the tax system, produces a price-dependent general equilibrium response that reflects the theoretical assumptions that the individuals represented by the model act to maximize their

welfare, given the constraints that they face. The CGE approach provides a tool to measure the magnitude of welfare effects of exogenous shocks, and can simulate a model's dynamic equilibrium path, given assumptions about individuals' intertemporal preferences. However, because they incorporate the premise that economies move rather quickly to equilibrium, CGE models tend to show unrealistically rapid adjustments to exogenous shocks. As noted by Whalley, a major proponent of this approach, "CGE models are not forecasting tools built to give an accurate picture of the future time path of actual economies, but are instead a form of theory with numbers which generates insights rather than precise forecasts." (Whalley, "What Have We Learned From General Equilibrium Tax Policy Models?", paper presented at the Tax Policy Conference at the Brookings Institution, October 30-31, 1986)

"Data and theory limitations impose a high level of aggregation, which limits the extent to which these models adequately represent the detailed dynamics of decision making, information processing and negotiation and transactions behavior. "Bottom-up" models and CGE "top-down" models assume these limitations away, yielding low estimates of adjustment costs; on the other hand "top-down" models incorporate such adjustment costs through lag equations but do not adequately account for them."

Page 33, Line 13. Suggest adding to Assumption 3 an additional component "3c) Technology choice"; and modifying Assumption 6 to read "Existing tax system and method of tax recycling".

Page 34, Line 13. Suggest modifying sentence: "... costs of GHG mitigation might be low to negative and top-down ..."

Page 34, Line 22. Spelling: statistical

Page 35, Lines 3-5. This is a very important point and needs to modified and amplified. Suggest modifying sentence as follows.

"Bottom-up models provide an extremely detailed analysis of the energy sector, but do not provide an equally detailed analysis of other sectors where unexploited profitable opportunities are equally likely to exist (such as the health care, education and communication sectors). As a consequence, they tend to provide a biased view of the low-cost welfare-enhancing opportunities in the energy sector, relative to the low-cost welfare-enhancing opportunities available elsewhere in the economy. Furthermore, the bottom-up approach assumes that choices are made based on certain very specific criteria without allowance for information costs, transaction costs and other intangible costs that are difficult to quantify or model; and it assumes that whatever factors currently constrain the rapid adaptation of "no-regrets" investments can be overcome at negligible cost. In contrast, top-down models are based on the observation that there are innumerable intangible costs in the world that influence complex choices, and generally assume that those frictions and costs continue in the future even under GHG limitation policies. As a consequence, bottom-up models are likely always to conclude that GHG limitation policies are

less costly than top-down models."

Page 35, Lines 50-51. Suggest a slight rewrite to this paragraph. Although some top-down models account for technological changes as stated, others, such as the Jorgenson-Wilcoxen model, do not. These other models cannot even in principle yield negative costs through technology alone. Paragraph should distinguish between types of top-down models.

Page 37, Line 2-3. Modify sentence:"many economists".

Page 37, lines 19-42. One of the major controversies in the estimation of mitigation costs is the extent to which deliberate policies can reduce intangible costs of adopting new technology. The key tenet of bottom-up modeling is that these intangible costs can be reduced through well-designed policies such as utility demand-side programs and energy efficiency standards. The empirical foundation of this assertion are evaluation studies of the impacts of these programs on end-use markets, product choices, consumers, and manufacturers and trade allies. In the current draft, this empirical basis of the bottom-up approach is not mentioned, and the pertinent refereed literature is not cited. The chapter should include a review of the body of research on end-use market efficiency and on policy options for reducing intangible costs. Such a section would smoothly fit in at the end of Section 3.3 (Page 37, line 28 ff.). Pertinent references are listed below:

DeCanio, S.J 1993: "Barriers within firms to energy efficiency investments," Energy Policy, Vol 21, Nr 9, pp. 906-914, September.
Eto, J., E. Vine, L. Shown, R. Sonnenblick, C. Payne 1994: *The Cost and Performance of Utility Commercial Lighting Programs*, LBL-34967, Energy and Environment Division. Lawrence Berkeley Laboratory.
Howarth, R.B. and B. Anderson 1993: "Market Barriers to Energy Efficiency," *Energy Economics*, October.
Howarth, R.B. and M. Winslow 1994: "Energy Use and Climate Stabilization - Integrating Pricing and Regulatory Policies," *Energy: The International Journal.*
Koomey, Jonathan and Alan S. Sanstad 1994: "Technical evidence for assessing the performance of markets affecting energy efficiency," *Energy Policy* Vol. 22, Nr.10, pp. 826-832.
Krause, F. et al. 1994: "Top-Down and Bottom-Up Methods for Calculating the Cost of Cutting Carbon Emissions: An Economic Assessment," Invited contribution to the 1995 IPCC Scientific Assessment, Working Group III, Intergovernmental Panel on Climate Change (IPCC), Toronto, Canada.
Krause, Florentine, Ed Vine and Sunita Gandhi 1989: *Program Experience and its Regulatory Implications: A Case Study of Utility Lighting Efficiency Programs.* Lawrence Berkeley Laboratory. LBL-28268. October.
Levine, Mark D. and R. Sonnenblick 1994: "On the assessment of utility demand-side management programs," *Energy Policy* Vol 22, Nr.10, pp. 848-856.
Nadel S. 1992: "Utility Demand-Side Management Experience and Potential - A Critical

Review." *Annual Reviews of Energy and the Environment*, 17: pp. 507-535.
Ross, Marc. 1986: "Capital Budgeting Processes at Twelve Large Manufacturers. *Financial Management.* (Winter 1986), pp 15-22.
Train, Kenneth. 1985: "Discount Rates in Consumers' Energy-Related Decisions; A Review of the Literature." *Energy.* Vol 10, nr. 12, p. 1234.

Page 38, Section 3.4. A major gap in this chapter is that only CO2 sequestration by biomass planting is considered. The study does not describe the wide body of literature available on the costs of CO2 removal from large CO2 sources like power plants and a number of industries (i.e. fertilizer, petro-chemical, iron and steel and cement). Although the costs appear prohibitive at this time, the potential contribution of CO2 removal and storage in empty gas and oil fields, and aquifers may be substantial, relative to the amount of CO2 to be removed from the system in the next century (as estimated in the first IPCC report). See the following references:

C. Hendriks, Carbon Dioxide Removal from Coal-fired Power Plants, Kluwer Academic Publishers Group, Dordrecht, The Netherlands (1994).
K. Blok, W.C. Turkenburg, C.A. Hendriks and M. Steinberg (eds.), Proceedings of the First International Conference on Carbon Dioxide Removal, Energy Conv. & Mgmt. 5-8 33 (1992).
Proceedings of the IEA Conference on Carbon Dioxide Storage, Energy Conv. & Mgmt. 9-11 34 (1993).

Page 38, Section 3.4.2. Section 3.4.2. on non-CO2 greenhouse gases is missing, so can not be reviewed. The current title of the section is not appropriate, as a substantial part of the emissions on non-CO2 greenhouse gases can be contributed to the extraction, conversion and use of energy. The section should be renamed "Other Greenhouse Gases".

Page 38, Line 24. Modify text: "identification of forestry and agricultural practices ..."

Page 38, Line 27. Modify text: "of those accomplishments in terms of GHG emission benefits as well as "double dividend" GDP and natural resource conservation benefits

Page 38, Line 29. Modify text: "forest and agricultural practices"

Page 38, Line 30. Modify text: "the size of natural resource sinks"

Page 38, Line 31. Modify text: "forestry and agricultural practice"

Page 38, Line 34. Modify text: "forestry and agricultural practices"

Page 38, Line 35. Modify text: "forestry and agricultural practices"

Page 38, Line 44. Modify text: "wood and agricultural products"

Page 39, Line 9. Modify text: "Examples of Forestry and Agricultural Practices to"

Page 39 Line 21. Add a line to Table 8.4: "Adoption of Advanced, Ecologically Sound Agricultural Practices (e.g. Crop Rotation, No-Till, Range Planting, etc.)"

Page 39, Line 31. Modify text: "forestry and agricultural programs"

Page 39, Line 45. Modify text: "and biomass energy as well as enhanced agricultural productivity on a sustainable basis."

Page 39, Line 48. Modify text: "... after harvest or during subsequent farm or ranch management."

Page 39, Line 50. Modify text: "... wood products and agricultural products."

Page 40, Line 8. Reference 24 should be 25.

Page 40, Line 16. Modify text: "... wood and agricultural product ..."

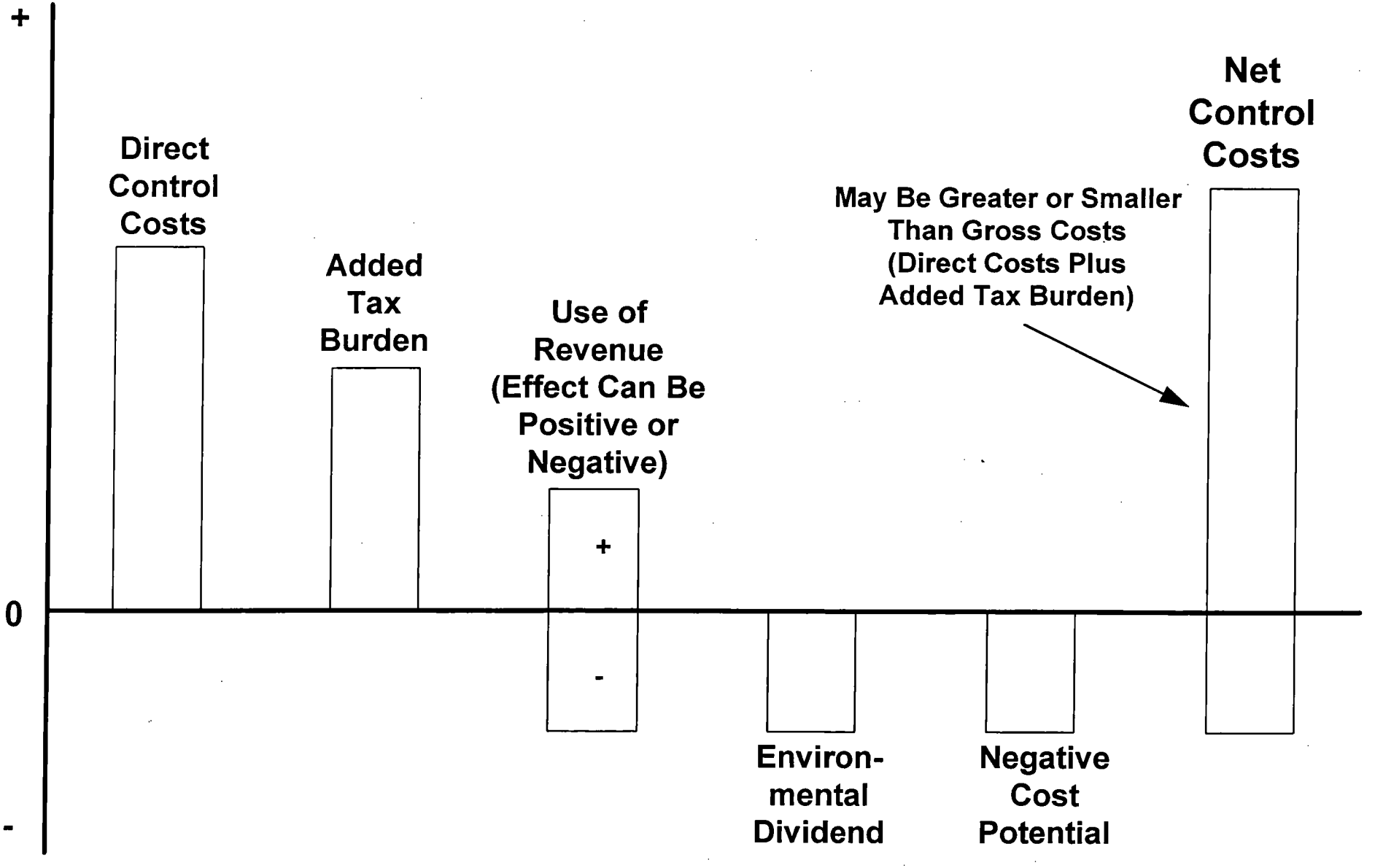
Page 40, Line 24. Modify text: "... forests and agricultural lands make ..."

Page 40, Line 25. Modify text: "... values of their forests and forested land are threatened by ..."

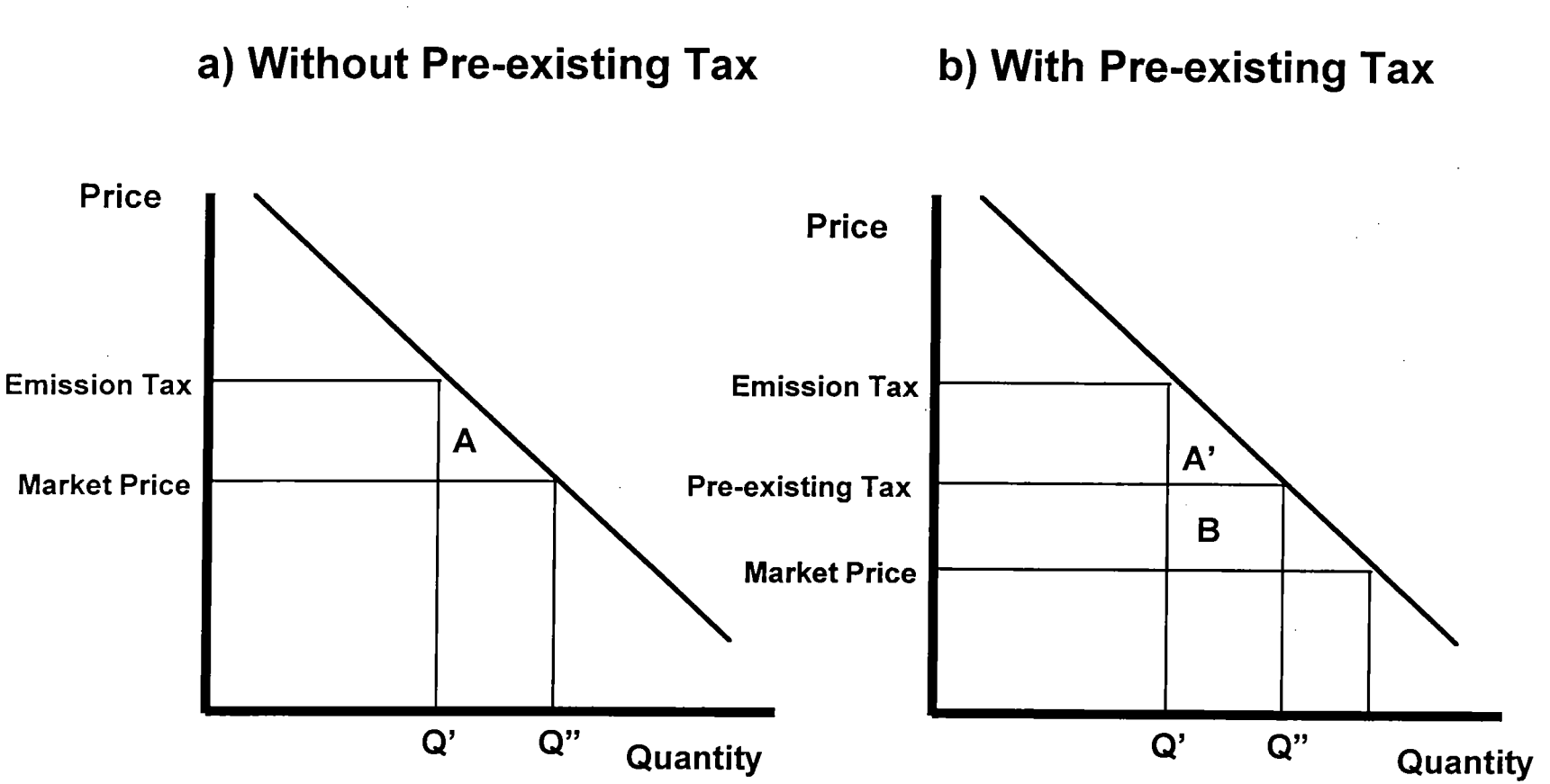
Page 40, Line 25. Add references, such as Adams et al., and work done using FASOM.

Page 41, Lines 4-45. Revise entire set of conclusions as per chapter summary on pages 3 through 6 of this review. The revision includes the points made in the existing conclusions but rearranges them and expands on them.

Figure 8.2
Gross and Net Economic Costs of Emission Reduction

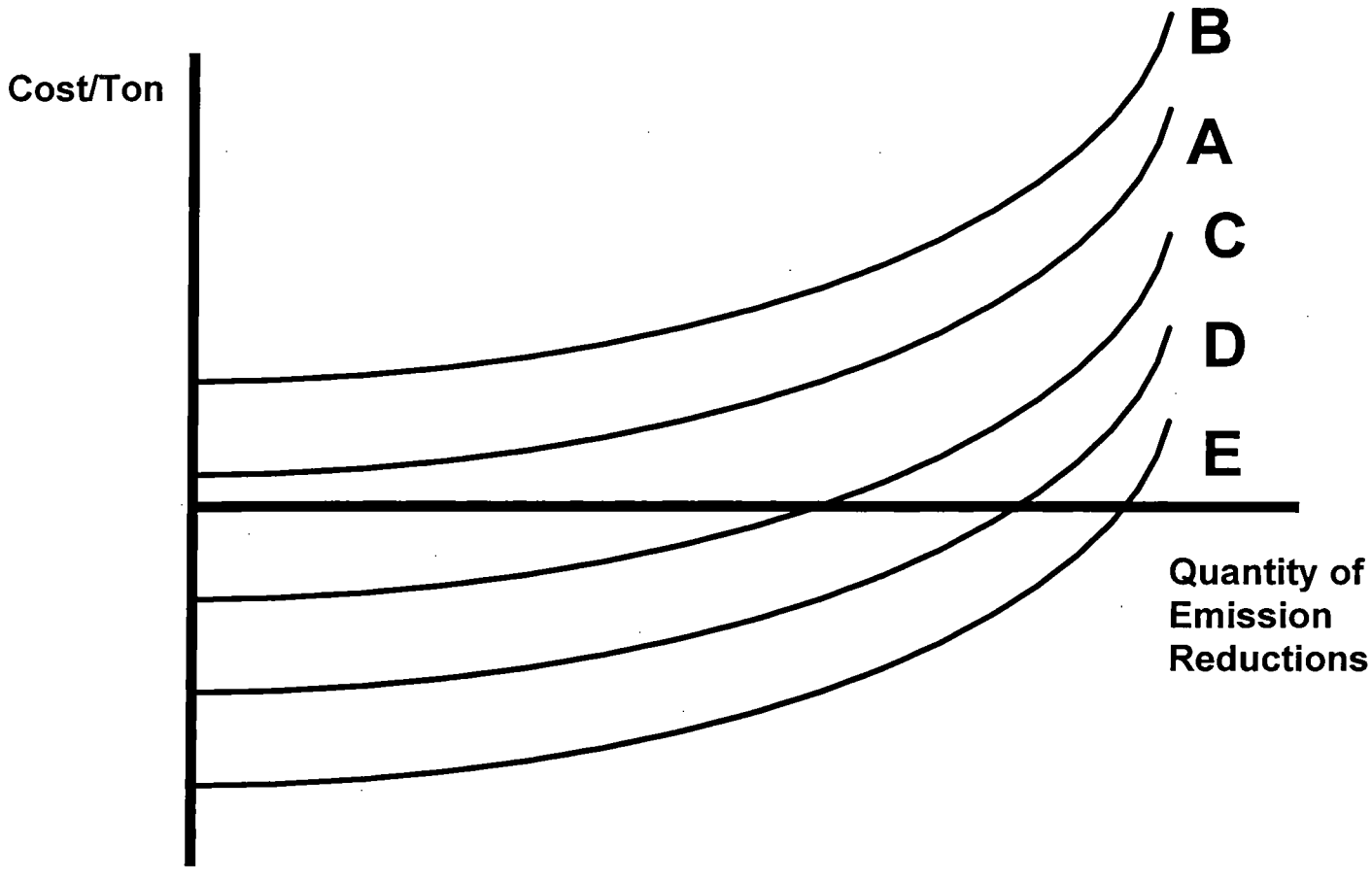


Control Costs and Added Tax Burden From Emission Tax



A - Control costs due to emission tax
A' - Control costs due to emission tax with pre-existing tax
B - Added tax burden due to pre-existing tax

Figure 8.4
Alternate Views of Costs of Emission Reduction



Key:
A - Lump Sum Recycling
B - Ineffective Recycling
C - Recycling Through Highly Distorting Taxes ("Economic Double Dividend")
D - Curve C Plus "Environmental Double Dividend"
E - Curve D Plus Elimination of Energy Market Imperfections ("No Regrets")

Chapter 9
A Review of Mitigation Cost Studies
Comments

GENERAL

The authors did an outstanding job of pulling together a vast amount of recent economics literature on the costs and economic impacts of mitigation programs and organizing that material for consideration. It is very clear that a lot of hard work went into putting this chapter together . It will be a valuable asset in informing the world community of the current state of knowledge on the costs of mitigation.

The chapter could make an even greater contribution to the understanding of the literature in this field if the authors included a section that integrated the material in such a way that readers could see where the most cost-effective programs are likely to be to reduce greenhouse gases among the energy and non-energy related conservation and materials management programs and the forestry programs to sequester carbon. It would have been nice to see the specific types of programs where we are likely to get the cheapest carbon reductions and what the relative cost differences are among them.

The authors need to describe and address the costs of geoengineering alternatives to reduce the impacts of GHG emissions and the use of agricultural lands (crop, pasture, hay and rangelands) to sequester carbon, especially in soils.

The reader needs to be warned in the introduction and repeatedly throughout the text that results beyond 2020 should be considered with considerable caution and have many large limitations. The insights gained from forecasting exercises such as this are what are valuable, not the actual numbers. Throughout the chapter, a stronger presentation of those insights and less attention to the specific numbers would be helpful.

It would be very useful to know from various forecasts how much of the loss of GDP or GNP is explained by reduced energy demand. The loss will not effect the overall social welfare of the population in the areas covered by various studies.

In the U.S. and OECD studies there is explicit mention of the difference the use of tax revenues makes in the impacts of the study; it would be very useful to know if the lessons from these studies are believed to be applicable to other areas of the world.

The authors have a daunting task in collecting and summarizing all the work that has been done on CO2 emissions. They do an excellent job on explaining the top-down literature and it is clear they have been able to take advantage of the excellent work that went into Energy Modeling Forum 12. A comparable job is needed in setting the stage in the U.S. section for the bottom-up literature. Please see suggested improvements in the detailed comments section.

The report focuses on "timing" as it relates to the period for achieving emission reductions.

Summary

The summary should provide the reader a stronger context for reviewing the cost study results and needs to also provide the results of cost studies covering carbon sequestration and non-energy related GHG emissions. We recommend using the proposed text in Attachment A to rectify these concerns.

Reviewing the specific items in the draft chapter summary, we would like to make the following comments on specific bullets in the summary.

Page 1, beginning line 3

The costs are also quite sensitive to the structure of the economy studied and assumptions made about the costs, efficiency, and commercialization of end-use energy options.

Page 1, beginning line 9

Unfortunately, the first sentence in this bullet is not true - the bottom-up and top-down researchers have hold significantly different views on this. Later figures and tables throughout this Chapter demonstrate the differences.

Page 1, beginning line 17

The point may be true, but is not apparent from reviewing the chapter.

Page 1, beginning line 32

The point should also include the level and adoption rate of R&D and the fossil fuel depletion rate.

Page 2, beginning line 19

The bullet incorrectly makes the point that many bottom-up studies suggest that costs will be negligible. The bottom-up studies generally conclude that there will be net savings from the actions they investigate.

Page 2, bottom of page

There is a need to add bullets that summarize what the chapter has to say on carbon sequestration and reducing non-energy GHG emissions. See Attachment for suggested language.

There are two major areas of research on the future costs of changing energy use patterns throughout the world. They have been labeled the "bottoms up" and "top down" literature and were described at length in Chapter 8. (It would be most efficient to concentrate the discussion of the differences between the two schools of research in Chapter 8, rather than have two separate author groups in different chapters trying to do this.)

The models are best at providing insights about the impacts that will occur from different types of programs to reduce carbon emissions and not for the actual cost numbers that they provide. The further out in time the projections are made, the less credence should be given to the results that are presented. Repetition of this point throughout the chapter would be valuable, since so much of the chapter is the reporting of the results of long-term forecasts.)

Page 4, this within section

We recommend that you include work in this section that shows how and where energy conservation measures to reduce emission rates may not fully achieve their intended levels of carbon reduction due to the increase in consumer demand for energy services in response to the lower costs that results from the gain in efficiency. The Department of Energy has examined this work in the past through the use of its IDEAS model that is used by its policy staff.

Page 4 beginning on line 9

At least one of the 14 models, the Markal model, is often considered a bottoms-up model.

Page 5 beginning on line 14

The differential form of the Kaya identity (page 5) is unnecessarily complicated. The simple form CO2=GDP*(Energy/GDP)*(CO2/Energy) is easier to understand in the cited context.

Page 7 beginning on line 40

The Leary and Scheraga, 1994 reference is missing from the list at the end of the chapter.

Page 7 , Line 44-45

The future availability of new and low-cost technologies is a function of the R&D budgets. At the moment budgets of governmental and energy industry R&D are decreasing. The assumption of this availability, therefore, assumes the increase of R&D budgets as a strong impetus. This should be underlined if concluding that delayed mitigation will reduce the costs.

describing bottom-up studies for a large number of countries. These are described in the international literature, presented at international conferences and a few (although) incomplete reviews are written, e.g. Lovins and Lovins wrote a review ("Least Cost Climate Stabilization", Ann. Review of Energy, 16 pp. 433-531 (1991). Another recent study that provides considerable background on the objectives, approaches and results of these studies in the U.S. and the rest of the world is the International Project for Sustainable Energy Paths' study Energy Policy in the Greenhouse, especially Chapter II.5.

Page 10 beginning with line 28

This whole section on the key assumptions and results could stand substantial improvement, as well as the key supporting tables (Tables 9.1.1.2.2.1 and 9.1.1.2.2.2) which are incomplete. Once the the Tables are improved, a comparable presentation to the top-down work of drawing out the conclusions that can be made about GNP changes, overall savings, and the types of programs that produce these changes should be drawn.

Initially, Table 9.1.1.2.2.1 (covering major assumptions) and Table 9.1.1.2.2.2 (covering results) need to be reconciled. The tables do not agree on what the forecast period is for Chandler & Kolar and although results of the RIGES and FFEF studies are reported, the assumptions for these studies are not included in the major assumptions table. What the forecast year entry "n/s" represents, is not provided. Also, commentors in the U.S. have indicated that there are forecast years for National Academy of Sciences (between 2015 - 2020) Lovins & Lovins (2015 - 2020), and Rubin et al (2015 - 2020). Its unclear whether the results table is complete, or if blank spaces denote an entry where additional information will be provided. This is an issue where GDP changes are given for 12 of the 15 studies listed. Did the other 3 studies not cover this?

Table 9.1.1.2.2.1 (major assumptions) needs to have a summarization of the kinds of actions that the U.S. will take to produce the indicated results. This would be more valuable than the current entries on energy prices and discount rates.

A 1992 study "An Alternative Energy Future" completed by The Alliance to Save Energy, American Gas Association, and the Solar Energy Industries Association should be added to the study list in the tables.

There is a definitional question regarding bottoms up studies that needs to be reconciled in considering the entries that are in these tables (and other tables and figures for other section of this chapter). The issue is whether a study can be in this category if it has GDP costs, since by definition the practitioners of this type of analysis are identifying the significance of market imperfections which they indicate will have a positive benefit for society when they are corrected. Adhering to this definition by practitioners would remove from the table the Carlsmith and Chandler studies with positive results (and results in later tables of this chapter).

Page 10 beginning with line 39

The acronym RIGES is used with no explanation and no reference. It appears to be some type of modeling study, but a reader without considerable background is unlikely to know what it is.

Page 11 beginning with line 12

Its unclear whether the broad conclusion of savings of energy of 10 percent to 30 percent in bottoms up studies refers to U.S. and Canadian studies, or just those of Canada. The results are not correct for the U.S.

Page 17 line 34

Where are the Tables 9.2.5 and 9.2.6?

Page 18 beginning on line 13

Recommend that authors develop a table that presents what has been done in OECD countries like the one found in the IPSEP study Energy Policy in the Greenhouse (Table II.5.1a) and ensure that all the studies in that table are reported on in this section.

Page 18, Line 4-8

Although it is claimed that the methodology of the three UNEP-studies is comparable, large differences exist in the underlying analysis of reduction options and their 'handling' in the model. While for the Danish study detailed analyses have been performed on the costs of individual measures in e.g. housing, the Dutch study uses the existing MARKAL-database for the Netherlands. In the Dutch study only sets of measures (with varying costs) can be implemented (see note in table 9.1.2.2.3.3). Baseline scenarios were also different for all three studies. For the Dutch study this is the consequence of the model employed. The MARKAL LP-model will choose all options with negative costs immediately in the base line scenario.

Page 18 , Line 41-42

The differences in the COHERENCE-study are mainly due to the assumed differences in expected economic growth, and also due to the impact of energy efficiency measures. For the EFOM-model several databases with emission reduction options were developed. However, in many model calculations with EFOM no suitable database for industrial energy efficiency improvement is available. For industrial energy use it is assumed that the energy intensity will decrease autonomously with

countries with lower natural gas prices. Other industries, which can use low cost coals to replace the use of oil or natural gas, may move to other countries, and hence will become more carbon intensive.

Studies of the Costs of Carbon Sequestration

There is some important literature that the authors should consider adding into the discussion in this section:

> Nilsson, S. and W Schopfhauser, in press. The carbon sequestration potential of a global afforestation program.
> Climate Change, in press. (includes cost estimates of a global program).
> Grainger, A. 1990. Modelling the impact of alternative afforestation strategies to reduce carbon emissions. In Proceedings of the Intergovernmental Panel on Climate Change (IPCC) Conference on Tropical Forestry Response Options to 1990. Report No. 20P-2003, pp, 93-104. Office of Policy Analysis, US Environmental Protection Agency, Washington, DC (includes cost estimates of a pan-tropics scenario to slow deforestation and reforest.)

There is a need for consistency between IPCC WGII and WGIII reports to avoid different sets of authors working within the same IPCC forum from producing conflicting conclusions. WGII forestry chapters and WGIII Chapter 9 on carbon sequestration are reasonably consistent. However, much of the material presented in Chapter 9 on carbon sequestration costs is presented in WGII Chapter IIIF: Establishment and Management of Forests for Mitigation of CO2 Emissions, which also contains much additional material. Chapter 9 authors or the author responsible for the carbon sequestration section should review the WGII material for consistency and completeness in WGIII's report.

Page 43 , Section 9.2

The use of sustainably grown biomass as an energy carrier to replace fossil energy carriers is not assessed as well, as should be expected due to the importance of this technology in scenario studies (e.g. RIGES by Johansson et al. (1993) and Kassler of Shell (1994)). The use of plantation biomass for energy production is also a very important determinant for the amount of CO2 sequestered (in the form of not used fossil fuels) and the costs of sequestration. References: T.B. Johansson, H. Kelly, A.K.N. Reddy and R.H. Williams, Renewable Energy: Sources for Fuels and Electricity, Island Press, (1993) P. Kassler, Energy for Development, Shell International Petroleum Company, London (1994)

Attachment

Recommended Chapter 9 Summary

- There is extensive research on the costs of mitigating greenhouse gas levels through changes in forecasted energy use, the emissions source of greatest concern. Less research covers programs that increase carbon sequestration and reduce greenhouse gas emissions from activities that do not involve energy use.

- Many countries have studied how to reduce greenhouse gas emissions by altering future energy use. There are also regional analyses and world-wide studies. Studies have time frames from about 25 years to more than 100 years. Although there is an extensive peer-reviewed literature on the results, the energy models themselves have not had extensive peer review. Despite the valuable research that has been completed, much more needs to done to improve the ability of energy models to provide insights to decision makers on the effectiveness of different types of government policies seeking to produce behavioral changes and the value of different energy use and supply technologies over time throughout the world.

- Given resource and data limitations, energy modelers have often employed their expert judgement in formulating the models and meeting energy data requirements. In an effort to get some sense of the cost of mitigation, some countries have applied economic models intended for economies unlike their own.

- The science of energy modeling stems from the use of statistical methods, such as econometrics, principles from economic theory, and engineering performance evaluations that support model development. There are two major areas of research on the cost of changing energy use patterns throughout the world that offer insights on the costs implications of actions that could be taken over the next 25 years, where current forecasts of energy use have the greatest validity. They have been labeled the "bottoms up" and "top down" literature.

- "Bottoms-up" research has considered where energy-efficient technologies are underutilized due to the reported existence of market imperfections. These studies have often concluded that countries should be able to reduce carbon emissions substantially with significant savings from energy use and fuel switching. Government actions include establishing energy efficiency standards, supplying information on better energy technologies, improving electric power generation and transportation planning, and using market incentive programs. The bottom-up studies that report these savings indicate that there could be adjustments in energy use and supplies that lead to annual carbon emissions that are 10 to 60 percent below what they would have been in a business as usual (baseline) scenario in 2020. Most of the literature suggests that annual carbon reduction levels would be under 40 percent for various countries. Longer term forecasts, suggest greater potential for annual carbon levels from the forecasted baseline.

- Infrastructure decisions on energy supply and energy use systems are critical. They can enhance or restrict the types of future options countries will have to address the greenhouse gas problem through energy efficiency improvements and fuel switching. For example, a country relying heavily on nuclear power for electricity, will not need to focus on conserving electricity to reduce carbon levels.

- There are large differences in the costs of reducing greenhouse gas emissions among countries due to their state of economic development, infrastructure choices, and natural resource base. This suggests that international cooperation can significantly reduce the global price-tag for emissions reduction. Some research has shown the potential for substantial savings that are possible in a global emissions trading program.

- Given the nature of the current global economy, some research suggests that the lack of international cooperation may lead to significant levels of "leakage" of carbon as manufacturing activities shift between nations, if some countries act to address the issue and others do not.

- Timing of programs for emissions reductions is a critical policy variable in determining the overall price tag due to the need for change over in the capital stock in a manner that is not disruptive to economic activities in various countries and the ability to take advantage of technological innovations that are becoming available.

- Removal of some types of energy subsidies could stimulate energy efficiency gains that produce carbon reduction benefits.

- Research on carbon sequestration has focused on increased forest management in the tropical, temperate, and boreal regions of the world. Four major approaches have been studied: using forest plantations, forest management to slow deforestation and increase regeneration on degraded lands, expand agroforestry practices combining forestry in agriculture, and production and substitution of bioenergy fuels for fossil uses. Most studies of the costs of enhanced carbon sequestration estimate positive costs ranging from less than $1 to about $50 per metric ton on carbon, although a few studies provide estimates as high as several hundred dollars per metric ton.

- The majority of studies, for all three forest regions, have suggested that a substantial amount of enhanced carbon sequestration can occur at the bottom end of the cost range. One major study indicates the potential to store about 50 billion tons of carbon for about $5 per metric ton, or less, and another 20 billion tons at less than $20 per metric ton. Country-specific estimates for Brazil, Russia. the United States, India, China, Central America, and Thailand confirm that between 50 and 90 percent of the potential carbon storage can be realized at costs less than $10 per ton of carbon. These estimates are confirmed by a survey of literature

INTEGRATED ASSESSMENT OF CLIMATE CHANGE: AN OVERVIEW AND COMPARISON OF APPROACHES AND RESULTS

Chapter 10

General Comments

This chapter contains a good description of integrated assessment, particularly given the delayed request for the chapter and consequent limited amount of time available for the authors to write it. The comments on Chapter 10 are divided into two parts. The first part contains general suggestions regarding changes in content that the U.S. Government judges would improve the chapter and both better reflect current understanding as well as help coordinate Chapter 10 with the rest of the WGIII report. Part 2 reflects selected editorial comments that we would like to pass along to the authors. We believe that these ideas would help improve the text, and also that the authors should have discretion as to whether or not to adopt the suggestions.

PART 1: RECOMMENDED CHANGES

Chapter 10 on integrated assessments provides an opportunity for providing policy-oriented insights from the integrated assessment research community to the decisionmaking process. These results should be highlighted in Chapter 10 more and brought forward to the chapter summary, given appropriate caveats.

Integrated assessment models contribute a convenient framework for integrating results from a wide range of disciplines, and most models provide estimates of benefits and costs that would be incurred by adopting certain policy options. The models are useful because they can provide insights about the climate change problem not available from an examination of individual disciplinary studies. The models are sensitive to input assumptions, such as damage functions, that are often calculated by other researchers. These models also place the research program into a perspective that allows the setting of research priorities.

Early model results are instructive to the policy debate. However, the state of integrated assessment modeling is still immature both because modelers have not yet fully assimilated disciplinary research results and because individual disciplinary research areas are themselves constrained in their ability to provide explicit results. There is much borrowing among models. Results need to be accepted with some care. Furthermore, certain low-probability/high-consequence outcomes might negate some of the results.

A measure commonly used to indicate the degree of action to reduce greenhouse gas emission is the optimal carbon tax or, equivalently, the marginal damage. Most integrated assessment models find that optimal carbon taxes in the near future (twenty years or less) are generally low ($5 to $13/tonne). These strategies with moderate near-term policies reflect cost advantages to waiting before initiating more intense emission reductions. Waiting saves because a) discounting makes future actions less costly in today's dollars, b) capital is not replaced before it is ready to be retired, c) research and development on technologies is likely to offer less expensive abatement alternatives, and d) research in the natural and social sciences will reduce some of the uncertainty. The models indicate that policy instruments of choice in the near term emphasize points c) and d), while more stringent policies are required later to meet specific atmospheric concentration objectives.

Replacement of carbon-based fuels with carbon-free fuels has a possible negative economic consequence that is represented in some integrated assessment models. Reducing carbon-based fuel use can result in lower sulfur emissions. Aerosols from the sulfur emissions are short-lived and reduce environmental insult from acid deposition, but reducing aerosols reduces their potentially beneficial climate cooling effect.

Further results or corollaries from the above points include:

1. The time path of meeting an atmospheric concentration level is important with respect to predicted economic costs of greenhouse gas emission reductions.

2. [Nordhaus result] Uncertainty increases the optimal carbon tax.

3. The text would benefit from careful editing.

4. Two ostensibly contradictory messages should be highlighted and/or brought forward to the summary. The first is the importance of communicating the relative newness of integrated assessments, their reliance on uncertain results from the broader research community also struggling with incomplete understanding, and the fact that integrated assessment results need to be presented with strong caution. Another caveat, state above, is that model results provide only one input to the decisionmaking process. On the other hand, integrated assessment is an extremely important tool for communicating results from the broader community and insights about potential costs and consequences of policy options that are very useful to the decisionmaking process.

5. An attempt should be made to expand the description of IAM's to include others that may not have been included first time around.

6. The section on further research needs should be described instead as shortcomings or warnings regarding existing models. Research needs should be discussed either more generally some other place in the report or not at all. One topic in that section that needs expanding is the difficulty of formulating and predicting technology innovation and diffusion.

7. To the extent possible, the chapter should cross-reference the other WGIII chapters. Integrated assessment is the way many of the issues raised in the other chapters, such as equity, discounting, and so forth, are synthesized and presented to the decisionmaking process.

8. There is no mention in the chapter of Global Warming Potentials. Economic efficiency argues in favor of policy actions that allocate resources appropriately across abatement strategies aimed at different greenhouse gases so as to minimize ultimate damages. Because damages are not the same as the impact of radiative forcing, integrated assessments provide potential tradeoffs to the policy process.

PART 2: EDITORIAL SUGGESTIONS

In general, Chapter 10 provides an excellent overview of integrated assessment models. The purpose of these models, differences in modeling approach and stage of development, and comparisons among model results are well described. The authors adequately convey the complexity of these models, the rapid rate of current development, the range of issues the models have addressed, and the future challenges faced by integrated assessment modelers.

The reviewer's comments involve three key points: (1) clearer statement of the chapter purpose in the Introduction, (2) better presentation of conclusions in the Summary, (3) and editorial changes to facilitate easier reading. The Introduction provides a very good definition of integrated assessment, its purpose, and the current state of assessment activity. However, a very clear statement at the beginning of the section as to the purpose and limitations of the chapter would be very useful to the readers.

The Summary provides a concise and well-written summary of key points and information presented in the Chapter. It does not, however, provide a clear statement of conclusions as to the contribution current modeling efforts have made to the overall development of policy options by working Group III or the most effective use of future modeling efforts in developing new policy options. As noted on Page 10, line 51, it is the insights (from model results) that seem most relevant

to the current debate on appropriate global change policies that are most important to stress. Such concluding remarks would help to highlight and/or put into perspective the importance of integrated assessments.

Although the Chapter is generally well written, use of shorter paragraphs and/or sentences (see section below) would improve the overall readability of the chapter.

Page Numbers: 1 - 5: The purpose of this chapter appears to be to: a) define integrated assessment and its purpose, b) discuss the structure, modeling approaches, and major weaknesses of present integrated assessment projects (page 5, line 52), c) review modeling results, particularly as relevant to the debate on appropriate global change policies (page 10, line 50), and d) discuss the modeling challenges that have been identified as high priority areas for future improvements. Some statement of these purposes at the beginning of the Introduction would be useful to the reader.

In general, This chapter was fairly inclusive of the topic area and a reasonably well-balanced presentation. It provides a set of working definitions of integrated assessments, the role and use in policy-making concerning climate change risks and an overview of results and "conclusion" from recent and ongoing integrated assessments of climate change. The one most noticeable missing piece was a more in-depth look at the disadvantages of employing this particular tool to guide decision-makers. There is a quick reference to the risks associated with compounding uncertainties in attempting to link individual models that are themselves subject to significant uncertainty, but it is somewhat limited discussion. It is fair to present the reader with an assessment of the relative value of these models over alternative approaches. It is not enough to say that these should be one set of tools available to policy-makers (although I personally think they should be). It is hard to come away from the existing text with a clear sense (not estimate) of the marginal value of these approaches in terms of specific decisions that governments are going to make in the near and medium term. It is important to show that integrated assessment are not just analytical curiosities but provide the prospect of a substantial value added to the single disciplinary approaches.

There is a lot of use of jargon that tends to muddy the discussion for all but the most sophisticated reader. There is some sense that the chapter was written by integrated modelers for integrated modelers. That certainly should not be the intended audience.

The chapter places a priority on the economics aspects of integrated assessment models in contrast to the physical sciences aspects. The authors should consider adding more information on natural science issues, such as development of reduced form models, scaling problems, etc.

The chapter hints at, but does not go into, a much broader range of assessment methods and techniques that have been used over the years (and are policy-relevance tested). The latter portion of the paper on comparisons of approaches and results, and especially the discussion on limitations and challenges, has promise of being quite useful, and needs building up.

The chapter needs a heavy edit. There are some typos and misspelled words. There also seem to be many extra words and missing words, often confusing the intended meaning. A good bit of text is just not necessary, wordy, or redundant, especially toward the first half of the chapter -- see detailed comments below for suggestions.

Integrated assessment is the appropriate way to address climate change because it attempts to combine disparate parts of the issue. Much of the Chapter identifies many of the current limitations of the underlying parts of the analytical process and indicates that the overall integrated assessment effort is also thereby limited. However, the Summary for Policymakers and parts of the Chapter make or imply much greater accuracy of assessment than is possible at this time. For example, the limitations behind an "optimal carbon tax" estimate for the 1990's (page ii, lines 25-28) are known to the modelling community, but not to the policymaker and the Summary for Policymakers in no way enlightens the policymakers to this limitation. In addition, the Summary is selective because it does not mention a conflicting conclusion of the PAGE model (see page 14, lines 34-38) that recommends "...adaptation rather than mitigation as a first best policy initiative."

The Summary misleads policymakers by not giving ample evidence of the very strong caveats that justifiably pervade this chapter. See for example caveats like: page 5 (lines 41-44) which states that "...integrated assessment is relatively immature and lacks a shared body of professional knowledge and standards of 'best practice'"; and page 16 (lines 44-48) that "The climate information required to most effectively project the impacts has in many cases not yet been determined, the most appropriate measures of climate impacts have not yet been determined...."

While integrated assessment is a vital tool, it cannot overcome the massive gaps that exist in our knowledge about the nature and extent of human activity in 100 years, the science of climate change, and the economic and non-economic impacts of possible climate change. The Summary of this chapter, by claiming to know the optimal carbon tax in the 1990's and the 2090's totally overstates the ability of integrated assessment to contribute to this issue and may well lead to a backlash against this most promising of tools.

This is an excellent, clear, concise explanation of the state of the art in the modeling aspect of integrated assessment. The principal concern is with the

decision of the Working Group III authors to limit the discussion of integrated assessment to the modeling efforts, worthy as they are of the thoughtful treatment they have received here. Whatever the shortcomings of the limited range of past efforts, we need to analyze and develop means for doing integrated assessments as a communication process, and not conceive of IA solely as a modeling product. IA models should be thought of as a significant component of an overall assessment process, which itself should receive greater analytical attention from the assessment community. There is a need for new mechanisms beyond periodically summarizing the scientific literature and the results of IA models to advise decision-making. IA should be formulated in the context of an institutionalized communication between research, assessment, and decision-making, to evaluate the fit of current climate change research and assessment activities to the perceived needs for decision-relevant information. This process has been ad hoc at best and not pursued systematically. Yet it is at the heart of ensuring that, in the future, IA is properly attuned to the institutional and political processes through which climate-relevant decisions will be made, and that the need to provide decision-relevant IA's comes to play a larger role in driving the supporting research agenda.

There are a number of good insights which have not been reported elsewhere. For example, the observation on page 5 that many integrated assessment models are very restrictive about the structure of policies they can examine, also the comment on page 8 about the distinction between including stochastic variables in a model vs. including agent behavior under uncertainty.

There is a significant lack of discussion of the different methods used in the various integrated assessment models. While there is good discussion of the various building blocks found in Figure 1, there is virtually no discussion of the fundamentally different approaches these models take to modeling climate and economy. The top-down, bottom-up debate is part of this. Some economic models are more aggregate than others. Some models are equilibrium models, some simulations, some explicitly disequilibrium. Some are general equilibrium trade models, some partial equilibrium. There should be much more of a critical assessment of the state of the art in terms of the different modeling approaches, rather than a cursory (though useful) discussion of some of the properties of the models. The authors should talk about the activity analysis used in Manne et al vs the more aggregate approach of Nordhaus. Different representations of climate could be discussed. Certainly the difference between the engineering (bottom-up) models and the economic models should be discussed.

Omission of completed work by some and inclusion of uncompleted work by others. The authors might cover all models that exist now and which have been published. Some significant models have been omitted, perhaps because the authors are relying excessively on EMF-14 which has intentionally omitted some

US models for international balance. In particular, the work of Michael Schlesinger with several authors is omitted as a "model". Furthermore, the work of Schlesinger is mentioned incorrectly as a deterministic model on page 12. Also omitted is the SLICE model, with Kolstad as the principal architect. SLICE is a stochastic, learning integrated climate economy model that has been used for a number of analyses and which has been published in a number of outlets:

CD Kolstad, "George Bush vs. Al Gore: Irreversibilities in Greenhouse Gas Accumulation and Emission Control Investment", Energy Policy, 22:771-78 (1994)

CD Kolstad, "The Timing of CO2 Control in the Face of Uncertainty and Learning," in E.C. van lerland (ed), International Environmental Economics, pp 75-96 (Elsevier, Amsterdam, 1994).

CD Kolstad, " Mitigating Climate Change Impacts: The Conflicting Effects of Irreversibilities in CO2 Accumulation and Emission Control Investment," pp 205-18 in Integrative Assessment of Mitigation. Impacts and Adaptation to Climate Change, N. Nakicenovic, W.D. Nordhaus, R. Richels, and R.L. Toth (Eds), IIASA, Laxenburg, Austria (May, 1994).

CD Kolstad, "Looking vs. Leaping: The Timing of CO2 Control in the Face of Uncertainty and Learning," pp. 63-82 in Y. Kaya, N. Nakicenovic, W.D. Nordhaus and F.L. Toth (eds), Costs , Impacts and Benefits of CO2 Mitigations, IIASA, Austria (June 1993).

Page i, Line 2.
Rewrite, simplify, e.g., Assessment is integrated when it draws from more than one discipline. Delete rest of paragraph -- irrelevant

Line 4.
If you want to define its purpose, do so directly, not by distinguishing it from disciplinary research which is self evident, not to mention redundant with the first sentence. It is not "to inform..." Real, effective integrated assessment is to directly involve technical information providers, policy analysts, and decision makers as joint partners in the decision-making and negotiating process so that they can iterate efficiently and effectively through the many complex issues and perspectives that must be accommodated (e.g. as occurred with the Montreal Protocols on CFCs and acid rain/Clean Air Act/NAPAP). If you only are doing an assessment of the state of knowledge on end-to-end, linked models, then clearly state that and don't tease the reader with the promise of more. line 9 as you hint in line 6, there are probably not many policy issues with simple, single-discipline answers -- isn't that sort of by definition? It is not necessary to state that IA is difficult...!

Page i, Line 6.
The parenthetical "infrequent" was gratuitous. Lots of significant policy issues that can be "well-informed" for a single disciplinary approach.

Page i, line 13 and p.2, lines 33-34.
Rather than "...severity of the impacts...prevent...", it might be more clear to state "benefits of the impacts prevented..."

Page i, lines 11-23.
Rather than philosophizing on what IA can do, why not jump right in with some specific examples/conclusions/results drawn from your review on how these purposes are being served? This should be the meat of your chapter, and specific examples should be summarized right up front. Nobody wants to read 2 inches of paper, single-spaced, double-sided, in 10-point type, and many won't even get to the last two paragraphs of your summary. Put the good stuff up front! Be concise. Maybe use bullets.

Line 27.
Centrality? The dictionary acknowledges that this is a word, but it means little to me as used here.

Lines 27-33.
You tease me with this discourse on other methods, but they are not developed further in the chapter.

Line 25-36.
The text should make clear that this paragraph is based strictly on results from CETA and DICE, limited early deterministic cost-benefit models that do not include significant complexity on climate, atmospheric chemistry, or ecological and economic impacts, and do not incorporate interactions, feedbacks, or uncertainty. The results of such modeling analyses should not be carried forward into summary text without being accompanied by the proper caveats.

Page ii, line 5.
Atmospheric is redundant

Page ii, lines 25-36.
Here and throughout the chapter, you need to make clear that these are projected, or modeled, optimal control rates (same applies for any projected/modeled result). Many, many assumptions underlie these numbers, and to express them so boldly as uncaveated facts can lead to trouble, especially when individual sentences can easily be extracted from the document and presented out

of context by someone in a way that is intentionally or unintentionally misleading.

Page ii, Line 25-28.
This will be read by policymakers as "the answer" when it fact it is based on terribly incomplete science, economic, and impact knowledge. Second, the conclusion is selective - it only covers part of the range of results. Third, as phrased (optimal control rates, defined as reductions from baseline emissions) the conclusions are difficult to interpret without the baselines (which are not included) and cannot be compared to the standard reference of the Working Group III document, that is 1990 level emissions.

Page ii, Line 37.
The Summary section could benefit from including a paragraph indicating some early findings from other efforts, e.g.: 1) Cline's analysis, which incorporates policymaker risk aversion and results in a much more aggressive optimal control policy; 2) Edmonds, et al.'s sensitivity analysis of the implications of more rapid introduction of advanced carbon-free energy technologies (this is discussed in the "Summary for Policymakers" (page 8, lines 25-28) but not in this chapter summary); and 3) Nordhaus' (1994) findings about the implications for the optimal carbon tax and control rate if uncertainty are taken into account. These examples would begin to suggest the potential for a richer analysis as IA modeling evolves beyond its earliest efforts.

Page ii Line - second to last paragraph.
The logic here is not correct. Linearity, per se, is not a key characteristic of the marginal benefit function. An interesting characteristic of this function is the relative insensitivity of marginal benefit to control rate (i.e. it is "flat"), due to the damages depending on the stock of CO2 and the stock not being much affected by a single period's emissions. This "flatness" matters for choice of policy instrument under uncertainty (See Peck and Teisberg, "CO2 Emissions Control: Comparing Policy Instruments," Energy Policy, March 1993, p. 229; and Nordhaus (1994) p. 184).What matters for the conclusion that control is modest in the early years is that damages from warming are represented as modest in the next few decades, and perhaps large sometime thereafter. However, discounting damages (even large ones) which are several decades in the future reduces the marginal benefit of control substantially, leading to low optimal emissions control rates now.

Page ii, lines 33-36.
Does this statement involve a fairly smooth linear perspective on the relationships between concentrations, warming, and impacts. Given how little we know concerning the possibility of thresholds, can we can be so confident in making this assertion? Perhaps, adding a caveat concerning current modelling results suggest...

Page ii, lines 38-42 see comments on pages 16-19.

Page ii, lines 30-41.
Comments above for page i apply. You state in the footnote on this page that you will depart from conventional IPCC terminology here, but you really do not do more than review the literature in this chapter.

Page 1, lines 44-50.
This footnote was very useful given the context for this chapter, i.e., part of an IPCC assessment. It should be moved into the introductory text.

Page 2, lines 1-27.
All true, but quite wordy, could be condensed.

Page 2, line 5.
There is a redundant line here.

Page 2, lines 26-27.
The NAPAP assessment effort is a strong precedent from which many lessons for GCC assessment could be learned.

Page 2, lines 30-52, p.3, lines 1-28.
These thoughts are repeated, with examples, beginning on page 11. Either delete this section, or better, reorganize the paper to bring the good stuff from the back to the front. You can probably shorten the paper by half by dispensing with the up-front philosophizing and jumping right in to the results. Lines 13 -28 are irrelevant to the chapter.

Page 2-3, lines 51,52,1,2.
Example of irrelevant, extra verbiage; delete.

Page 3, line 4.
Redefine "it".

Page 3, line 9.
There is a redundant phrase here.

Page 3, lines 4-11.
This paragraph--as well as the previous two--raise the questions of whether integrated assessments can always help address all three policy perspectives or questions. What are the conditions under which one kind of assessment or model is better able to address a given "fundamental policy question."

Page 3, lines 4-11.
You need to say--as you have in other chapters--that there are other decision criteria beyond benefit/cost that make sense and talk about how well the integrating modelling efforts are able to help inform those decisions (e.g., equity).

Page 3-5, lines 10-35.
The particularly long paragraphs in this section hamper the readability. Some suggested paragraph breaks include:

Page 4, Line 10 "Certain policy audiences...
Page 4, Line 25 "On the other hand,...
Page 4, Line 35 "Other audiences....
Page 5, Line 20 "Doing integrated assessment....

Similar editing to shorten paragraphs and simplify long, complex sentences would be useful throughout the chapter to improve the readability for "lay person" readers.

Page 3, lines 31-52, p.4, p.5.
Comment: long paragraphs, redundancies, much of this should be condensed or go away completely. It distracts and bogs down.

Page 3, line 52.
Comment: there is no such decision maker; there is a global community of decision makers, none with such authority.

Page 4.
Whole page is confusing and doesn't make too much sense.

Page 4.
This section would be improved by breaking it into a few paragraphs. Put paragraph breaks at beginnings of sentences on lines 7, 25, and 35.

Page 4, line 12.
Redundant sentences.

Page 4, lines 45-50.
Bill Clark makes an interesting point, but he may not be using a broad enough conception of "useful" and "used." Assessments "conducted at relatively fine levels of spatial or sectoral aggregation, by or for those agents directly bearing potential impacts or responsible for implementing proposed responses," may be "the most useful, and most used...to inform specific decisions." But is there not also a role for assessments that contribute to framing a broad issue, to putting a new range of options on the agenda, and to shaping an evolving consensus about how to think

about an issue? Does Clark's formulation understate this agenda-framing, consensus-building, consciousness-raising function of assessments-- especially if we think in terms of the multiple assessments over a period of time that will contribute to analysis and decision on the climate change problem? Should climate assessments be conducted only at "fine levels of aggregation," and be aimed only at informing "specific decisions," or can they also usefully play a broader role?

Page 5.
Eliminate the "domain" and "sub-domain" jargon.

Page 5, Lines 6-14.
Suggest providing citations, examples, and perhaps more explication of such non-modeling integration and assessment efforts.

Page 5, Line 20.
Suggest a new paragraph on line 20.

Page 5, Line 20.
Brewer (1986) is not included in the References, page 20.

Page 5, Line 28.
"Imposing" should be "impose."

Page 5, Line 32-41.
"Integration through integrated modeling may be particularly weak in representing policies and decisions realistically, and in reflecting knowledge of relevant social, political, institutional, and negotiation processes." Given this: 1) Shouldn't there be some additional discussion of this key point in the "Directions for Future Research" section (page 16)? 2) Doesn't this suggest a need to develop more systematically the interaction between IA and the policy/institutional arena? See summary comments in Section II above.

Page, 5, lines 32-35.
If integrated modeling is "...particularly] weak in representing policies and decisions realistically, and in reflecting knowledge of relevant social, political, institutional, and negotiation processes", then why are we doing it? Why is this chapter devoted exclusively to this so-limited technique? Why not discuss other, complementary techniques that could fill in for these weaknesses?

Page 5, Line 48.
...integrated, not integrate.

Page 6, Line 14-20.
This definition of integrated assessment is incomplete, misses a most fundamental feedback mechanism, and assumes humanity operates in the "dumb farmer" mode. The definition starts with human activity and goes through science to impacts. However, it does not go the complete circle because it assumes that humanity makes absolutely no response to hypothesized changes in climate. This clearly overstates potential damage and promotes public policies to damages that are over-estimated under a "dumb farmer" assumption because they neglect "no-regrets" actions to changing conditions.

Page 6, Line 20.
New paragraph on line 20.

Page 6, lines 22,25.
The blocks shown in fig. 1 do not seem to me to be "disciplines". NAPAP combined every one of these blocks (or their acid-rain analogs) in an integrated assessment.

Page 6, Line 45.
There is a reference here to the "third" major design consideration. Which are the other two?

Page 7, Line 13-18.
This understates the usefulness of the simple exercise of saying how much it would be worth to reduce a particular uncertainty by amount X by time T. Such a calculation is a good first step in directing attention to where the research payoffs are high, and diverting attention from areas where the payoff is low. If the payoff is low in some area, that is important information in itself. In areas where the payoff is found to be high, it becomes important to try to estimate costs of reducing uncertainty. But this is very difficult to do. Moreover, the best research strategy is to work on all important uncertainties to some extent, modulating the degree of effort expended in each area appropriately, depending upon one's evolving perception of the prospects for success. Replace the sentence beginning on line 13 with the following: "Such calculations can provide a useful screening of uncertainties to determine where research expenditures may or may not have large net expected benefits. Combined with estimates of research costs and success probabilities, they can help set initial research priorities in a rational way. Of course, these priorities can be expected to change over time as research itself changes perceptions of research benefits and costs."

Page 7, Lines 20-40.
How was the list of models generated? What criteria are used for including non-operational models? Why have some models been excluded (including some of Nordhaus' earlier models)? Why is a model like ISM or MAGICC included when they appear to have no economic sector? Why is a model like Goulder's omitted?

Page 8, lines 1-4.
Don't tell us what isn't; delete such verbiage and tell us concisely what is.

Page 8, Line 13.
Puzzled about how one values information in a simulation model. The value of information depends on differences in model objective function values obtained using (1) an optimal policy under uncertainty before uncertainty is resolved, and (2) tailored optimal policies after uncertainty is resolved. Impression is that these differences are not large, at least relative to the objective function values themselves. A simulation model cannot calculate optimal policies, so the simulation analyst experiments with a range of pre-defined policies (necessarily a small subset of the infinite number of possible policies), and chooses the one that works best as the (approximately) optimal policy. But the failure to find truly optimal policies may contribute as much to differences in objective function values as do the differences in information. Here is a suggested substitution: Replace "full value of information calculations" with "approximate value of information calculations"

Page 8, line 27.
State of the art... much redundancy in this section, e.g. lines 28-33; lines 7-11 on p.9 redundant with lines 15-20 on p.10; lines 30-34 on p.9 redundant with lines 31-35 on p.10. Atmospheric is redundant as in summary

Page 9, lines 21, 45.
Maybe other places as well: "imbed" seems a strange word, distracting use of a non-standard word; why not just replace with "include".

Page 9, line 53 through page 10 Line 35.
Page 9, line 53 through page 10, line 9 is a repetition of page 8, line 46 through page 9, line 2. Page 10, lines 13-20 is a repetition of page 9, lines 6-13. Page 10, lines 22-35 is a repetition of page 9, lines 20-34.

Page 10 Line 43.
"be" should be "been."

Page 9-10 Line 11-53.
Verbal summaries of quadrants referred to in Figure 4 would be useful. For example: Page 9, Line 53 upper left hand quadrant (simpler, deterministic)... Page 10, Line 11 upper right hand quadrant (more complex, deterministic). Page 10, Line 22 lower left hand quadrant (simpler, uncertainty focused); Page 10, Line 37 lower right hand quadrant (more complex, uncertainty focused)..

Page 10, lines 47-50.
Redundant with somewhere

Page 10, lines 53-55.
We do not want to hear what is difficult; we want to be told what is known -- delete such extraneous verbiage.

Page 11, Line 2.
The preceding section does an excellent job of categorizing integrated assessment models on the basis of complexity vs uncertainty. The model results in this section, however, are categorized on the basis of cost-benefit type models and systems models that include linkages and interactions. Why the change in categorization? Is there any way to be consistent from one section to the next?

Page 11, lines 8-18.
This would be interesting to see in more detail than just this general verbiage --maybe show comparisons among models in a table. Such comparisons could go a whole lot further than things listed here. Suggest looking at the NAPAP State of Science/Technology report no. 14 by Thornton et al. for an example of a comprehensive review/comparison of models proposed for use in assessment.

Page 11, lines 18-22.
This seems to be a key point that you leave totally unsupported. Can you elaborate how these parameters have emerged as standards, with some references? Is the fact that they have emerged as standards in the literature policy relevant? Are they key policy issues, likely to remain so? Are there others that are or are likely to become key issues?

Page 11, lines 24-28.
Make simpler by shortening the 4 lines to "Several approaches have been used to evaluate uncertainties:"

Page 11, lines 34-37.
Delete "We end...high priority"; replace with "The uncertainty results suggest a number of".

Page 11, Line 39 through Page 12 Line 20.
This section is supposed to concern deterministic analyses but the section talks about models that include damages and also discusses work by Kolstad and Schlesinger that are explicitly stochastic, not deterministic. This section needs reworking.

Page 11, lines 42-48.
One sentence?

Page 11, lines 50-54.
Jump right into the results; no need for 5 lines of self references; you repeat all the references in the next pages (or could include them all) anyway.

Page 11, Line 55.
Here are references to Peck and Teisberg (1993) and (1994), but the list of references lacks these. Here are some possibilities:

Peck, Stephen C. and Thomas J. Teisberg, "Global Warming Uncertainties and the Value of Information: An Analysis using CETA," Resources and Energy Economics, Vol. 15, No. 1, 1993.

Peck, Stephen C. and Thomas J. Teisberg (1994), "Optimal Carbon Emissions Trajectories When Damages Depend on the Rate or Level of Global Warming," Climatic Change, November, pp. 289-314.

Peck, Stephen C. and Thomas J. Teisberg (1994), "Optimal CO2 Control Policy with Stochastic Losses from Temperature Rise," Electric Power Research Institute, October 14.

Page 12, line 1.
Change to "Table 6 shows the [emissions reductions projected to] balance the costs and benefits."

Page 12, Line 1-12.
This section alleges to report results from four models, but only gives results from two (note Table 6). The results also might be recalculated to refer to reductions with respect to 1990 emission levels, rather than reductions from baselines which are not provided, for comparability with the rest of the Chapters.

Page 12, lines 8-12.
Not many non-economists will understand this jargon...

Page 12, line 14.
Hammitt has two t's

Page 12, lines 18-20.
Do these "if's pertain? Are these results policy relevant?

Page 12 Line 33.
"ans" should be "and."

Page 12 Line 36.
"as heavily" should be "as heavily as."

Page 12, line 37, 44.
And on next page: please explain/define "zero rate of time preference" for non-economists.

Page 12, Line 39-41.
Cline does not really find optimal policies; he just determines that some arbitrarily chosen policy does or does not have benefits in excess of costs. This sentence perhaps should be as follows: "Thus, Cline endorses a much more aggressive control policy than the optimal control policies of most of the other studies."

Page 12, Line 48-53.
It is not really correct to say that "carbon taxes are usd (sic) to reduce carbon emissions in the model results discussed here." These models are optimization models which find optimal paths of carbon emissions over time; the "taxes" are shadow prices that provide a useful representation of the intensity of control effort (at the margin). In practice, however, the optimal paths could be achieved equally well with carbon taxes or tradeable permits. Here is alternative language for the sentence beginning on line 48: "These 'carbon taxes' are actually the marginal costs of efficiently reducing carbon emissions by the optimal amounts."

Page 11-16.
These pages provide useful summaries of the type of analyses that can be carried out with integrated assessment frameworks by different models, and this should remain in the report. Examples of identified sensitivities of the individual models, such as changing a discount rate 3 percentage points resulting in altering the "control rate" from 50% to 15%, is vital to providing an understanding of these current models. However, acknowledgment of these sensitivities is lacking in the Summary section of the chapter.

Page 13, Line 1.
The addition of "control rate" after "15%" would make this clearer.

Page 13, lines 35-48.
Values in parens make this paragraph difficult to read/understand smoothly. The text could probably be rewritten to make it easier.

Page 13, Line 36-45 and Table 7.
These comments provide numbers that may be used to correct CETA model data in Tables 6 and 7 (see comments 19 and 23). Some of the numbers presently in these tables appear to be rough approximations, presumably obtained by "eye-balling" figures from Peck and Teisberg (1992) and Peck and Teisberg (1993), and perhaps by inappropriately combining results from the two papers. In addition, the discount rate sensitivity numbers are transposed. It was puzzling about how many of these numbers were obtained. Perhaps figures and/or tables

from Peck and Teisberg (1992) and Peck and Teisberg (1993) were used to calculate these numbers. If so, there is a problem in that the model changed a little between papers, most notably with the substitution of the Maier-Reimer and Hasselman carbon cycle model. The following table provides the necessary numbers to re-do Table 7 correctly. These numbers were assembled from the raw data for the Peck and Teisberg (1993) paper.

Control Rate (%)

2090	2100					1990 Warming per 2XCO2	2000
Low - 1	0%	0%	1%	1%	Baseline - 3		
0%	2%	11%	10%	High - 5	0%	4%	67%	82%
Dam. Func. Pwr.							
Low - 1	0%	1%	3%	3%	Baseline - 2		
0%	2%	11%	10%	High - 3	0%	2%	27%	47%
Utility Disc. Rt.							
Low - 2	0%	1%	18%	29%	Baseline - 3		
0%	2%	11%	10%	High - 4	0%	4%	11%	10%

Carbon Tax ($/t)

2090	2100					1990 Warming per 2XCO2	2000
Low - 1	2	2	8	9	Baseline - 3		9
=20	12	57	66	High - 5	22	29	165	198
Dam. Func. Pwr.							
Low - 1	8	9	17	18	Baseline - 2		9
12	57	66	High - 3	10	13	131	162	Utility
Disc. Rt.							
Low - 2	19	24	115	136	Baseline - 3		9
12	57	66	High - 4	5	7	33	38	

Sources: Peck and Teisberg (1993)
Unpublished results from model in Peck and Teisberg (1993)

Page 14, Line 10.
This discussion raises the question as to whether the cost associated with anticipating a carbon constraint and thus resulting in lower baseline emission should be counted in the costs of control.. The answer is seemingly yes, but the discussion seems to suggest otherwise

Page 14, Line 11-20.
This section refers to Figure 6. The figure needs to be more clearly labeled. Without the text it is impossible to know what is being presented.

Page 14, Line 11-21.
Manne and Richels (1993) is not listed in the References. This draft language needs more transparent exegesis, to clarify the relationship between theory and reality. All energy consumers? Why would they, as individuals, say, decide to analyze the carbon content of their locality's current mix of electricity supply and ascertain opportunities to reduce their emissions on this basis? Can this be connected to a plausible real-world recommendation to individuals, or is it a strictly theoretical point?

Page 14, Line 34-38.
The brief discussion of the PAGE model is about the only acknowledgement of the likely large role that adaptation could play in integrated assessment. This discussion and model result should remain in the WGIII report and perhaps in chapter 10.

Page 14, line 43.
Parameters described in text are confusing and there is little reason given to care about the results

Page 15, line 1-3.
Should reference table 8.

Page 15, Line 43.
"analysis" should be "analyses."

Page 15, Line 42-43.
What is the intended distinction between tactical and strategic?

Pages 16-19.
Add several items to the future research agenda on page 16-19. One issue concerns aggregation of costs and benefits. There is a tendency to adopt the compensation principal in evaluating climate policy. Yet the great income differentials across the world call such an approach into question. Another issue concerns computation and solving integrated assessment models. More research needs to be done on methods for solving integrated assessment models more easily. This particularly applies to stochastic models.

Page 16, lines 28-34.
Not just in the developing countries. It seems another major challenge is how to handle adaptation such as unpredictable new technologies, switching to lower

carbon-content fuel mix (e.g. natural gas vs coal), etc. and their feedbacks. [see Part 1 points]

Page 16, lines 37-52.
Except for the way the last line is stated, this is good and important. Page 17 Line 15: Again, Peck and Teisberg (1994) is not in the reference list. Perhaps the correct reference is:

Peck, Stephen C. and Thomas J. Teisberg (1994), "Optimal CO2 Control Policy with Stochastic Losses from Temperature Rise," Electric Power Research Institute, October 14.

Page 18, lines 7-12.
It seems population growth assumptions could be a user-selected input variable -- let the user make his/her own assumptions.

Page 18, lines 23-33.
Consider the possibility that such end-to-end linking cannot credibly be done and still retain everything we want in terms of variety of effects, level of uncertainty, etc. Are there pieces of the chain that policy makers may want to evaluate, not necessarily linking everything? Can information be passed from module to module "manually", with the user developing an intuitive "feel" for the complexity and uncertainties that may not be credibly carried end-to-end in a model? Also, what is meant by "...optimistic assumptions about technical change in some parts of the analysis, but not in others"? (lines32-33)

Page 18, lines 51-55.
And onto next page: be sure not to consider such models independent after they have been hybridized like this!

Page 19.
The text could benefit from adding a concluding section that addresses in a preliminary way the problem of integrating the relationship between IA, research, and decision-making. Something that would reflect the sense of the following comments: "The design of an integrated assessment should start with the identification of outcomes that matter to key policy-makers--not with the science. Different outcome measures will be important to different actors....The challenge of performing integrated assessment is enormous. First, there is the challenge of casting the problem from the perspective of a variety of key decision-makers.... Finally, there is the institutional and political challenge of using integrated assessments to evaluate various policy objectives, to identify better policy strategies for meeting these objectives...and to set priorities in policy-motivated research." (Hadi Dowlatabadi and M. Granger Morgan, "Integrated Assessment of Climate Change," Science, Vol. 259, 3/26/93, p.1932)[underlining added] And:

"There is a growing need to ensure that [global climate change] research is focused in a more effective way to assist decision makers. However, defining the research most relevant to policy is not simply a technical question that can be answered by scientists. The complexity of the global climate change issue, and its urgency for decision makers, requires two-way communication between scientists and decision makers on what information is needed for policy development and what research can provide. This vital dialogue between the two communities has long been ad hoc at best and not pursued systematically....To be most effective, research on the climate system, impacts, and responses must be specifically designed and managed to support integrated assessments. The science-driven outputs of typical research cannot easily be adapted for direct use in policy-relevant assessments....Most importantly, assessments should be an integral driver of the supporting research agenda....The joint development of research agendas and priorities, incorporating the needs of decision makers and the input of researchers, facilitates a more successful translation of science into policy-relevant information." (J. Christopher Bernabo, written testimony submitted to the Committee on Science, Space, and Technology, U.S. House of Representatives, Washington, D.C., hearing on "Global Change Research: Science and Policy," May 19, 1993) [underlining added]

Page 19, line 11.
We should not suggest an "ultimate model" as a possibility, let alone as a goal. We will always want/need fundamentally independent alternative approaches. The structural uncertainty of these models is unknowable (except after real time has passed) and we should not lead anybody to believe one of them might be "right".

Page 27.
Table 5 is incomplete--covers only 6 of 16 models.

Table 5 Figure 4.
It's not a big deal, but it is odd to classify CSERGE as dealing with uncertainty,while DICE (and CETA) are classified as deterministic. His model is a lot like DICE or CETA, with a few stochastic states of the world represented. If so, it's about as stochastic as the version of CETA in Peck and Teisberg (1993), and it is probably less stochastic than the version of DICE reported on in Nordhaus (1994), Section III.

Table 6.
How were the numbers in the Table obtained? The numbers below are calculated from the actual numbers underlying Figures 5 and 6 in Peck and Teisberg (1992). These may be used to do Table 6 correctly.

		Control Rate (%)						
							1990	2000
2090	2100						CETA	
	Linear	0%	1%	3%	3%	Cubic		0%
2%	40%	68%						

		Carbon Tax ($/t)						
							1990	2000
2090	2100						CETA	
	Linear	7	8	18	19	Cubic		8
12	174	209						

Source: Peck and Teisberg (1992), Figures 5 and 6

Table 6 and 7.
It is impossible to review results that are not included in the Tables: either remove the GCAM and MERGE lines or enter results and recirculate for review. As noted elsewhere, both tables give results as percent reductions below baselines, but without the baselines it is impossible to comprehend the nature of the proposed policies. In Table 7, the CETA results for "utility discount rates" are inconsistent: high control rates are associated with low carbon taxes.

Figure 6.
The meaning of the figure must be clarified, and a source given.

U.S. GOVERNMENT COMMENTS ON INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE WORKING GROUP III DRAFT ASSESSMENT

CHAPTER 11: AN ASSESSMENT OF ECONOMIC POLICY INSTRUMENTS TO COMBAT THE ENHANCED GREENHOUSE EFFECT

GENERAL COMMENTS

Relative Merits of the Different Regulatory Regimes

The chapter provides a good discussion on the different types of regulatory regimes available to policymakers. It would benefit by expanding discussion on the relative merits of the different regulatory regimes with respect to the circumstances under which the advantages and disadvantages most important. These relate to uncertainties about the likely damages of emissions and the cost of emission reductions, and the curvature of the social cost damage function from emissions, among other factors.

We have solicited a short comparative analysis of these issues from an expert in the field, Gary Yohe. His analysis appears at the end of these U.S. Government comments on the chapter. We suggest the authors incorporate this analysis into the chapter to enrich the discussion of the relative merits of the different regulatory policies.

Expanded Discussion of Implementation

The chapter would benefit from an expanded discussion of the institutional and empirical aspects of implementing the various regulatory regimes, referencing recent experience with lead, SO2, and CFC's (which included both a tax and a cap). It is hoped this would shed further light on the relative merits of the various regulatory regimes. A publication by the U.S. Department of Energy from October 1989 entitled "A Compendium of Options for Government Policy to Encourage Private Sector Responses to Potential Climate Change" (Richard Bradley & Ted Williams, editors) is a helpful source of information. Also, Barry Solomon has written "Global CO2 Emissions Trading: Early Lessons From the U.S. Acid Rain Program" (1995).

Precise vs. Average Control of Emissions Over Time

The chapter emphasizes the fact that a carbon tax instrument would equalize the marginal costs of control but would have the disadvantage of only loose control over the quantity of emissions. Tax rates might have to be changed frequently to meet emission targets. In contrast, the chapter notes that a marketable permit system would allow much firmer control over the quantity of emissions.

While the literature emphasizes these points for toxic pollutants where exposure levels can be very important, it is difficult to see why the distinction is as important for carbon dioxide of other greenhouse gas emissions. Is there a need for great precision at a particular point in time in the control of the emissions of one greenhouse gas from one country (or a group of countries)? Rather, it is the overall magnitude of worldwide greenhouse emissions over long periods of time that ultimately may matter.

Incentives for Innovation
The potential effect of a carbon tax on the incentive to invent environmentally cleaner production technologies is also important. The welfare gains from stimulating such innovation, may be more significant than the (static) Pigouvian welfare gains. This issue is touched on, but ought to be expanded on. Does allowing for endogenous environmental R&D by the private sector affect the optimal carbon tax, or create an argument for using carbon taxes over carbon quotas?

Rent-seeking Behavior under Quotas
Also, we suggest the authors consider analysis along the lines of Krueger (1974), who suggested that once quotas are introduced, firms have a strong incentive to resist their removal, since they will lose the rents that such quotas create. This is not the case under taxes, since the rents are transferred to the government. This suggests higher deadweight losses due to rent-seeking expenditures under quotas.

Other Greenhouse Gases
We would like to see an expanded treatment of incentive approaches for controlling greenhouse gases other than carbon dioxide. While carbon dioxide is certainly the most studied of the greenhouse gases, methane and other greenhouse gases are important and potentially amenable to control through incentive mechanisms. An empirical description of what is known about the relative importance of the gases would also be helpful.

Transportation
The discussion of transportation and greenhouse policies is brief, in view of the importance of transportation emissions in global climate change. Also, the political difficulties associated (at least in some countries) with strategies such as fuel taxes and congestion pricing should be discussed.

SPECIFIC COMMENTS

Pages 12-13.
The chapter could elaborate on the potential for eliminating farm subsidies with the benefit of reducing methane emissions.

Page 14, Line 33.
In the United States, home energy ratings or energy efficient mortgages are examples of public policies designed to encourage the purchase of more energy efficient homes.

Page 32, Line 38.
For example, monitoring wood burning as a source of carbon dioxide emissions can be difficult.

Page 20, Footnote 14.
The footnote indicates that there are no production vehicles using lean burn technology that are able to meet the current U.S. (Californian) standards should mention the Honda production based

Accord 2.2 liter 4 cylinder lean burn engine, which meets California ULEV standards. (Contact Bob Thurber of the U.S. Department of Transportation for more information, if needed).

Page 26.
Note that tradeable quotas do not have to be time-limited. Rather than having annual quotas, they could be issued as stocks allowing emissions at any time.

Pages 29-30
The U.S. Initiative on Joint Implementation which began in 1994 could be mentioned here. This program allows for CH4 and N2) projects as well as energy and forestry projects for carbon savings.

Page 38
It should be noted that both compliance and enforcement were relatively easier under the Montreal Protocol than is likely to occur under an international agreement to reduce greenhouse gases, because there were a finite number of producers of chlorofluorocarbons.

US GOVERNMENT COMMENTS
CHAPTER 12: An Evaluation of the IPCC IS92 Emission Scenarios

General Comments

1. The US Government prefers that this chapter not be included in the Working Group III report. This material is already published as part of the 1994 special assessment. We believe that individual chapters and the Summary for Policymakers can and should refer to that document whenever relevant to the points being made. It is not necessary to include this in the report. It would only reopen these points for discussion at the Working Group III plenary.

Climate Change and Future Generations: Do We Care Enough?

Andrea Beltratti and Domenico Siniscalco

1. Introduction

Climate change has several implications on the equity ground. It has to do with horizontal equity, as climate change and mitigation policies affect differently countries and regions. It has to do with inter-generational equity as climate change is a very long run phenomenon, which implies deep and irreversible consequences. This paper deals with inter-generational equity (henceforth IE).

Equity across generations requires equal treatment of agents born at different points of time; this, in turn, implies a criterion which takes into account the utility of all the generations, without any discrimination. This is not done in any model which discounts the utility of future generations, as the standard growth model.

The issue of discounting and discrimination is becoming more and more relevant to economic theory and policy-makers to the extent that it interconnects strongly with climate change. While in the past the problem had mainly arisen in relation with the exploitation of exhaustible natural resources (e.g. oil), now it is used in relation to environmental degradation which touches directly upon the utility of future generations. It is our contention that the problems raised by climate change make IE even more relevant than before when evaluating the consequences of economic policies.

The article is divided into six sections. Section 2 provides a definition of IE, while Section 3 discusses it with reference to climate change and other environmental phenomena. Section 4 deals with discounting in the Utilitarian framework. Section 5 considers the Rawlsian criterion. Starting from the observation that the above criteria are basically normative, section 6 considers some positive aspects of inter-generational equity, and discusses the scope for further research.

While IE and the issue of discounting seem to be very abstract ones, we would like to point out that they have relevant consequences on actual policy making. Any calculation of costs and benefits related to mitigation policies, as those carried out in the context of IPCC, are currently based on models and calculations which embody some form of discounting. Even small changes in the discount rate can lead to substantial changes in the policy recommendations. For this very reason it is crucial to experiment with alternative criteria, which are ethically defensible and empirically sound.

2. Inter-generational equity: a definition

We define IE by means of a two-period example, with two generations consuming a flow of consumption c_t from a stock A_t, which can be seen as an environmental asset or a natural resource. Therefore $A_1 = A_0 - c_1$, $A_2 = A_1 - c_2$. Consumption of the stock allows for utility $u(c)$, where the utility function has the standard properties. A planner who is considering the problem from the point of view of period 0 would consider maximisation of the following function:

$$\max u(c_1) + (1/[1+\delta])\, u(A_0 - c_1)$$

where the resource constraint has been substituted in. The scalar $\delta \in [0,1]$ is the utility discount rate, or the rate of time preference. When $\delta = 0$ the utilities of the two generations are given equal importance in the criterion. For any $\delta > 0$ the utility of the future generation is given less weight, and gives rise to lack of IE. From the necessary conditions for maximisation of such a function, $u'_{c1} = (1/[1+\delta])\, u'_{c2}$, it is clear that consumption (and utility) is constant across generations only if $\delta = 0$, i.e. with no discounting. The larger is δ, the lower is the share of the stock left over for the future generations, the lower is the ratio between future and current utilities. The literature has spent many efforts in discussing the logic of discounting. The discounting practice has been objected to by several authors in the history of economic thought, first of all by Ramsey in 1928 (F.P. Ramsey, A Mathematical Theory of Saving, Economic Journal, 1928, pp. 534-559), who claimed that attaching a lower weight to the utilities of the

future generations arises "merely from the weakness of the imagination". Nevertheless, most of the economics literature has been cast in the framework of a model where the agent does attach a lower weight to future utility. Why is that?
The answer is connected with the choice of the time horizon over which to devise policies. In the simple two-period example given before it is of course not necessary to consider $\delta > 0$, but then the relevant question is: why two periods? How do we know there is no need to plan for the further future? In fact, to the extent that an infinite horizon seems more natural, it becomes necessary to consider a positive discount rate to maintain a finite value of the sum of all future utilities in the continuous time formulation. Such objective functions are well-defined only if a positive discount factor forces the sum to converge to a finite number. Lacking such convergence, many programs may yield a sum of utilities that is equal to infinity, and there is no way to choose among them. It therefore follows that problems related to discounting in the context of analytical models arise because of the impossibility to choose a final date for the planning horizon; moreover, problems would be solved only if such a date corresponded to extinction of the system under consideration, since otherwise there would be a problem of attaching a value to the stocks that are left at the terminal date of the planning period, which would by itself require an evaluation of what happens after the end of the planning period.
In fact, stochastic elements related to uncertainty about the survival of the system under consideration are one way to give discounting a proper microeconomic justification. This is done in two frameworks: the first is explored in the papers by Dasgupta, Heal, Majumdar, Beltratti and Chichilnisky, where it turns out that including some stochastic elements into the model, for example the possibility of finding backstop technologies or changing preferences, is equivalent to augmenting the discount rate in the deterministic problem for a certainty-equivalence property. The second is the Yaari-Blanchard framework based on continuous time overlapping generations, where each agent discounts the future at a rate which includes the instantaneous probability of death. In both cases one may assume a very tiny pure rate of time preference for the sake of writing down the model as a discounted utility problem and being able to apply the standard solution techniques, but then augments such a discount rate with a certainty equivalent term which becomes the true motivation for discounting.

3. The environment and inter-generational equity

Even though the problem of IE can be described in general terms as a decision about the use of resources at different points of time, that is how much should be saved and how much should be invested out of the production obtained from a given capital stock, it should be recognised that its relevance is particularly visible in discussing allocations of natural and/or environmental assets. Exhaustible resources are a good example: their use on the part of the current generation is clearly a deduction from the use of future generations, and as such poses a problem of equity.
Is the use of environmental resources, e.g. atmosphere, also part of the equity problem? The answer depends crucially on the *degree of reversibility* of their use, and on the *time lags* necessary to bring the stock to the original state. It is true that marine pollution and deforestation are phenomena that in principle can be reversed by cleaning up or by stopping the cases of overuse of the resource; however the time which is necessary to achieve purification and reforestation can be very long, and the costs can be extremely high. Moreover in practice high degrees of marine pollution and deforestation affect the ecological system in ways that are totally irreversible, causing the extinction of species which cannot live in the new polluted habitat. In other cases matters are even worse: each year six million hectares of productive dry land are turned into desert, turning such a resource from the class of reproducible to that of non-reproducible assets.
Global warming and climate change is another example of contrasts among generations: the current generation reaps the benefits of economic activity and increases the concentration of gases that might change the climate with a permanent negative impact on welfare of future generations. This phenomenon raises new concerns to the extent that it adds an important dimension of uncertainty: the very existence of the issue is under consideration, and its

consequences are highly uncertain, both from a climatic and from an economic point of view. Moreover, only co-ordinated international action among large industrialised countries may take useful actions; a voluntary decrease of emissions of a single country is useless given the public goods nature of the atmosphere.
Finally the economic consequences of environmental phenomena are long-lived, due to the characteristic of environmental assets to yield services for a long period of time. Excessive use of a resource deprives many (possibly all) future generations of a highly valuable income, which in some cases cannot be substituted with other assets. If current economic activity is pushed to the extent of causing a permanent change in climate, the damage to future generations may be unwieldy large.

4. Decreasing the discount rate

If on the one hand the main problem with discounting is discrimination of future utilities, and if on the other hand discounting is necessary for the comparison of different policies, could not one use a very low discount rate, or even better the limit of the solution for the discount rate tending to zero? This section gives three examples of why this may not be appropriate:

(i) In endogenous growth models there are solutions with permanent growth, where the rate of growth of consumption g depends on the difference between the marginal productivity of capital ρ (also equal to the interest rate) and the rate of time preference δ, given the elasticity of marginal utility η, $g = (\rho - \delta)/\eta$. The equation shows that decreasing the rate of time preference is going to increase the rate of growth of consumption, and therefore is going to increase the saving ratio of the current generation to the benefit of the future. This policy amounts to increasing inter-generational differences in utilities. Moreover, from the point of view of the solutions of the models, a lower bound on the rate of time preference is required to preserve finiteness of the integral of utilities given a positive rate of growth of consumption. In this setting, decreasing the discount rate is not always possible, and not even desirable for achieving IE.

(ii) In a standard cake-eating problem one has to devise the best rate of consumption of an exhaustible resource. Under a utilitarian criterion, the optimal rate of change of consumption over time is equal to $g = -(\delta/\eta)$. The limit of this solution as the discount rate tends to zero, implies a consumption level which is close to zero and declines very gently over time. In some sense, solutions corresponding to lower rates of discount are more equitable. However, the solution to the problem of consuming a cake from the point of view of IE implies no use of the resource. The only solution which maintains perfect equity for an infinite population is the one in which *nobody* consumes any portion of the stock. There is a discontinuity in the policies suggested by a tiny discount rate and a zero discount rate.

(iii) Finally, decreasing the effective discount rate may even lower welfare in a second-best situation where there are some market failures. In some cases, as the discount rate goes down, the difference between the private and public solutions increases, by making the externality problem even worse. This may for example be due to the fact that a lower rate of discount increases patience and the equilibrium marginal productivity of capital, increasing investment and the capital stock. To the extent that a larger capital stock puts more pressure on the use of resources, a lower quality of the environment may result. The relative welfare of the decentralised and the centralised solutions may decrease, leaving the market economy in an even worse situation. In a second-best world, the government has to correct for the market externalities before correcting for discrimination against the future.

5. The Rawlsian criterion

If decreasing the discount rate cannot be recommended as a valuable general strategy, one has to start the quest for alternative criteria. The most well-known alternative has been formulated by Rawls (J. Rawls, 1971, A Theory of Justice, Harvard University Press, Cambridge), who suggested maximising the utility of the least advantaged generation in order to reach a situation where utility is constant from one period to the other.
The plausibility of the solutions suggested by the Rawlsian criterion is highly model-dependent: Solow

showed that the Rawlsian criterion applied to a one-good economy described by a standard production structure of the type $K_t = F(K_t, L_t) - C_t$ predicts a solution that never leaves the initial conditions, $C_t = F(K_o)$, for any $t \geq 0$.
Generation 0 could well save and increase the future stock of capital, but this would decrease immediate utility without any possibility of compensation from the future to the present. This solution is not very satisfactory, from both a descriptive and a normative point of view.
However, in the same paper Solow shows that such a "degenerate" policy does not necessarily hold if one modifies the specification by adding a flow of natural resource r in the production function, $Y_t = F(K_t, r_t)$. In this case the sacrifice of the present in terms of accumulation of capital is compensated by a larger use of natural resources that may yield consumption goods: there are trading opportunities between the present and the future. The resulting dynamics is complicated and not very intuitive. Asako (in Asako, K., 1980, Economic Growth and Environmental Pollution Under the Maxi-min Principle, Journal of Environmental Economics and Management, 7, 157-183) considers a model where agents derive utility $u(c,P)$ from consumption c and disutility from a stock of pollution P that is increased over time by production, $\dot{P}_t = g(k_t) - h(P_t)$. In this case the increase in consumption goes with the increase in pollution, and the Rawlsian criterion suggests a way to balance the two in order to maintain utility constant.
At a more easily interpretable level, Hartwick, in the context of the same model considered by Solow, shows that the solution is simpler if one is concerned with a path maintaining a constant level of consumption, without necessarily looking for the one with the largest consumption. Hartwick finds that society may maintain forever a constant level of consumption as long as there is net investment in physical capital which equals the rent obtained from extraction of exhaustible resources, $\dot{K}_t = (\partial F/\partial r)\, r_t$. In the Cobb-Douglas case considered by Hartwick, $Y_t = K^{\alpha}_t\, r^{1-\alpha}_t$, the rule therefore calls for $\dot{K}_t = (1 - \alpha)Y_t$, that is a constant investment-output ratio, which, given constancy of consumption and output, implies a constant investment over time. This rule is simple and intuitive, even though it is based on a constant saving rate which may not be compatible with the choices made by optimising agents (subsequent contributions have further examined Hartwick's Rule, by pointing out its connection with the concept of a regular maxi-min path, introduced by Burmeister and Hammond. Two problems may prevent the wide application of the criterion:

(i) The dynamic paths may be difficult to obtain in market economies. Becker has shown that one can find a regular maxi-min path which can be sustained as a competitive equilibrium as long as it is possible to implement a system of effluent charges, environmental rental charges and lump sum transfers which is however very complicated and requires a knowledge of the structure of the economy which is not likely to be possessed by the central authority.

(ii) The second problem comes from the lack of inter temporal consistency of Rawlsian programs. Dasgupta and Calvo have shown that generations which manifest altruism towards future generations will deviate from equitable plans decided by previous altruistic generations.

6. Normative models and positive theory

The models and criteria recalled so far are primarily normative, as they provide guidance for a benevolent inter-generational planner. If we move to the positive level, and analyse the economic incentives that lead agents to implement a certain criterion, we run into serious problems.
In the absence of a equitable inter-generational planner, the inter temporal allocation of environmental and natural resources (and the related costs) can be characterised as a game among generations, just like the inter-generational allocation can be seen as a game among countries.
The difference with the horizontal allocation, however, is substantial. In the inter temporal game, one set of players, namely future generations, is simply missing and has no representation in current decisions.
In a positive setting, the present generation has necessarily dictatorship over the future. And this situation obviously leads to "bad" allocations unless the present generation cares about future generations and adopts an equitable criterion. Let us conventionally call this attitude "ethics", and define

"ethical" an agent or a population that cares about future generations.
The previous remark leads to a crucial point: in a positive setting, there is *no inter-generational equity without ethics*. This can be seen as a negative result. But it can also be seen as a starting point for further research. As is well known, some theorists (e.g. Amartya Sen) have long been working on ethics, and claim that ethics is crucial for the orderly working of market economies.
We believe that some degree of ethics exists in our societies and systems of values (in some more than in others). We could also provide some examples of it. But from the economist's point of view the relevant question does not concern so much the existence of ethics, but how to transform ethics into decisions which implement equity.
In this area, we believe there is much to be gained by orienting our research and policy analysis in some specific directions.
First of all, we should work in designing appropriate institutions that implement inter-generational equity when at least one share of the population is ethical. We are thinking of mechanisms that prevent free riding by the few, voting systems and public choice mechanisms which favour long run considerations; education and the diffusion of information.
Over and above research on institutions, we also recommend applied work to highlight rules of the thumb which are somehow robust to changes in models and key parameters
Finally we would like to conclude with a plea for the preservation of cultural diversity. In several cultural systems (the catholic, the buddhist etc.). inter-generational equity is a deep-rooted value. One cannot say the same of the simplistic version of *homo oeconomicus*, which admittedly is strictly self interested. This assumption is convenient and fruitful from the theoretical point of view. But it should not be taken as a recommendation or a guidance for the design of society and educational systems, as *homo oeconomicus* appears to be unsustainable in the presence of environmental resources. Different cultural systems seem to be superior in the sustainability dimension, and this should start a reflection by the advocates of totally unregulated societies.

Paper presented at the July meeting on equity issues rela climate change organised by the IPCC Working Group Nairobi, Kenya. A full version is available as a Wc Paper: *Feem Nota di Lavoro* 49.94

1/24/95

To: Ray Squitieri
Fm: Joe Stiglitz

p. 2 par.2

Most of the report is not conducted from the framework of a singl global decision maker. Replace beginning with second sentence:

The report identifies a number of general principles and findings that are relevant, no matter what the decision making process, su as those concerning the design of cost effective policies.

p. 2 at B

There is not consensus on the desirable of the use of regulatory instruments.

p. 3 fn. 5 First sentence does not read well. Second sentence m not be correct, because of the "sink" capacity of forests.

p. 4 par. 1 , line 22

"...reflects its objectives, economic conditions, and constraints "

The list of considerations that follow mix up conditions that are particular to a given country, and those which are more "universa such as "international equity."

More generally, the laundry list of possible factors does not see to say much, and does not reflect any consensus about what are th most salient factors. I suggest deleting remainder of paragraph. (Otherwise, it could be used as an "excuse" for less developed countries not to take any action.)

p. 5 after line 4

Need to add a sentence to the effect that

"Clearly, the dangers of significant harmful effects from global warming increase the greater the degree of concentration of greenhouse gases. The discussion below focuses on the effects associated with concentration levels in the order of magnitude of...."

par 2.

Delete the last sentence (in quotes) and add the following senten

Studies cited here establish that the pattern of timing of reductions of emissions can have a major effect on the overall costs of mitigation. More paced emission reductions reduce the costs associated with premature retirement of capital and allow taking further advantage of technological improvements that are likely to become available in the future.

par. 3

It is not true that stabilization of atmospheric concentration of greenhouse gases will require

The discussion referring to alternative scenarios will not be of much use to most policymakers, who will not be apprised of the assumptions that underlie them. If one refers to them at all, on should spell out their key assumptions.

p. 6 Since at this point in the report, there is no accepted goa of eventual concentration levels, it would be better simply to describe the thresholds: (a) if the eventual goal is stabilization at the level of.... then emission reductions of thi magnitude are likely to be required; (b) if the eventual goal is.... then.....; (c) On the other hand, if the eventual goal is stabilization at a level of or above, then it is likely that n further substantial interventions will be required, at least before.....

p. 6 first full par

I have criticized this par. before. Few economists would subscri to, let alone know what the report is talking about, when referri to a "safe minimum standard." All of these standards can be embraced in cost benefit analysis, incorporating different degree of risk aversion. Using this kind of language would significantl interfere with the creditability of the IPCC report in the economics community and beyond, and is likely to be sharply criticized by some governments. This is particularly true, given that the term k"dangerous anthropogenic interference..." is nowhe defined. The order of magnitude of anthropogenically induced climate changes is smaller than those which have occurred natural in the past. While it is true that environmentalists often argue for the absolute standard, and it is sometimes used in establishi health standards, most economists are strongly opposed to these approaches.

Safe minimum uses two terms that few economists would find meaningful: "reduce the risks of climate change to an acceptable level at an acceptable cost."

In the discussion of cost benefit, you should explicitly say that risk considerations can and should be brought into the cost benef analysis.

If reference is made to the absolute standard and/or safe minimum standard, it must be clearly stated that most economists do not accept these approaches and argue for the use of a cost benefit approach, with appropriate attention paid to the treatment of ris

par 3
in Figures 3(a) or 3(b), where non-economic effects of climate change are brought into the analysis, but without the development of a formal way of quantifying the effects and/or valuing those effects relative to the economic impacts.

p. 7 First sentence of first full par. I do not believe that there is a consensus on this conclusion. Better to say

"Because of the large uncertainties...., it is difficult in practice to rely solely on cost benefit analysis for the selectio of an appropriate stabilization objective at this time. Still, t information provided by cost benefit analysis is critical in maki judgments not only about that decision, but also about the timing of emission reductions and the design of cost effective strategie

I would delete the last two sentence. The next to the last sentence is somewhat misleading. One can easily extrapolate the benefits and costs associated with different levels of atmospheri concentration (climate change) within a range, at least, based on currently available studies.

p. 7 par. 4 Need to add sentence that estimates of damages for many economies in the temperate and Northern climate zones are small, and in some cases possibly negative.

p. 8 par. 2

no reducible market or government induced imperfections

later "assume market failures or government induced imperfections...

p. 9 first full par.

Discussion would be enhanced by a brief discussion of the most important differences in "input" assumptions.

p. 11

Somewhere in this section one needs to add:

"Issues of equity and efficiency can, however, for the most part separated. Cost effective strategies can be developed embracing variety of ways for sharing the burden. Efficiency will require full participation of the developing countries, including some forms of commitments for emission reductions. Without some form commitment, actions by the developed countries can be partially, largely, or more than completely offset by actions in the developing countries."

Same page, around line 8, par.1

Total emission increases arise both from increases in emissions p capita and increases in population. The extent to which "rights emission" should be distributed on a per capita basis, and the extent to which they should reflect country's obligations to control population growth will be questions that will also have t be addressed by future negotiations.

Add somewhere on this page

However, the extent to which past emissions will have contributed to ambient concentrations 100 or more years from now, when the impacts of greenhouse gas concentrations are most likely to be felt, are limited.

p. 12

Add after second par. (replacing last sentence of par.)

"It is important to bear in mind that in making choices concernin alternative policies, while the differences in consumption at different dates will be valued using the SRTP, those differences consumption will themselves be affected by the opportunity cost o capital, which typically is in the range of 7% to 15% real. Thus where mitigation projects displace other forms of investment yielding these higher returns, they typically will not be chosen unless the mitigation projects themselves yield returns at least equal to those on the displaced capital."

Second par.

The numbers cited are neither consistent with Chapter 4 nor with the scenarios chapters.

p. 13, last par after "quotas."
Though there are implementation problems associated with each, bo can be made consistent with equitable international burden sharin

On the other hand, most economists believe that technology standards and other regulatory mechanisms are among least cost effective ways of attaining emission reductions.

Minor comments

p. 4 par. 3.

"relatively costly. However..."

p. 4, par 4

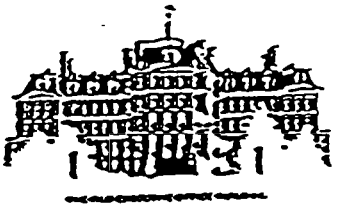
"...emissions. Hence..."

6

Dear Erik,

Thanks for letting us take a look at the policymaker summary. My recollection was that the previous draft was, in some ways, both stronger and more complete. What concerned me most was the overa "tone" which too often was normative. This should be simply a presentation of scientific evidence for the use of policymakers, not telling policymakers what they should do. To the extent that there are explicit policy statements, they should be of the form, "If this is your objective.....then the least cost way of addressing this problem is....."

Moreover, there are some ideas that get considerable attention in the policymakers summary which are far from the concensus view--indeed, I would describe them as explicitly rejected by 99% of al economists. We should either drop these perspectives (saying somewhere in the introduction that there are other views, discuss in the papers, but the policymaker summary focuses on the "concensus perspectives.") or introduce them <u>briefly</u>, with the above described caveat. Unless we say that, the report will not b taken seriously, and the entire report will be dismissed out of hand as not reflecting the overall judgment of the disciplines.



EXECUTIVE OFFICE OF THE PRESIDENT

COUNCIL OF ECONOMIC ADVISERS

Date: 1/24/95

Please deliver to: Ray Squitieri

FAX number of addressee: _____

Telephone number of addressee: _____

From: JOSEPH E. STIGLITZ, MEMBER/
Lisa D. Branch, Exec. Assistant

FAX number of sender: 202-395-6958

Telephone number of sender: 202-395-5036

Number of pages, including cover sheet: 7

IPCC

January 24, 1995 4:25 pm **--Revised Memo--**

MEMORANDUM TO JOE STIGLITZ

FROM: Ray Squitieri

SUBJECT: Cline's Discount Rate Estimate

Howard Gruenspecht just pointed out to me that Cline's discount rate calculation is not consistent with the growth rates in the IPCC scenarios. Cline assumes per capita consumption growth of 1% annually, while the IPCC scenarios give it as 1.0% to 2.3% annually for 2000-2100, with about 1.6% for the central scenarios (A and B) that are most often quoted. As this is to be an IPCC report, I suggest we make our estimates consistent with other IPCC results. That would move the SRTP from 1.5% to 2.4% (= θg = (1.5)(1.6)) and Cline's "effective discount rate", assuming consumption/savings = 80:20 to (80%)(2.4) + (20%)(6) = 3.12%.

Thus I suggest a replacement for the following paragraph:

Specific applications in the still new economic literature on global warming have adopted important differences in estimation of the discount rate. In a benefit-cost analysis of greenhouse abatement, Cline (1992) adopts a zero rate of pure time preference (ρ), and sets the SRTP at 1.5% per annum, the result of an assumed consumption growth rate of 1% per capita multiplied by an elasticity of marginal utility of 1.5. After taking account of the share of resources coming out of capital (20% economy-wide, versus 80% out of consumption) and taking into account the opportunity cost of displaced capital and depreciation, Cline's effective discount rate is closer to 2 per cent. This is in keeping with recent work by Pearce and Ulph (1994).

Replacement text:

Specific applications in the still new economic literature on global warming have adopted important differences in estimation of the discount rate. To follow the approach suggested by Cline (1992), with a zero rate of pure time preference (ρ), and using the consumption growth rate of 1.6% per capita from the IPCC scenarios (IPCC 1992) multiplied by an elasticity of marginal utility (θ) of 1.5, gives an SRTP of 2.4%. If instead it is assumed that per capita growth is only 1% (perhaps because of slower growth after 100 years), or if θ = 1, then the SRTP becomes 1.5%. After taking account of the share of resources coming out of capital (20% economy-wide, versus 80% out of consumption) and taking into account the opportunity cost of displaced capital and depreciation, the effective discount rate becomes 2% to 3%.

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cc: Sally Kane

100
-80 -22
-ΔC -ΔC
+ΔC =

$\frac{(1+g)(100) - 22}{1.02} = 80$

$1+g = 80(1+i) + 20(1+r)$

$\frac{(1+g)(100) - (1+r)20}{1+i} = 80$

Insert for Summary for Policymakers -- Discount Rate and Intergenerational Equity

[replaces 2 paragraphs on page 12, Jan 20 draft, beginning "Assuming long-term ..." and "Increasing the discount rate ..."

Ethical considerations suggest zero as the rate of pure time preference. The opportunity cost of capital (or market rates of interest) are used to calculate the cost of an investment. The result is a stream of changes in consumption. To this is applied the social rate of time preference. Assuming long-term per capital growth of 1.6% annually (adopted in the IPCC scenarios for 2000-2100), other standard parameter estimates, the social rate of time preference becomes 1.5% to 2.5% annually. If eighty percent of this total is assumed to displace consumption and 20% to displace investment, the effective discount rate becomes 2% to 3%.

Another approach gives more importance to market rates of interest, which have been higher than these figures because of higher returns to invested capital, and because of higher rates of individual time preference. Advocates of *descriptive* approach, as it is sometimes called, recommend discount rates of 4 to 5 percent.

Increasing the discount rate becaue of risk is generally inappropriate. [delete rest of paragraph to "... and even negative."

gas emissions (see Figures 5 and 6), vulnerability to climate change (Chapter 6), wealth, resource endowments, and institutional capacity to respond effectively. The Convention provides that these circumstances be reflected in differentiated responsibilities. Developed countries have undertaken commitments through the Convention for technology transfer and contributions to the financial mechanism.

A rigid "north-south" delineation of equity issues is inappropriate and may be highly damaging in the long run, although it permeates much of the debate at present. The implications of climate change for developing countries are different than those for developed countries because the former are generally poorer, have contributed much less to past emissions and still emit much less per capita, have shorter policy time-horizons, often weaker institutions, other urgent priorities, and are generally more vulnerable to climate change. However, there are substantial variations within the "north" and within the "south" in terms of absolute and per capita emissions, the likely impacts of climate change, institutional strengths and preferences, and endowment of natural resources that may be affected by mitigation. Similarly, over the next century some developing countries will continue to make marginal contributions to the problem, while emissions from others may well start to dominate it.

Countries (such as low lying coastal regions and islands or drylands) and special groups within society (such as the poor, and sometimes women or children, or specific occupations or regions) that are especially vulnerable to climate change — those on whom the costs of abatement and coping would be especially burdensome — merit special attention.

All Parties have equal status under the Convention. Procedural equity also requires that all Parties be able to participate effectively in international negotiations related to climate change. Assistance to enable developing country Parties to participate effectively in negotiations would increase the prospects for achieving effective, lasting and equitable agreements on how best to address the threat of climate change.

Discount Rate and Intergenerational Equity

The discount rate raises some of the most profound philosophical issues of policy toward climate change, because it confronts the trade-off between the interests of the present and future generations. The discount rate is the mechanism used to make economic effects at different points in time comparable. The choice of discount rate

is important in climate change analyses because the time horizon is extremely long and the abatement costs tend to come earlier than the benefits of avoided damages.

Economic literature suggests that the proper rate for discounting *consumption* at different points in time and across generations is the social rate of time preference (SRTP). The SRTP is composed of two components, "pure time preference" and the incremental welfare derived from future consumption:

- Pure time preference is a reflection of impatience. Although there is debate in the literature, values tend to range from zero to 3%

- The incremental welfare of future consumption accounts for rising per capita income over time and the resulting decline in the incremental welfare (marginal utility) derived from the higher future consumption.

Assuming long term per capita growth rate of ~~no more than 1%~~ 1.6% (adopted in the IPCC Scenarios) per year, the social rate of time preference has been suggested by some authors as about ~~1.5%~~ per year but various other analysts have suggested values ~~between 0.5% to +6.0%~~ 2.4% per year.(**CHECK WITH REVISED CHAPTER 4**). The SRTP discounting approach is equally relevant for developing and developed countries, however, low income countries would be expected to have higher SRTPs initially. Typically the rate of return on private investment will be higher than the SRTP.

~~Increasing the discount rate because of risk is generally inappropriate. Because one component of the SRTP can involve uncertainty about the future growth rate, risk considerations might justify *reducing*, rather than raising, the SRTP. However, because the relative price of environmental services is likely to rise over time the effective discount rate for environmental services can be lower than the goods discount rate, and even negative.~~

Policy Instruments

A clear distinction needs to be drawn between actions to reduce the impacts of climate change and actions to reduce emissions. The former also involve consideration of adaptation policies.

Policy instruments designed to mitigate climate change need to be assessed at the international and domestic levels. Such instruments can help participating countries comply with multilateral commitments on climate change abatement, including international transfers of resources and technology. The international and domestic

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DATE: 09 JAN 95

NUMBER OF PAGES TO FOLLOW: 4

FAX TO: JOE STIGLITZ
CEA

ADDRESSEE'S FAX NUMBER (202)395-6958

ADDRESSEE'S CONFIRMATION NUMBER (202)395-5036

FAX FROM: RAY SQUITIERI
U.S. TREASURY

SENDER'S FAX NUMBERS: (202) 622-1294

SENDER'S CONFIRMATION NUMBER: (202) 622-2340

COMMENTS/SPECIAL INSTRUCTIONS:

January 24, 1995

Post-it™ brand fax transmittal memo 7671	# of pages ▸ 1
To J. STIGLITZ	From R. SQUITIERI
Co. CEA	Co. Treasury
Dept.	Phone # 622-2340
Fax # 395-6958	Fax # -1294

MEMORANDUM TO JOE STIGLITZ

FROM: Ray Squitieri

SUBJECT: Cline's Discount Rate Estimate

Howard Gruenspecht just pointed out to me that Cline's discount rate calculation is not consistent with the growth rates in the IPCC scenarios. Cline assumes per capita consumption growth of 1% annually, while the IPCC scenarios give it as 1.0% to 2.3% annually for 2000-2100, with about 1.6% for the central scenarios (A and B) that are most often quoted. As this is to be an IPCC report, I suggest we make our estimates consistent with other IPCC results. That would move the SRTP from 1.5% to 2.4% (= θg = (1.5)(1.6)) and the Cline's "effective discount rate", assuming consumption/savings = 80%/20%, = 80%(2.4) + 20%(6) = 3.12%.

Thus I suggest that the following paragraph:

Specific applications in the still new economic literature on global warming have adopted important differences in estimation of the discount rate. In a benefit-cost analysis of greenhouse abatement, Cline (1992) adopts a zero rate of pure time preference (ρ), and sets the SRTP at 1.5% per annum, the result of an assumed consumption growth rate of 1% per capita multiplied by an elasticity of marginal utility of 1.5. After taking account of the share of resources coming out of capital (20% economy-wide, versus 80% out of consumption) and taking into account the opportunity cost of displaced capital and depreciation, Cline's effective discount rate is closer to 2 per cent. This is in keeping with recent work by Pearce and Ulph (1994).

be replaced by:

Specific applications in the still new economic literature on global warming have adopted important differences in estimation of the discount rate. To follow the approach suggested by Cline (1992), with a zero rate of pure time preference (ρ), and using the consumption growth rate of 1.6% per capita from the IPCC scenarios (IPCC 1992) multiplied by an elasticity of marginal utility of 1.5, gives an SRTP of 2.4%. After taking account of the share of resources coming out of capital (20% economy-wide, versus 80% out of consumption) and taking into account the opportunity cost of displaced capital and depreciation, the effective discount rate is around 3 per cent.

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cc: Sally Kane

Table 2.4.3
GNP per Capita Growth Rates
(Annual Percentage Growth)

	OECD	USSR/ E. Europe	China & CP Asia	Other	Global
IS92a,b					
1990-2000	2.8	-0.6	3.6	1.4	1.3
2000-2025	2.0	2.9	4.5	2.4	1.7
2025-2050	1.6	1.3	3.2	2.4	1.4
2050-2100	1.1	1.1	3.0	2.4	1.7
IS92c					
1990-2000	2.0	-1.6	2.3	0.2	0.3
2000-2025	1.5	2.1	3.7	1.7	1.1
2025-2050	1.1	0.6	2.5	1.6	0.8
2050-2100	0.7	0.4	2.3	1.7	1.0
IS92d					
1990-2000	2.8	-0.5	3.6	1.5	1.3
2000-2025	2.1	2.9	4.7	2.6	1.9
2025-2050	1.9	1.6	3.6	2.7	1.7
2050-2100	1.5	1.4	3.4	2.7	2.0
IS92e					
1990-2000	3.6	0.6	4.8	2.5	2.2
2000-2025	2.5	3.6	5.3	3.2	2.3
2025-2050	2.1	2.1	3.9	3.1	2.1
2050-2100	1.6	1.9	3.8	3.2	2.4
IS92f					
1990-2000	2.7	-0.5	3.2	1.2	1.0
2000-2025	1.8	2.7	4.4	2.2	1.5
2025-2050	1.4	1.1	3.1	2.1	1.2
2050-2100	0.9	0.8	2.9	2.2	1.5
SA90-Low					
1990-2000	1.4	1.9	2.0	0.7	0.7
2000-2025	1.5	1.7	2.1	1.3	0.9
2025-2050	1.0	1.4	2.3	0.8	0.7
2050-2100	0.9	1.5	2.4	1.5	1.2
SA90-High					
1990-2000	2.5	4.0	4.0	2.6	2.1
2000-2025	2.2	3.7	4.1	2.8	2.1
2025-2050	2.0	2.9	4.1	3.0	2.3
2050-2100	1.2	2.2	3.7	2.9	2.2

1.6

1.0

1.8

2.3

1.4

Given these per capita growth rates for IS92 scenarios use of 1% or less annual consumption growth for purposes of an "example" is hard to justify -- 1.6 percent would be a better choice.

life to consumption in another year--will not equal the SRTP. In standard life cycle models, even with no technological progress and an economy in steady state, there would be no discounting for society's purposes -- each generation is identical, so the marginal utility of consumption of each is the same. Nonetheless, the market rate of interest will be positive in any efficient equilibrium under certain reasonable assumptions about utility functions (such as individual impatience and zero bequest motive; Diamond, 1965). In such models the market rate of interest would thus always overestimate the SRTP. Under some special conditions, with governments intervening with non-distortionary taxation to optimally redistribute income across generations, then observed market rates of interest will accord with the SRTP. But these are highly specialized conditions. (See Stiglitz, 1985, Pestieau, 1972). The market rate of interest, of course, remains relevant, because it reflects the opportunity cost of capital; the changes in consumption generated by any change in policy will be strongly affected by the opportunity cost of capital, as the discussion below will illustrate.

3.3.8 Discount Rate Estimates -- Prescriptive Approach

The approach described in the previous sections, under plausible assumptions, leads to low discount rates for changes in consumption of future generations. With high rates of productivity increase (and high g), of the order of 1.5%, and high values of the elasticity of marginal utility (θ), the social discount rate is of the order of 3%; with low rates of productivity increase, of the order of .5%, and low values of the elasticity of marginal utility, the social discount rate is of the order of .5%.

It must be emphasized that these discount rates apply to consumption only, and that they can be applied only after the foregone benefits of other investments have been included in the costs of the program.

In general, there is no reason why the discount rate should be constant over time even if ρ and θ are constant, since g need not be constant. In fact, if we assume a gloomy scenario where future output and consumption decline, then g and thus the SRTP may be negative (Munasinghe, 1993).

Developing countries, with higher rates of productivity increase, can justify higher rates of discount, at least until the gap between their standards of living and those of the more developed countries have been closed. With labor productivity increases and per capita income growth of the order experienced by the Asian miracle countries of 5 to 8% per year, and elasticities of marginal utility of 2, discount rates of the order of 10% to 16% could be justified. Similarly, low-income countries close to subsistence levels could have high elasticities of marginal utility (rapid dropoff of marginal utility from initially extremely high levels associated with privation), so that their SRTPs could be high even if they were experiencing slow growth over long periods. These distinctions have important implications for global warming policy, because they would tend to mean that the calculus of trading off present abatement costs against future benefits from avoidance of global warming damage could be less attractive for developing countries than for industrial countries. However, there are other elements in the calculus that could go the other way, such as the likelihood of higher relative future damage from global warming for the developing countries (see chapter 6).

Specific applications in the still new economic literature on global warming have adopted important differences in estimation of the discount rate. ~~In a benefit-cost analysis of greenhouse abatement, Cline (1992) adopts~~ a zero rate of pure time preference (ρ), and ~~sets the~~ SRTP at ~~1.5%~~ per annum, the result of an assumed consumption growth rate of ~~1%~~ per capita multiplied by an elasticity of marginal utility of 1.5. After taking account of the share of resources coming out of capital (20% economy-wide, versus 80% out of consumption) and taking into account the opportunity cost of displaced capital and depreciation, ~~Cline's~~ the effective discount rate is closer to 3 per cent. ~~This is in keeping with recent work by Pearce and Ulph (1994).~~

3.4 Formulation of Descriptive Approach

IPCC

INSTITUTE FOR INTERNATIONAL ECONOMICS

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FACSIMILE TRANSMISSION COVER SHEET

PLEASE DELIVER TO:

NAME: Joe Stiglitz

COMPANY: CEA

FACSIMILE NUMBER: 395-6958

TELEPHONE NUMBER: 395-5036

TRANSMISSION SENT BY:

NAME: Bill Cline

DATE: 1/23/95 TIME: _____

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Our facsimile number is (202) 328-5432

Joe, here are my proposed revisions. They basically sharpen the core argument. Let me know if you disagree.

Best,

Bill

W Cline
1-23-95

Suggested revisions to January draft of discount chapter.

1. Page 6, line 6. Add the following at the end of this paragraph:

In short, all effects are converted to their consumption equivalents (as discussed in section 3.6), and then discounted at the SRTP.

2. Page 11, line 1. Insert "as low as" before "one quarter of one percent"

3. Page 11, line 9.
change to
... illustrates [and as discussed below with respect to shadow pricing capital]. Most global warming ...

4. Page 12, line 12. Add the following:

However, as shown in the box, the real return on treasury bills has been close to zero. This return is conceptually the closest to that at which households can transfer consumption over time without risk. It thus matters crucially, even in the descriptionist approach, whether the relevant discount rate is that for investment, that for consumption, or some mixture of the two (section 3.6 below).

5. Page 12, line 49.

Replace "It is sometimes argued ... not feasible." with the following:

In the context of climate change, the central argument of the prescriptionists is that other alternatives are not feasible. As suggested in the previous box, it is implausible that society can undertake a firm commitment over a three-century horizon to set aside incremental investments in other capital goods and earmark the proceeds for eventual compensation of those adversely affected by global warming.[1] Even if such a commitment could somehow be

---

[1] In this important respect, the nomenclature of the two schools should switch. The descriptive school, which emphasizes a positive (observational) rather than normative approach, becomes considerably divorced from what would be the most plausible future behavior, as it implicitly prescribes that all relevant resource decisions should be viewed as solely affecting investment rather than consumption at the margin. Instead, it is much more consistent with positive (descriptive) analysis to assume that resource decisions on an issue this large will broadly resemble those for the economy as a whole, meaning that the great bulk of

entered into credibly, there would be no guarantee that the rate of return on capital would remain as high over this horizon as it is today.

[Paragraph] Accordingly, {if the long-term consumption rate ... (continue original line 50)}

6. Page 14. line 9. Add the following footnote at the end of this line:

Cline (1992) proposes a shadow price of capital set equal to the present discounted value of an annuity paying equal annual installments over a lifetime of *N* years (set at 15 years for typical lifetime of capital equipment), with a return of *r* equal to the rate of return on capital, and discounted at the social rate of time preference (SRTP). With plausible ranges for *N*, *r*, and *SRTP*, the shadow price of capital tends to be in the range of 1-1/2 to 2 units of consumption equivalent per unit of capital.

NOTE: scanning the document, I could not find where footnotes 1 and 4 belong.

NOTE: p. 10 line 7 Pestieau

---

resources allocated to dealing with climate change will come out of consumption rather than alternative investment. As discussed in section 3.6 below, there is a considerable literature on the importance of determing whether resource sourcing is from consumption or investment.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

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cc: Ray S.

FACSIMILE TRANSMITTAL

Date: January 16, 1995

To: Dr. Joseph Stiglitz

Fax: (202) 395-6958

From: James Bruce

This transmission consists of 12 page(s) including this cover page.
If there is a problem with this transmission, please call (416) 369-0900.

COMMENTS/MESSAGE:

Here are some general points and suggestions for revisions to your chapter. Could you please make as many of these changes as possible and return a revised hard copy and diskette to the Technical Support Unit by **Friday, January 20**. I apologize for the short turn-around time, however, we must have the final versions of all chapters at that time in order to meet our deadline so we may mail the report for government review next week.

Thank you.

OMM WMO

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

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MEMORANDUM

TO: José Goldemberg
Joseph Stiglitz
Ray Squitieri

FROM: IPCC Working Group III Bureau

RE: Changes to draft chapter 1

DATE: January 16, 1995

A much better chapter! Thanks for the hard work.

Some specific suggestions:

Page	Line	
3		Sometimes confusion in a number of places between greenhouse gases (all) and CO_2 (or is it CO_2 equivalent)
3	5	by → before
3	20/21	will → could — "benefits in some economic sectors and damages in others" for some countries
3	23	risk of mid-continent drought and desertification (WGI)
3	31-43	add benefit-cost analysis
3	48-51	drop sentence "This chapter..."
5	8	tangible/intangible: does this mean market/non-market? — refer to chapter 6
5	16-20	future climate range given by WGI (1990) and (1992) reflects the uncertainties
		confuses natural and social sciences — add "well being" to last sentence rather than earlier
5	31-33	disrupt "deep water formation" and the North Atlantic ocean circulation which is
6	12	delete last sentence — suggests leakage > 100% most

		ocean circulation which is
6	12	delete last sentence — suggests leakage > 100%, most estimates are much less also effects of high mitigation costs affect economic growth and hence trading partners
6	19-20	all countries will suffer damage, some will also benefit in some sectors of their economy (Chapter 6 suggests no region or country with net benefits)
6	24	"analysts have ..." →(estimates are presented in chapter 6)
6	26-29	delete or focus on costs of change
6	34	add reference to Global Warming Potentials (WGI)
6	36-37	carbon sinks → GHG sinks?
7	box	"uncertainty" — more than 1 or "a range of outcomes"
8	45-46	reference Chapter 6 for estimates of regional damage
9	30-33	delete last sentence or balance the argument
9	39	delete "on the model of the Manhattan project" (politically sensitive)
10	41	driving forces for any greenhouse gas, such as CO_2
10	43-47	consider using the version in endnote 24
11	5	slowly increasing (rather than stable)

11	14-15	reword to something like "energy efficiency and GHGs per unit of energy must change to offset per capita output (consumption) and population growth"
11	15-16	capital is not directed to GHG mitigation → capital needs to be directed from investments with higher GHG emissions to alternatives with lower GHG emissions should note that "Energy efficient development pathways for developing countries have been proposed"— Goldemberg and Reddy, 1988
11	31-38	note that for the atmosphere, sustainable stock = stable concentrations and current emissions are estimated to be about 2x emissions consistent with stable concentrations
11	40	should → could
11	46-49	time period = next century? Coal not exhaustible over this period
12	8-9	probably only true over next 2 centuries or less
12	34-35	"some other resources" delete, put rest of last sentence as intro to paragraph
13	25-28	[While] "Climate... and another" — delete rest
13	30-37	polluter pays is another widely accepted principle — should be mentioned
14	7-9	Are coordinated taxes - differential tax rates by country that equalize consumer prices in all countries? Or the same tax rate (eg. $10/tonne C) in all countries. This distinction should be noted in the text or an end note.
15	25	chapter 7 is now chapter 11
15	33-34	"may actually increase world emissions" - replace with "may be only partially effective" Most estimates of leakage are much < 100%
15/16		No existing or proposed permit systems allows borrowing of future emissions — rather futures markets and options develop

16	20	refer to GWPs
16	24-25	Would it be possible to go through each of the components of the Kaya identity — population, per capita output/consumption, energy efficiency, carbon intensity in turn?
16	39/40	"likely " is too strong (or delete sentence) add mention that high costs of climate change mitigation can affect other countries through trade (ABARE)
16/17	47-2	see chapter 11 for fuller discussion of leakages, section 11.6.4.2
18	3-7	the word "rights" is a problem — even though everyone emits "GHGs" no one has a "right" to do so. It could also be interpreted as advocating a specific approach to FCCC policy.
19	9-16	This discussion is too definitive — "energy prices <u>will</u> rise, land rents <u>will</u> fall in an almost fully offsetting way" (theses are major assumptions not proven) Climate change will have many impacts other than temperature - precipitation changes, changes in extremes, etc. Assumes perfect competition?
19	18-24	The national security discussion is too narrowly focused on emission controls - climate change itself has national security implications for many countries - and policies to reduce GHG emissions may have national security implications for energy exporting countries
20	4	It should be made clear that these tradeable emission permits are for SO_2.
20	26-28	not appropriate for section on <u>within</u> country equity (delete?)
21	16	most cost-effective should be "least cost". All measures implemented should be cost-effective. Once negative and zero cost options are exhausted, the lowest cost measures should be selected.

		general conclusions - refer to chapters 8 & 9
section 1.5.1		revise to be consistent with summaries of chapters 8 and 9 (enclosed)
section 1.5.2		Policy reform rather than government reform
22	23-26	privately generated electricity is also usually price-regulated with price = AC. Historically, this was because economies of scale meant that HC < AC so that with prices + HC the producers would not cover their total costs
22	46-49	provide more examples. Add first sentence of endnote 61 to the text
24	40-41	this last sentence is too categorical
		Wouldn't section 1.5.2.4 be better as part of section 1.5.3? (some of endnote is good and might be brought forward)
26	29	no → less
26	1.5.4	The discussion of patents should discuss high patent costs as an impediment to the transfer of technology to developing countries
27	10-11	An auction or allocation according to benchmarks (eg. per capita as of a given date) or historical emissions levels (grandfathering).
27	28-32	This is well handled in the equity chapter (3)
28	1.5.5.1	This section should be reasonably consistent with chapter 9 summary.
28	44	Could it be clarified that this section compares energy taxes and carbon taxes to control GHG emissions, not energy taxes to address other energy related externalities such as NOx, VOC, CO emissions.
27		Near bottom: should point be made that a carbon tax is difficult to adjust to achieve a specific desired emissions reduction.
29	1.5.5.3	tradeable permits better suited to large sources
55		refer to results from Chapter 9 — include both "Top-down" and "Bottom-up" estimates

The IPCC 1992 scenarios span a very wide range, with little geographical detail, and thus do not embody a clear view of the distribution of emission trends. A more recent and much more thorough development of emission scenarios for fossil fuels is that by the World Energy Council (WEC, 1993), which developed regional scenarios both from a global perspective and with regional teams. Interestingly, their reference scenario was also criticised by participants from the developing world and former USSR for being too optimistic about the prospects for improved energy efficiency in these regions; taking account of these concerns led to a variant of the reference scenario with much higher emissions particularly in South Asia, Central/East Europe, and Africa.

Whichever variant of future scenarios is considered--and especially for the higher growth cases favoured by many in the developing world--the vast majority contain a clear message. The ambiguities about whether the developing world holds significant responsibility for contributing to climate change will not persist for long. Even in relatively restrained scenarios of emissions growth from the developing world, such as the original WEC reference case, fossil CO_2 emissions alone from these countries those of the OECD by 2020. And in many scenarios, before the year 2050, fossil CO_2 emissions from the current developing nations exceed the global total emissions today--despite still being considerably lower in per-capita terms (both factors of course partly reflecting population growth). Furthermore, in terms of the distribution of abatement efforts, there are significant spill-over effects, both positive and negative.[27] Bradley *et al* (1994) note on the basis of a range of abatement scenarios, 'anthropogenic climate change cannot be controlled by the OECD nations alone'.

Emissions from deforestation do not--probably cannot--keep pace with projections of fossil fuel emissions; the projections reviewed in the IPCC 1992 assessment almost all stay below 2GtC/year, and decline after 2030, compared with global projections of global fossil fuel emissions rising above 10GtC/yr by this date in many 'reference' scenarios. Methane projections are highly uncertain but also suggest slower growth. Clearly, neither is likely to alter substantially the overall trend in the distribution of emission sources. Whatever the past and current responsibilities and priorities, it is not possible for the rich countries to control climate change through the next century by their own actions alone, however drastic. It is this fact which necessitates global participation in controlling climate change, and hence, the question of how equitably to distribute the burden of climate change on a global basis.

III.4 Vulnerability to climate change

Another aspect--distinct but again partly correlated with both wealth and institutional capabilities--is the likely differential impact of climate change. The work in both the IPCC Working Group II, and the chapter in this report on assessing and valuing the impact of climate change, note that impacts may vary considerably between countries. Small island states and countries with low-lying coastal areas are an obviously vulnerable group, not only because of their greater susceptibility to sea-level rise, but also their heavy dependence upon natural resources that may be affected by climate change, and traded commodities that may be affected by abatement (Saha, 1994). In addition to these adverse economic impacts, these countries may face

destruction or uninhabitability of all or part of their territories. This in turn may have profound consequences for their human communities as well as entire ecosystems. This is an important equity issue not only because the impacts differ, but also because those most vulnerable to climate change are to a large extent those contributing very little to its causes. For small islands, but also for may other developing countries, adaptation to climate change may be a more important, and more urgent, task than planning and undertaking national mitigation policies.

Possible implications of this for international responses aimed at coping with climate change and minimising the impacts are considered in the next section. Here it is important to note that assessing the consequences of the vulnerability of countries to climate change requires valuing the damage that may arise from climate change. Any attempted valuation of damage unavoidably requires estimating and aggregating impacts on different people in different countries across different timescales. But as discussed in the introduction this chapter, there is no single "right" way to do this; it can only be done by making ethical judgements about what to measure, and how to measure and compare the welfare of different people in different countries across time. Considering only impacts on Gross World Product is a poor enough indicator for the reason outlined in the introduction (and discussed in the chapter on evaluating impacts below) that this indicator makes no pretence to be a real measure of welfare. But if it is predominantly poorer people who are affected, it is even worse as an indicator, because poor people add very little to aggregate wealth--and impacts on them are similarly discounted (Ayres and Walter, 1991).

Attempts to allow for 'non-market' impacts, such as those on human health and environment, require assumptions to be made about how to value and aggregate such impacts on different people in different countries. Scaling impact costs according to relative GDP implies valuation of human impacts based upon average earning power. Implicit valuation also differs greatly between countries, partly because it is constrained by aggregate wealth, and the blunt fact is that societies clearly do not value people in other countries equally. One of the most significant aspects of climate change is that activities of people in one country can have destructive consequences for people in other countries. Any aggregation that evaluates and aggregates impacts in relation to national wealth (such as impacts on GWP, plus non-market impacts related to national GNPs) in effect embodies an assumption that the human impact is less significant if it is poor people, or people in poorer countries, that suffer

If poorer countries are more vulnerable and are likely to suffer more, the dominant impacts are likely to be precisely in those regions. The question of how they are valued thus becomes central to any evaluation, and cannot be passed off simply as inevitable economic logic (Grubb, 1993). Hence, it needs to be recognised that attempts to quantify the costs associated with climate change involve inherently difficult and contentious value judgements, concerning which different assumptions may greatly alter the conclusions.

III.5. Social Considerations

Methodological disputes about the best way to measure vulnerability may also disguise the fact that it may be impossible or inappropriate to attempt an economic evaluation of some of

CHAPTER 8

4. Conclusions

• It is important to be clear what types of costs (direct, sectoral, macroeconomic, welfare) are included in the analysis. What matters from the point of view of policy are the net costs, not the total costs of emissions reduction (i.e. the total costs minus any positive side-effects of mitigation).

• It is the insights generated by modelling analyses (e.g.the areas of greatest potential for cost-effective emissions reduction, the directional effect of tax recycling on emissions reduction costs), not the specific numerical results of any one analysis, that matter.

• The size of the costs of mitigation depends critically upon assumptions about the efficiency of the baseline scenario used in the analysis. The higher the underlying economic growth in the baseline scenario, the greater the costs of mitigation. The more emissions reduction built into the baseline, the higher the costs of further reduction.

• Whether a "no regrets" potential for emissions reduction exists depends on whether the economy under consideration is on or below its theoretical production frontier. The existence of a "no regrets" potential implies that (ii) significant market failures exist (the society is below the frontier) which give rise to increased GHG emissions, and (ii) that policies can be designed and implemented that correct those market failures.

• There exists a range of quite different socio-economic and technological development paths that would give rise to quite different emissions scenarios and costs of mitigation. Existing energy and emissions models do not address these underlying factors in a very effective way. Future analysis should make use of multiple baseline scenarios to help capture the differences in these factors.

• Infrastructure decisions are critical because they can allow or restrict future options, and different infrastructure decisions can lead to very different cost outcomes. This issue is of particular importance to developing countries, where major infrastructure decisions will be made over the next 25 years.

• Mitigation costing analyses reveal the costs of mitigation relative to a given baseline. The results of different studies cannot easily be compared to each other unless differences in baselines are taken into account. Neither the baseline nor the intervention scenarios should be interpreted as representing likely future conditions.

• There is growing integration of bottom-up and top-down analyses of the costs of energy-related GHG mitigation. This convergence means that differences in results are increasingly driven by differences in input assumptions rather than differences in model structure. Nevertheless, differences in structure remain important as different types of models are best suited to answer different kinds of questions. Substantial disagreement still exists, over the existence and size of a significant "no regrets" potential for GHG emissions reduction.

CHAPTER 9

9.4 General Conclusions

- Estimates of the cost of GHG emission reduction are sensitive to assumptions about appropriate model structure, demographic and economic growth, the cost and availability of energy demand-side and supply-side options, the desired level and timing of abatement, and the choice of policy instruments. Different assumptions have led to a wide range of emission reduction cost estimates.

- Despite significant differences in views, there is agreement that some energy efficiency (perhaps 10-30% of current consumption, depending on baseline assumptions and the implementation time frame) can be realized at negative to slightly positive costs. The existence of such a "no regrets" potential depends upon the existence of substantial market or institutional imperfections that prevent cost-effective emission reduction measures from occurring. The key question is whether such imperfections can be removed cost-effectively by policy measures.

- Energy-related emissions can be reduced through both demand-side (energy efficiency) and supply-side (alternative sources of supply) options. In the short term, demand side options are cheapest in most countries.

- Estimates of the costs of stabilizing CO2 emissions vary widely as a result of differences both in the baseline scenarios used (e.g. how much energy efficiency or what rate of economic growth is contained in the baseline scenario), and in the calculated costs of various policy measures.

- There has been much more analysis to date of emission reduction potentials and costs for industrialized countries than for other parts of the world. Moreover, many existing models are not well suited to study economies in transition or developing country economies. Much more work is needed to develop and apply models outside of developed countries.

- The overall cost of abatement programs will ultimately be determined by the rate of capital replacement, the discount rate, and the effect of R&D. Appropriate long-run signals to encourage R&D will reduce long-run costs. The implementation of any "no regrets" potential will increase the time available to learn about climate risks and to bring new technologies to enter the market-place.

- Infrastructure decisions are critical because they can enhance or restrict the number and type of future options, and different infrastructure decisions can lead to very different cost outcomes. This issue is of particular importance to developing countries, where major infrastructure decisions will be made in the near term.

- If the climate issue is formulated in terms of stabilizing atmospheric concentrations, the choice of emissions time path is critical in determining the overall price-tag. It is important to identify those paths that minimize the costs of achieving a particular concentrations target.

- The overall impact of a carbon tax will depend not only on the size of the tax, but also on the uses to which the revenues are put. If carbon tax revenues are used to reduce more distortionary taxes, overall emission reduction costs will be reduced. Inefficient tax recycling could, however, increase costs.

- There is need for both detailed (bottom-up) analysis of technological options and also more aggregate (top-down) analysis of economic effects. Whereas historically these two approaches have been associated with very different cost estimates, this need not be the case. Indeed widely differing methods can produce quite similar results when calibrated to the same set of input assumptions.

- Given differences in marginal emission reduction costs among countries, international cooperation can significantly reduce the global price-tag for emissions reduction. Economic efficiency would be enhanced by carrying out emissions reduction where it is cheapest to do so.

- Estimates of the costs of stabilizing CO2 emissions at 1990 levels in *OECD countries* vary widely. Many bottom-up studies suggest that the costs of achieving this target over the next few decades may be negligible. Given rising baseline emissions over the longer term, however, many top-down studies suggest that the annual costs of stabilizing emissions may ultimately exceed 1-2% of GDP.

- The costs of stabilizing emissions for *economies in transition* may be small relative to OECD countries. The potential for cost-effective reductions in energy use is apt to be considerable but the realizable potential will depend upon what economic and technological development path is chosen. A critical issue is the future of structural changes in these countries that are apt to change drastically the level of baseline emissions and the emission reduction costs

- Analyses suggest that there may be substantial low-cost emission reduction opportunities for *developing countries*. However, these are likely to be insufficient to offset rapidly increasing emissions baselines, associated with, for example, increased economic growth. In the absence of a highly favorable allocation of carbon emission rights, the likely magnitude of emissions reduction will be particularly costly for developing countries.