SAP 2.1a: Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations: Response to Public Comments

Wednesday, November 08, 2006

INTRODUCTION & GENERAL RESPONSES

This document provides the public comments and responses from the authors to the public comments received on SAP 2.1a, *Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations*. Comments are provided in black, and responses from the authors are in red. This section begins with responses to consistent themes that emerge from the comments. The next sections provide responses to specific comments.

The majority of the public comments as well as comments provided by members of the CPDAC were addressed in the draft of the report that was passed to the CPDAC on November 1, 2006 and posted on the website. Since that time, most of the remaining comments have been addressed. They are also described below and will be included in a draft of the report to be delivered to CPDAC by November 13. Any changes between the November 1 and November 13 draft will be noted.

Expansions to the Scope of Effort: Several comments encouraged the authors to undertake substantial additional analyses, most notably sensitivity analysis on key assumptions and comparison to previous scenario exercises. The authors agree that these additional analyses would be valuable. However, these additional analyses would constitute a substantial expansion of the scope of the effort and were not included in the Prospectus.

Inclusion of Additional Tables and Figures: Several comments encouraged the authors to add a range of additional tables and figures to the report. Many additional tables and figures could have been constructed beyond those included in the report based on the data collected for this study. However, the authors needed to strike a balance between an already large number of tables and figures and the desire for readability. The authors believe that this balance has been reached, so they have left the set of tables and charts largely unchanged. Note that the dataset included as an appendix to the report will allow the generation by others of many of the requested additional tables and figures.

Explanation of the Radiative Forcing Limits: Several comments indicated confusion regarding the manner in which the radiative forcing limits were constructed. The confusion primarily had to do with whether the radiative forcing limits corresponded directly to the CO_2 concentrations of 450, 550, 650, and 750 ppmv (it was not) or whether some allowance was made in the radiative forcing limits for contributions from non-CO_2 greenhouse gases (it was). The text in the report and one explanatory table have been revised [to be included in the November 13 draft] to better explain the way radiative forcing limits were constructed.

Effectiveness of the Executive Summary: One reviewer argued that the Executive Summary would benefit from substantial revision. The authors agree, and this part of the report has been completely rewritten. Most important, the discussion of the scenario results is now written around substantial number of key figures accompanied by descriptive text. Important caveats, including those about the absence of any consideration of benefits, have been added and made prominent. These changes should help the Executive Summary serve much more effectively as a stand alone document and should enhance its accessibility by non-experts.

Users and Uses of the Scenarios: A number of commenters requested a clearer discussion the potential users and uses of these scenarios, pointing to varying descriptions that appear in different portions of the report. The relevant language will be made consistent in the November 13 draft.

SUMMARY OF REVIEWERS

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COMMENTS OF STEVEN ROSE

General Comment: The report is very nice in that it provides the reader with numerous and insightful points of comparison across models including informative modeling details. However, given that the report is a model comparison and more than just another set of stabilization modeling results from a single model, and is likely to have high visibility with the scenarios potentially being regarded as pseudo-USG scenarios, the report has somewhat of an obligation to provide focused discussions and summaries of (i) key factors behind results differences across models, and (ii) how the scenarios fit into the recent stabilization scenarios literature. Since the exercise did not attempt to "span the range," assign likelihoods, perform sensitivity analysis, nor coordinate on the investigation of specific futures or future assumptions, the report should provide sub-sections dedicated to discussing the key factors behind differences and that help readers put the results into proper context. The report should also be sure to include points from these sections in the Executive Summary and Chapter 5**.**

Response: (i) The report is structured specifically to provide the information that will illuminate the differences between the scenarios. The report already includes extensive discussion along with extensive graphical reporting of the underlying characteristics of the scenarios. However, in response to this and other comments, the authors have sharpened various elements of the report that describe the basis for differences between scenarios. For example, the authors have sharpened the discussion of differences in total abatement costs. (ii) With respect to comparisons to other scenario exercises, see the general response above regarding expansions to the scope of effort.

General Comment: A formal single discussion of key factors behind significant results differences is needed, in particular in the context of the IGSM results, which are very different from those from the other models. IGSM suggests, among other things, that substantially more emissions mitigation is required for stabilization, which implies substantially higher stabilization costs than the other models—e.g., over 10% of global world product in 2100 alone for Level 1 vs. less than 2% from the other models. This is an enormous difference that merits a dedicated subsection in Chapter 4, Chapter 5, and the Executive Summary that discusses key drivers of the results and sensitivities. Unfortunately, sensitivity analysis was not part of the 2.1A exercise; however, each of these models has run and published alternative scenarios, in particular

alternative reference scenarios. The authors should be able to draw on that experience to discuss the implications of alternative assumptions (e.g., less constrained nuclear penetration, increased ocean uptake, increased penetration of liquid gas fuels, constant marginal costs of coal extraction). The authors might consider providing simple characterizations of the sign and relative magnitude of changes associated with changes in assumptions.

Response: (i) With respect to formal sensitivity analysis, please see the general response above regarding expansions to the scope of effort. (ii) The authors agree that less formal efforts to gain insight into sensitivities would be interesting, but the authors have chosen to stay within the charge of the Prospectus and to report these scenarios without speculation as to what different scenarios might look like. (iii) The authors have sharpened the discussion of the factors that result in the differences in abatement costs.

General Comment: It would be very helpful to add a units of measure appendix or table somewhere for readers (especially policy-makers) not as familiar with the topic and looking across the literature.

Response: A list of acronyms and units of measure will be added to the final draft.

General Comment: While I recognize that space is limited and the scope may be binding, more discussion and figures/tables for non-US regions and results is appropriate. For instance, very different relative emissions pathways are depicted for Annex 1 and non-Annex 1 across models. More discussion (and quantitative illustration) of drivers (e.g., gdp, population, energy, land use, technology options, productivity changes) and the implications for mitigation would be very helpful. At the moment, the reader can review regional reference GDP and population, but is left wonting with regard to an understanding of how differently (in absolute and relative terms) the models portray other regions of the world.

Response: The authors agree that such information would be valuable, but an appropriate level discussion would substantially increase the scope of the effort. For this reason, the authors have chosen to focus on world and U.S. information.

ES, Page ES-9, Line 30. New wording needed – “has the main effect”?

Response: The discussion referred to in this comment has been revised.

ES, Page ES-10, Line 6. I’m not sure what the following text means: “…an efficient pattern of increasing stringency over time.”

Response: The phrase has been rewritten. [November 13 Draft]

Chapter 1, Page 1-11, Line 29. Citation needs to be revised—here and in the references listing. The correct reference is:
Weyant, J. and F. de la Chesnaye (eds.). (2006) in press. Multigas Mitigation and Climate Change. Special Issue of the *Energy Journal*

Response: The change has been made. [November 13 Draft]

Chapter 2, Page 2-8, Lines 42-44. As is, it isn't clear these technologies that "are introduced using the same structure" are distinguished within the model. I am fairly certain that I know how, but I think that a more concrete description will benefit the general reader.

Response: The text has been modified. [November 13 Draft]

Chapter 2, Page 2-17, Line 1. The table is very useful as is. I wonder if something like it could be used in the summary and chapter 5 with quantitative (or qualitative) information that summarizes the relative quantitative differences across models and pools together results across variables for a few time steps. Food for thought…

Response: The authors appreciate the suggestion. Rather than a table, the authors have substantially revised the Executive Summary, including the addition of a number of the most explanatory figures and tables from the report.

Chapter 3, Page 3-1, Lines 23-25. The numbers there would be more meaningful if you add the level values in 2100 vs. the changes from pre-industrial currently reported.

Response: The authors agree that the increased radiative forcing from current or 2000 levels is a useful piece of information. However, the authors also believe that it reduces confusion to present a single measure of radiative forcing throughout. The report is therefore written in terms of radiative forcing from pre-industrial levels, but information is provided on the 2000 levels of radiative forcing (roughly 2.2 W/m^2 for the gases considered in this study), and this information can be used by readers to determine the further increases beyond 2000.

Chapter 3, Page 3-7, Line 11. It would be extremely useful to include a table in this section that summarizes relative energy costs across sources within a model and across models. Recognizing that a quantitative cost table could be misleading because the values are not always directly comparable, I wonder if it would be possible to identify an energy source that is more-or-less homogeneous across models and then provide some ordinal ranking of the other sources by cost within each model and then a second ordinal ranking of costs across models by energy source type? Ordinal rankings of this kind could be provided by decade or for a few select time periods (e.g., 2020, 2050, 2100). At the moment, it is very hard to think about the cost differences between sources within a model and across models**.**

Response: The authors have provided this information in Figure 3.7 and the associated text, which shows the evolution of natural gas, electricity, crude oil, and coal prices. To make the interpretation of this information more clear, the authors have also expanded the discussion in the appropriate sections to make clear that this information indicates the marginal cost of the energy technologies deployed in the scenarios.

Chapter 3, Page 3-18, Line 10. While there is some discussion of the literature, the comparison is not very informative. It would be more useful to policy-makers and researchers to make a more direct comparison to recent specific scenario results in the literature. For example, in

addition to the in press EMF-21 Energy Journal papers, IIASA's MESSAGE and MNP's IMAGE 2.3 integrated assessment models have new stabilization work in press that covers similar targets:

Riahi, K., Gruebler, A. and Nakicenovic, N., in press: Scenarios of long-term socio-economic and environmental development under climate stabilization. Special Issue of *Technological Forecasting and Social Change*.

van Vuuren, Detlef, Michel den Elzen, Paul Lucas, Bas Eickhout, Bart Strengers, Bas van Ruijven, Steven Wonink, Roy van Houdt, in press-b: Stabilizing greenhouse gas concentrations at low levels: an assessment of reduction strategies and costs, *Climatic Change*.

A comparison on main aspects such as reference global emissions (CO2 and non-CO2), radiative forcing, and energy would provide a better context for the CCSP 2.1A results. For additional possibilities for providing better context, the authors should also review the IPCC WGIII AR4 Chapter 3 Second Order Draft that is currently available for expert review.

Response: See the general response above regarding expansions to the scope of effort. The figure mentioned in the text in the section that the comment refers to is meant to give a simple high-level context for interpreting emissions levels.

Chapter 3, Page 3-24. Please add "World" totals to Tables 3.1 and 3.2. Also, the order of FSU and E. Europe is not consistent across the three 3.1 tables.

Response: World population totals are provided in Figure 3.1, which is in the same section. The ordering of the regions has been adjusted [November 13 Draft]. World GDP totals have not been provided because of issues associated with comparing GDP across regions (see Box 3.1) and because GDP numbers are provided in different year dollars.

Chapter 3, Page 3-25. Please convert all the GDP data to the same year (e.g., 2000 US$).

Response: The data from IGSM has not been converted to 2000$ because exchange rates varied substantially in some regions between 1997$ and 2000$. The text makes clear that these adjustments in exchange rates are a source of difference between GDP in different regions.

Chapter 3, Page 3-25. For convenience, please add GDP per capita tables and/or figures.

Response: The requested figures have not been added to the report. See the general response above regarding additional tables and figures.

Chapter 3, Page 3-27. Please add a figure for global GDP like Fig. 3.2. Obviously, the reader can construct it from the tables, but there is no reason they should have to.

Response: The requested figures have not been added to the report. See the general response above regarding additional tables and figures.

Chapter 3, Page 3-29. Please add a figure for global primary energy like Fig. 3.5**.**

Response: The requested figures have not been added to the report. See the general response above regarding additional tables and figures.

Chapter 3, Page 3-37. Please add figures for US CO2 and non-CO2 GHG emissions.

Response: The U.S. CO_2 emissions figure has been added. The additional figures have not been added to the report. See the general response above regarding additional tables and figures.

Chapter 3, Page 3-41. Why not include the emissions from land use and land-use change in Fig 3.21, or better yet, a second graph that includes the land use emissions?

Response: Information that breaks out the various components of net-terrestrial emissions was not included in this study. Instead, modeling teams were asked to submit net terrestrial emissions, which include the changes in net uptake of natural and managed ecosystems in response to increasing CO_2 and climate factors, and the effects of modeled land-use change, for example from afforestation, reforestation and deforestation. The participating models do not consider terrestrial ecosystems and land use systems in exactly the same way or at the same level of detail, and therefore the authors judged that they lacked the appropriate data to support a clear comparison across models of the underlying components.

Chapter 4, General. The stabilization results really need to be put into context with respect to the literature. A direct comparison to recent specific scenario results is necessary to give readers a better sense for how to think about the results. For example, in addition to the in press EMF-21 Energy Journal papers, IIASA's MESSAGE and MNP's IMAGE 2.3 integrated assessment models have new stabilization work in press that covers similar targets:

Riahi, K., Gruebler, A. and Nakicenovic, N., in press: Scenarios of long-term socio-economic and environmental development under climate stabilization. Special Issue of *Technological Forecasting and Social Change*.

van Vuuren, Detlef, Michel den Elzen, Paul Lucas, Bas Eickhout, Bart Strengers, Bas van Ruijven, Steven Wonink, Roy van Houdt, in press-b: Stabilizing greenhouse gas concentrations at low levels: an assessment of reduction strategies and costs, *Climatic Change*.

A comparison on main aspects such as stabilization global emissions (CO2 and non-CO2), radiative forcing, energy, carbon prices, and global world product would provide a meaningful context for the CCSP 2.1A results. For additional possibilities for providing context, the authors should also review the IPCC WGIII AR4 Chapter 3 Second Order Draft that is currently available for expert review.

Response: With respect to comparisons to other scenario exercises, please see the general note above regarding expansions to the scope of effort.

Chapter 4, Page 4-10, Line 18. I might have missed it in this section, but it wasn't clear to me how energy efficiency responds to a carbon policy and what proportion of the energy use reductions could be attributed to increased energy efficiency in response to a carbon policy (vs. reduced energy use due to higher consumer energy prices). Energy efficiency is an important emissions reduction strategy and its role should be discussed and illustrated in the figures if possible. At the moment, I feel that the figures implicitly suggest that the exhibited energy reductions are all associated with reduced total use, instead of some improved energy efficiency.

Response: In all three models changes in energy input per unit of output is an important response to energy prices and GHG emissions reductions, but because of the different structures of the models there is no common variable to support a calculation of the measure the comment seeks. The models do show reductions in energy intensity (EJ per unit of GDP) but this effect reflects a combination of effects as prices change including, (1) changes in the energy efficiency of production at the sector level (e.g., EJ/kwh or EJ per dollar of agricultural output), (2) shifts in the structure of intermediate inputs to production, and (3) shifts in consumer demand among products. Because the models impose different sectoral breakdowns in both production and consumption, and apply different methods of representing production structure, there is no clearly defined measure of "energy efficiency" that can be applied across all three models.

Chapter 4, Page 4-17, Lines 9-18. This strikes me as odd. My understanding is that IGSM also models land-use competition between ag (crops + pasture), forest, and biomass that, under a carbon policy, includes consideration of forest carbon and non-co2 gases. The text here suggests that only MiniCAM does. Maybe it is simply a matter of re-wording the text to clarify the point being made. Are you trying to say that MiniCAM (via AgLU) models unmanaged land in the economic decision (unlike IGSM). As is, it gives a misleading impression of the land modeling in IGSM. Furthermore, it also gives the misleading impression that MiniCAM is considering the net carbon affects of land-use change decisions (lines 9-12), which as discussed in the next two paragraphs (starting on line 21) is not the case.

Response: The associated text has been revised. Both models link emissions of substances such as N_2O and CH_4 to land use activities. MiniCAM also derives its land use change emissions (e.g., deforestation) from its land use model. Because of this linking, there is an increase in deforestation in the stabilization scenarios as the demand for bioenergy crops leads to greater deforestation. [November 13 Draft]

Chapter 4, Page 4-17, Lines 21-43. Sands and Leimbach (2003) should be cited here. Sands and Leimbach illustrate this point very clearly**.**

Response: The citation has been added. [November 13 Draft]

Chapter 4, Page 4-28. Table 4.1 suggests that the concentrations include only CO2 forcing, but not non-CO2 forcing. This is inconsistent with the Executive Summary (page ES-3) which states that these are CO2eq concentrations**.**

Response: Text has been added to clarify this point. [November 13 Draft]

Chapter 4, Page 4-31. A editing comment from the authors needs to be removed from the text below Table 4.7.

Response: The change has been made.

Chapter 4, Page 4-36. The Figure 4.4 keys appear to have been cut-off**.**

Response: Comment noted. The figures will be fully redone in final production, and the keys will not be cut off.

Chapter 4, Page 4-38. Given that the report includes the US energy results under stabilization, it would be nice if the report included US GHG emissions results as well similar to Figures 4.6, 4.7, and 4.8.

Response: The requested figures have not been added to the report. See the general response above regarding additional tables and figures.

Chapter 4, Page 4-44. Would it be possible to illustrate the CCS associated with biomass (BECS) as well in Figures 4.10, 4.11, and 4.14?

Response: None of the scenarios includes CCS from biomass. It is for this reason that none is shown in the figure.

Chapter 4, Page 4-44. Across the energy figures, it would be helpful to be consistent in the order of the level and change results figures. Global primary energy changes are before the levels in Figures 4.9 and 4.10, but levels are before changes in global electricity (Figures 4.11 and 4.12). Consistency will make it easier for readers to find tables and less likely to make a mistake. My preference is for levels before changes.

Response: The figures will be reordered in the final draft of the report.

Chapter 4, Page 4-54. Please add the following sets of figures:
US electricity by fuel levels
Global non-electric energy use by fuel – levels and changes
US non-electric energy use by fuel – levels and changes

Response: The requested figures have not been added to the report. See the general response above regarding additional tables and figures.

COMMENTS OF SARAH WADE

General Comment. Thank you for developing these scenarios for public consumption. The combination of three scenarios mutually reinforces the “big picture” concepts related to the scale and magnitude of change that will be needed to address climate change along with the potential role of emerging technologies. At the same time, the differences between the model outputs highlight important limitations that should be considered in using the results to inform policy.

The output regarding potential pathways for changes in the energy system could be extremely useful in communicating the need for and potential role of a variety existing and new technologies, such as CCS.

My general comment is that the information in the report is not easily accessible to the decision-makers and others in the public who are not expert modelers but who are an important target of the report. In particular, the Executive Summary does not adequately summarize the findings or the caveats for using the findings that are contained in the report. And, the focus on radiative forcing needs to be presented in terms that are easier to compare to more commonly presented concepts of actual emissions and CO2e or CO2 concentrations. In addition, a close read of the report raises several additional questions of clarification.

I would also point out that the requested format for comments is cumbersome and perhaps will discourage comment. It would have been useful to obtain a briefing on the findings during the comment period so that easily answered questions could be resolved during the comment process. I have organized my comments by general theme and include specific page and line references at the end of each section.

Response: (i) The authors appreciate the positive comments. With respect to the Executive Summary, the authors agree on the need for improvements. To this end, see the general response above regarding the organization and presentation of the Executive Summary. (ii) With respect to the construction of the radiative forcing levels and the relationship to CO_2e, please see the general note above regarding the explanation of the radiative forcing limits. [November 13 Draft]

General Comment 1. Make the Executive Summary a Stronger Summary. The prospectus states: “The scenarios are intended primarily for decision-makers and analysts who might benefit from enhanced understanding of the potential characteristics and implications of stabilization.” It is conventional wisdom that the decision-makers will read the summary and the analysts will dig into the detailed report. This underscores the need for the summary to serve as a stand alone document. From a substantive point of view, the Executive Summary needs to include more quantitative statements, when appropriate, to reflect the findings in the report. Right now, most of the statements in the bullets are broad generalizations that can be of little help to experts or the general public alike. In cases in the Executive Summary where numeric ranges or examples are presented, the points are much more useful and easier to understand.

In addition, the Executive Summary should include at least two sets of graphs in the Reference Case Findings section that summarize all of the scenarios in both radiative forcing and tonnes. It should also contain graphs summarizing the stabilization scenarios in the Stabilization Scenarios Findings section.

Chapters 1 and 5 of the report are very important in framing the scenarios. Chapter 1 reminds the reader that these are but one input to be used in decision making and that the scenarios do not consider the benefits from reducing greenhouse gases. Chapter 5 provides some guidance regarding the limitations on using the scenarios and some insights about how they might be used in the future. These are very important points to reinforce with non-experts and they should be featured more prominently and accurately in the Executive Summary. In several places in the

Executive Summary, the frame for considering the costs of changing the energy system is presented in only one-dimension and is not tied to sufficient reminders to the reader that other factors influence the total cost equation. For example, choosing a more stringent radiative forcing limit will increase the magnitude, cost and timing of change in the energy system, but some of these costs might be offset by increases in the benefits of choosing the stringent limit. This may seem like re-stating the obvious or even digressing from the scope of the report, but it is important to remind people that these scenarios are not cost-benefit analyses but rather insights into what it might take to achieve various levels of radiative forcing limitations from the perspective of changes to the energy system. I am not suggesting that this report delve into the policy arena, but I do think it is important that it not leave much room for a reader who is not well-versed in these matters to walk away with the impression that controlling "costs" is primarily a function of choosing a high enough radiative forcing limitation (see ES 8 line 20).

Response: The authors agree with the comments above. See the general response above regarding the organization and presentation of the Executive Summary.

From an editorial point of view, it is difficult to comprehend the information from the Executive Summary because it is presented as a long series of unstructured bullets. I suggest what I think is a more comprehensible structure that would tie findings to the three main questions of modeled emission trajectories, modeled energy system implications and modeled economic implications. To this end, section ES.4 would be restructured as follows:

ES.4. Findings
- ES.4.1 Reference Scenarios
  - ES.4.1.1 Emission Trajectories
  - ES.4.1.2 Energy System Implications
  - ES.4.1.3 Economic Implications
- ES.4.2 Stabilization Scenarios
  - ES.4.1.1 Emission Trajectories
  - ES.4.1.2 Energy System Implications
  - ES.4.1.3 Economic Implications

Within the sections of ES.4., each bullet should be reorganized under the appropriate sub-group and include a paragraph heading that indicates the main point of the bullet. Based on my read, this may result in adding some new bullets and merging others. I would also suggest that where possible broad statements be underscored with quantitative ranges or examples.

Response: The authors appreciate the input. The final decision on how to rewrite the Executive Summary was based on a number of inputs, including the comment above. The final version is broken into reference and stabilization sections, but each of these sections is communicated as a whole.

Some of the specific suggestions are below:

Chapter ES, Page 1, Line 41. After the first full sentence of the paragraph, add some version of this sentence from Part A Chapter 5, Page 12, Line 4: "Finally, the problem of how to respond to

the threat of climate change is ultimately a problem of decision-making under uncertainty that requires an assessment of the risks and how a policy might reduce the odds of extremely bad outcomes. One would like to compare the expected benefits of a policy against the expected cost of achieving that reduction. By focusing only on emission paths that would lead to stabilization, we are able to report the costs of achieving that goal without an assessment of the benefits." The point here is emphasize up front and in a very direct manner that the scenarios present one part of the assessment in forming climate policy. This point should be repeated a few times throughout the Executive Summary.

Response: A bolded caveat to this effect has been placed prominently in the Executive Summary.

Chapter ES, Page 1, Line 42 and Part A, Chapter 1, Page 1, Line 41. The Executive Summary and Chapter 1 both describe the potential value of the scenarios. They use two different phrasings: The Executive Summary reads "be concerned with the energy system and economics effects of policies leading to stabilization of human influence on the atmosphere," while Chapter 1-1-41 reads: "benefit from enhanced understanding of the potential implications of stabilizing greenhouse gas concentrations at various levels." What is the difference between the focus on stabilizing human influence versus stabilizing GHG concentrations? And, neither statement sufficiently indicates that the scenarios provide insights about the costs but not the benefits of such change. Both questions should be clarified.

Response: See the general response above regarding the users and uses of these scenarios. [November 13 Draft]

Chapter ES, Page 4, Line 35. As a summary of the reference scenarios, this section should include two graphs depicting the 3 reference scenarios. One graph should include the top line of all three radiative forcing scenarios and a second should include the top line CO2 emissions along with a description of the assumed levels of emissions of non-CO2 GHG in the reference case. To the extent either the radiative forcing or the CO2 projections are contingent on modeled emissions of non-CO2 GHGs, this should be indicated as well. (note – the graphs could also be inserted after the bullet points at ES 6, line 32).

Response: In the spirit of this comment, the authors have added a number of figures to this part of the Executive Summary. See the general response above regarding the organization and presentation of the Executive Summary.

Chapter ES, Page 4, Line 36. Add a sub-group heading entitled ***Energy System Implications.***

Response: See the general response above regarding the organization and presentation of the Executive Summary.

Part A, Chapter ES, Page 4, Line 37. Add the paragraph heading ***Global Primary Energy Production.***

Response: See the general response above regarding the organization and presentation of the Executive Summary.

Chapter ES, Page 4, Line 44. Add the appropriate header – something like ***Global Primary Energy Production by Fuel*.**

Response: See the general response above regarding the organization and presentation of the Executive Summary.

Chapter ES, Page 5, Line 7. Replace or expand this paragraph so that it includes a specific statement on the ranges of nuclear energy, renewable energy, and efficiency assumptions in the reference case. If replacing with several paragraphs, add appropriate headers, if expanding this paragraph bold the header: ***Non-Fossil Fuel Energy Use*.**

Response: See the general response above regarding the organization and presentation of the Executive Summary. Numerical details are now presented graphically in the Executive Summary.

Chapter ES, Page 5, Line 23. Add a paragraph summarizing important transportation assumptions in the reference cases; add appropriate header.

Response: See the general response above regarding the organization and presentation of the Executive Summary.

Chapter ES, Page 5, Line 23. Add a paragraph with header that refers to the ***High Level of System Improvements In Reference Cases***; include in this paragraph some summary of the points raised throughout the report that a high level of improvements in energy efficiency, transport efficiency, use of nuclear energy, etc are already built into the reference case assumptions. This needs to be highlighted somewhere in the summary.

Response: The point is explicitly made in the Executive Summary

Chapter ES, Page 5, Line 23. Add a sub-group heading that reads: ***Economic Implications*.**

Response: See the general response above regarding the organization and presentation of the Executive Summary.

Chapter ES, Page 5, Line 24. Add heading ***Energy Prices*** to the paragraph.

Response: See the general response above regarding the organization and presentation of the Executive Summary.

Chapter ES, Page 5, Line 31. Add the sub-group heading: ***Emission Trajectories*.**

Response: See the general response above regarding the organization and presentation of the Executive Summary.

Chapter ES, Page 5, Line 31. This paragraph should have the heading: ***Fossil Fuel CO2 Emissions*.**

Response: See the general response above regarding the organization and presentation of the Executive Summary.

Chapter ES, Page 5, Line 36-46. Combine this into one bullet; add the paragraph heading: ***Non-CO2 GHG Emissions***; keep it under the sub-section of emission trajectories.

Response: See the general response above regarding the organization and presentation of the Executive Summary.

Chapter ES, Page 6, Lines 2-20. These three paragraphs should be combined into two bullets; the first should have the header: ***Ocean Sinks***; the second should have the header: ***Terrestrial Sinks***; the point about natural biogeochemical removal processes should be made in both bullets. I earlier made the suggestion to replace the reference to stabilizing the human influence with the language from Chapter 1 that referenced stabilizing GHG concentrations because it seems like the non-human impact of sinks is factored into to scenarios. If the important point is that human influence also impacts the capacity of natural sinks then it may be more appropriate to reference stabilizing human influence but the point should be explained in the context of these paragraphs.

Response: See the general response above regarding the organization and presentation of the Executive Summary. The authors believe the referenced text is adequate.

Chapter ES, Page 6, Line 34. The section should include two sets of graphs depicting the stabilization scenarios in terms of radiative forcing limits and in terms of emission tonnes.

Response: Tables have been added to explain the radiative forcing limits. Also, see the general response above regarding the explanation of the radiative forcing limits.

Chapter ES, Page 7, Line 29. Insert sub heading: *Emission Trajectories*.

Response: See the general response above regarding the organization and presentation of the Executive Summary.

Chapter ES, Page 7, Line 30. Insert the heading: ***Variable Impacts of Sinks*** or something more appropriate.

Response: See the general response above regarding the organization and presentation of the Executive Summary.

Chapter ES , Page 7, Line 33. Insert Sub-heading: ***Energy System Implications*.**

Response: See the general response above regarding the organization and presentation of the Executive Summary.

Chapter ES , Page 7, Line 34. Insert paragraph heading: **Substantially Different Energy System Needed**; also, it is worth reiterating how difficult it may be just to achieve the aggressive improvements assumed in the reference case. See, for example the statement at Chap 3- page 8-line 20: "The important point here is that these reference scenarios already incorporate substantial technological improvements."

Response: The text in the Executive Summary has been substantially revised, and the authors believe that this point has now been adequately made in the text.

Chapter ES, Page 7, Line 40. This paragraph has a typo in the last sentence, it is missing some word(s). The reference to nuclear energy should be separate from the discussion of the implication of not using CCS technologies unless the point was to suggest that CCS and nuclear are the primary tradeoff. Further, this paragraph has several components and should be broken up or expanded to give adequate summary. I would like to see something more quantitative than the term "more heavily" in describing modeled reliance on non-fossil energy sources. Presumably the term "more" refers to the reference case. Therefore, it is worth reiterating the fact that the reference case is built in aggressive reliance on non-fossil energy relative to today's levels. This paragraph should have the heading: ***Non-Fossil Energy Sources***; it should focus only on non-fossil energy sources; it should include more quantitative assessments of the range of nuclear energy, renewable energy and reduced consumption in the stabilization scenarios. The discussion of CCS technology relates to fossil fuel and should be moved to the following paragraph which starts at ES8, Line 4.

Response: The text has been rewritten for clarity. With respect to the broader points about presentation and organization, see the response above regarding the organization and presentation of the Executive Summary. Quantitative information is now provided in the Executive Summary through a range of figures that have been added to the Executive Summary.

Chapter ES, Page 8, Line 4. Add reference to CCS from paragraph preceding this (starts on page ES7, line 40). The statement about CCS should include some quantitative range, the paragraphs should have the header: ***Fossil Energy***.

Response: The referenced text from the previous paragraph has been rewritten. Quantitative information is now provided through a series of figures from the body of the report.

Chapter ES, Page 8, Line 9. This paragraph should get the heading: **Non-CO2 Emissions**; it should be moved up under the sub-heading of emissions trajectories that I suggested be inserted at Part A, Chapter ES, Page 7, Line 29; and the point needs to be better described here in the summary and in the Chapter 4. Chapter 4 presents graphs of emissions of N2O and CH4 but does not talk about the other non-CO2 GHGs in the same fashion. The reader is not able to tell what kind of reductions need to occur in these GHGs and cannot tell what the impact would be if those "substantially reduced" emissions levels are not achieved**.**

Response: See the general response above regarding the organization and presentation of the Executive Summary. A figure on radiative forcing has been added to illustrate the changes that will be required in the non-CO_2 GHGs.

Chapter ES, Page 8, Line 12. This paragraph should have the heading: ***Biomass***.

Response: See the general response above regarding the organization and presentation of the Executive Summary.

Chapter ES, Page 8, Line 20. This is perhaps the most important message from the entire scenarios effort yet it is buried here and is written in such a way that it is difficult to comprehend how important it is. I'm sorry that I don't have a suggestion for language that I think would be appropriate and accurate – l defer to the authors. I would like to see some indication of the tradeoffs between high and low radiative forcing limits not only in relation to magnitude and timing of changes in the energy system but also in the potential for inducing climate change impacts related to warming. I realize this is out of the scope of the report, but as written, it seems like the "easy" solution is to simply select a higher radiative forcing limit in order to avoid or delay substantial changes in the energy system -- there is no indication of the potential consequences of such a selection. Chapter 5, page 12 line 4 presents potentially suitable language that could be referenced here. I would also like to see language that is more quantitative if possible.

Response : The Executive Summary has seen substantial revisions, and the authors believe the text and associated figures clearly demonstrate that increasing stringency of stabilization would result in increasingly large changes in the global energy system. In addition, text that alerts readers to the fact that this report only considers the costs of stabilization and not the benefits is prominent in both the Executive Summary and the body of the report.

Chapter ES, Page 8, Line 24. This paragraph should be moved up to the emissions trajectories sub section that I suggested be inserted at line ES7 line 29; it should have the heading: ***Scale and Timing of Reductions***; it should include a summary of the range of reductions in tons from the scenarios – at least for CO2.

Response: See the general response above regarding the organization and presentation of the Executive Summary. Quantitative information in the Executive Summary is now provided through an extensive set of figures.

Chapter ES, Page 8, Line 30. This paragraph should be moved up to the emissions trajectories sub-section I suggested be inserted at line ES7 line 29; it should have the heading: ***Long Term CO2 Emissions Fall Toward Zero*.**

Response: See the general response above regarding the organization and presentation of the Executive Summary.

Chapter ES, Page 8, Line 45. Because this statement is so broad, it is not clear how the statement in this paragraph differs from the statement in the paragraph at ES7 line 40. If appropriate, I suggest combining them and including them under the sub-heading of Energy System Implications – if instead there is an important and distinct point, it should be made more clearly.

Response: The associated paragraphs have been combined. [November 13 Draft]

Chapter ES, Page 9, Line 5. Because this statement is so broad, it is not clear how this paragraph differs from the paragraph at ES8 Line 4. If there is a distinct point that is not made in the earlier paragraph, it should be clarified here.

Response: The authors have chosen to leave the associated text. The first paragraph makes the point that fossil fuels continue to supply energy throughout the century. The second paragraph points out the reductions in freely-emitting fossil fuels in the electricity sector.

Chapter ES, Page 9, Lines 11- ES10, Line 16. These bullets would clearly fall under the subgroup of Economic Implications of the Stabilization Scenarios Findings section and should be placed in this section and given appropriate headers.

Response: See the general response above regarding the organization and presentation of the Executive Summary.

Chapter ES, Page 9, Line 35. The discussion of non-CO2 GHGs here relates to their ultimate potential impact on the cost of meeting the various radiative forcing limitations based on their impact on the necessary stringency of changes to CO2 in the energy system. It would be more clear if the rationale were described in a less convoluted manner and if some qualitative statement about the range of impact could be made. The implication seems to be that if the Non-CO2 GHG limits are not achieved then there would be a need for additional (and presumably more costly) CO2 reductions. Regarding the discussion of radiative forcing throughout the report, it seems like the Levels 1-4 radiative forcing limits in the scenarios only compare to the approximate range of 450-750 ppm CO2 if the modeled reductions of non-CO2 GHGs are achieved. If not, then do the radiative forcing limits compare to higher levels of CO2 concentrations?

Response: See the general response above regarding the explanation of the radiative forcing limits; how they were constructed and how they were implemented.

Chapter ES, Page 12, Line 20. Chapter 5 (page 1, lines 41-45) identifies potential users and uses of scenarios as follows: “The possible users of emissions scenarios are many and diverse and include climate modelers and the science community, those involved in national public policy formulation, managers of Federal research programs, state and local government officials who face decisions that might be affected by climate change and mitigation measures, and individual firms, farms, and members of the public.” But, Chapter 5 goes on to describe that such users would require different scenarios than called for in the Prospectus and as a result, it seems, provided in the report. Further, throughout the report there are caveats suggesting that the report provides the “barest glimpse of the uncertainty (ES-12-25) or that it is only the first step in a process of developing information. With these statements, the report sends mixed messages about who could use the insights from the report and to what purpose. Today, there are several pieces of legislation being debated in the US Congress, millions (if not billions) are being spent on climate technology development, and several states and other nations are implementing

climate policy. The information in this report may be supplanted by other scenario analyses in the works today and it may need to be vetted against sensitivity and uncertainty analyses, but it also represents the best of what we know and think now. I would rather policy makers use it than rely only on older, less sophisticated thinking. Yet it is difficult to get a clear sense of how the information in this report could be considered by people involved in those activities today. It would be helpful if the authors could more clearly articulate guidance for using the information in this report as it stands today.

Response: See the general response above regarding users and uses of the scenarios. [November 13 Draft]

General Comment 2. Concept of Radiative Forcing Requires Better Explanation and Comparison. I am an "interested non-specialist" who is better informed on climate science than the average person, yet I am struggling to fully grasp the concept of radiative forcing and to compare it to atmospheric concentrations – especially of CO2e. Ultimately it is going to be important to relate these scenarios to emissions. For this work to be useful in the public and private discussions of decisionmakers, the report should contain a plain English explanation of why radiative forcing is the primary metric used in the report as well as something of a primer to help interested non-specialists to navigate this approach. Chapter 1 attempts to do this but falls short of fully explaining the comparison.

The radiative forcing limits are presented in relation to their approximate CO2 concentrations. However, since the non-CO2 GHGs make up 20-30% of the radiative forcing in the reference scenarios, it is hard to figure out what that means regarding the approximate CO2 concentration – is Level 1 approximately 450 ppm or is it approximately 450 ppm CO2 plus some concentration of non-CO2 GHGs? And, if so, is the potential impact on climate equivalent to 450 CO2, 450 CO2e or a number greater than 450 ppm CO2 or CO2e? It would be helpful to find an easy-to-understand explanation of the difference and the implications for potential climate effects.

Response: See the general response above regarding the explanation of the radiative forcing limits. [November 13 Draft]

Chapter ES, Page 3, Line 39. Radiative forcing needs to be explained and compared to CO2 or CO2e concentrations in a clear manner. Such an explanation could be inserted at this point or referenced as an Appendix.

Response: See the general response above regarding the explanation of the radiative forcing limits. [November 13 Draft]

Chapter 1, Page 3, Line 1. The description of radiative forcing reads: "the Prospectus also directed that stabilization levels be chosen to provide results easily compared with those from previous scenario exercises based only on CO2 concentrations. Radiative forcing levels were constructed so that the resulting CO2 concentrations, after accounting for radiative forcing from the non-CO2 GHGs, would be roughly 450 ppmv, 550 ppmv, 650 ppmv, and 750 ppmv. Based on this requirement, the four stabilization levels were chosen as 3.4 W/m2 (Level 1), 4.7 W/m2

(Level 2), 5.8 W/m2 (Level 3), and 6.7 W/m2 (Level 4)." It may not be a material concern, but this does not add up to me – or, rather, it is not an easy comparison to make. For example, in Figure 4-2 the IGSM Level 1 limit of 3.4 W/m2 is actually roughly 450 PPM CO2 plus between roughly 0.75 -1 W/m2 of effect from the non-CO2 GHGs. In this case it appears that a radiative forcing limit of about 2.5 W/m2 is more closely aligned with the CO2 concentration of 450 PPM. Is this correct?

To focus on the higher level of 3.4 W/m2 means that a certain level of non-CO2 GHG must be achieved. Two things are not clear: 1) if the modeled levels of non-CO2 GHGs are not achieved would the limit of 3.4 W/m2 actually be more like a higher concentration of CO2 (in other words, how dependent on the non-CO2 GHGs reductions is the comparison)? And, (2) how does the effect of the proposed Level 1 limit of 3.4 W/m2 compare to what is believed to be the climate impacts of 450 PPM CO2 or 450 PPM CO2e?

The models include "substantial" reductions in the non-CO2 GHGs, are these similar to what is already considered in studies that assess climate impacts of 450 PPM CO2 or 450 PPM CO2e? in other words, is this not a material difference than what is already discussed as the basis of CO2 PPM scenarios? Also, at least the MiniCAM model, prices non-CO2 GHGs are based on conversion to C using global warming potentials – this brings to mind CO2e.

These questions need to be addressed, given that non-CO2 GHGs appear to represent about 20-30% of the radiative forcing in both the reference case and the scenarios – this is too big a piece of the scenarios to leave questions of comparison unexplained. And, if this report is attempting to highlight the important role of non-CO2 GHGs in containing the cost of CO2 reductions, that concept should be more clearly indicated.

Response: See the general response above regarding the explanation of the radiative forcing limits. [November 13 Draft]

General Comment 3. Link Radiative Forcing to Tonnes More Clearly
It should be easier for the reader to translate the findings into tonnes and to relate the findings to both global and US systems.

Chapter 3, Page 17, Line 17. The text of the report refers to: "Figure 3.15 Global and U.S. Emissions of CO2 from Fossil Fuels and Industrial Sources across Reference Scenarios." Yet on page 3-37 Figure 3-15 shows only the global emissions. A new graph showing the US emissions from the reference cases should be included here.

Response: The U.S. figure has been added. [November 13 Draft]

Chapter 3, Page 19, Line 7. Figure 3-18 should be modified to include the modeled US reference case for these gases.

Response: The requested figures have not been added to the report. See the general response above regarding additional tables and figures.

Chapter 3, Page 19, Line 38. Figure 3-19 should be modified to include the modeled US reference case for these gases.

Response: The requested figures have not been added to the report. See the general response above regarding additional tables and figures.

Chapter 4, Page 8, Line 41. A new figure should be added to complement Figure 4-6 but to present the findings for the US (Fossil Fuel and CO2 Emissions Across Scenarios for the US).

Response: The requested figures have not been added to the report. See the general response above regarding additional tables and figures.

Chapter 4, Page 10, Line 16. New figures should be added here that present the stabilization scenarios for the long-lived and short-lived F gasses, these figures should mirror the information presented as the reference case for each in Figure 3-19. New figures should also be added to this section to complement Figures 4-7 and 4-8 and the new figures for the F gases to present the findings for the US.

Response: The requested figures have not been added to the report. See the general response above regarding additional tables and figures.

General Comment 3. Remind Readers of Important Caveats throughout the Report
First, is it the case that the results in these scenarios would tend to understate the cost and degree of difficulty in achieving the stabilization targets? It seems that this tendency would be driven by at least three features of all the scenarios:

- There are aggressive technology assumptions in the reference case
- It is assumed the whole world participates in reductions
- There appears to be a relatively frictionless market

If true, this point should be emphasized throughout the report. If not true, it would be helpful to explain why this is not the case.

Response: The authors agree on the need to more effectively remind readers of important caveats throughout the report. In the spirit of this comment, the authors have been more explicit about particular characteristics of the scenarios that are important context for their interpretation. In particular, the authors have focused on emphasizing that the scenarios do not consider the benefits of stabilization and that the implied policy regimes employed to reduce greenhouse gas emissions are highly stylized.

In addition, there are a few instances where it would be useful to ground the report's findings in the larger context of being just one piece of information necessary to assess climate change policy. Experts will most likely keep in their minds a set of caveats regarding the interpretation of results in this report. The average reader may forget to do so and thus the burden is on the authors to continue to remind the reader of these caveats. In particular:

Chapter 4, Page 3, Line 31. The sentence reads: "There is a strong economic argument that mitigation costs will be lower if abatement efforts start slowly and then progressively ramp up, particularly for CO2." The following paragraph adds the caveat that: "What constitutes such a cost-effective "slow start" depends on the concentration target and the ability of economies to make strong reductions later." The caveat needs to be emphasized more strongly and linked more closely with the first statement. It seems that the report is trying to make the point that no matter what target is selected, it will generally be more cost-effective to progressively ramp up abatement than to attempt more rapid wholesale change, provided the economy has the ability to increase reductions in the future. As written, I fear people will miss the caveat and only focus on the economic argument for a "slow start" – it does not seem like this is the sole point of the section and so should be clarified.

Response: The authors believe the text as written makes the point that was raised in the comment.

Chapter 4, Page 23, Line 33. This paragraph starts with the question: "Estimating the macroeconomic cost of stabilization is not a simple task either conceptually or computationally. From an economic perspective, cost is the value of the loss in welfare associated with undertaking the required policy measures – or equivalently, the value of activities that society will not be able to undertake as a consequence of pursuing stabilization?" This seems to be an incomplete question at this point in the report. A more complete question would remind the reader that there are consequences from not pursuing stabilization (i.e., the benefits) that are not valued in the scenario work and which I think are important in considering the macroeconomic cost of stabilization. If they are not important in considering macroeconomic cost of stabilization, the rationale should be explained to reader at this point in the report.

Response: The text has been slightly revised: the question mark has been removed. The statement is not a question. [November 13 Draft]

Chapter 5, Page 3, Line 22. This section should include a reminder that all three reference scenarios include aggressive assumptions about renewable energy, efficiency and nuclear energy.

Response: The point is made in the paragraph. It is not possible to say that all the scenarios include substantial improvements in renewable energy and nuclear energy, because at least one of the models assumes limits on the growth in the penetration of these technologies.

General Comment 5. Discuss Technology Changes More Completely.

Chapter 4, Page 12, Line 20 (Section 4.4.2). This section presents an interesting discussion of the potential role of CCS technology. I would like to see the same assessment of the role of nuclear and renewable energy included here. This assessment should also be included for the US – even if the US numbers represent simply one potential pathway.

Response: The authors have chosen to provide an additional focus the discussion on CO_2 capture and storage as a single example to demonstrate the scale of the energy changes that would be required and because of its prominence in all three sets of scenarios. The authors have chosen not

to provide similar discussions of other technologies based on considerations of the flow, length, and focus of the report. However, the information requested in the comment will be available in the database that accompanies the final report.

Chapter 4, Page 13, Line 29. Table 4-5 should include modeled cumulative CCS in 2030 as well. (assuming virtually no CCS in 2000 and a linear progression in the increase of CC per year between then and 2030, would the cumulative modeled CCS numbers range from 9-40 GTCO2 in 2030 for Level 1? If so, this is a lot easier to conceptualize the implications than it is by considering 17-42 PgC by 2050.) The report should present the same type of information as is presented tables 4-4 and 4-5 for the other main energy sources (nuclear, renewable energy, biomass and efficiency) in separate tables for each energy type. This information should also be presented for all energy sources and CCS as a modeled US number as well. Even though these are caveated model results and not predictions of the future, these are the kind of concrete numbers that people today can relate to in order to get a better appreciation for the scale of change being discussed. It would be preferable to provide similar tables for the US based on the modeled pathways. It seems like this information could based on Figures 4-13 and 4-14.

Response: (i) The numbers for 2030 have been added. [November 13 Draft] (ii) As stated above, the authors have chosen to provide an additional focus the discussion on CO_2 as a single example to demonstrate the scale of the energy changes that would be required and because of its prominence in all three sets of scenarios. The authors have chosen not to provide similar discussions of other technologies based on considerations of the flow, length, and focus of the report. However, the information requested in the comment will be available in the database that accompanies the final report.

Miscellaneous Comments.

Chapter 4, Page 14, Line 36. It is unclear whether the figures presenting US energy statistics (Figure 4-13, 4-14, 4-15 – and Figure 3-8) are based on US energy consumption or production. It appears they are based on consumption which is represented in Chapter 3 as being greater in the US than production because of imports. Therefore, the implications for US emissions from energy are not entirely clear.

Response: This will be clarified. [November 13 Draft]

Chapter 4, Page 22, Line 6. Table 4.7 includes a note at the bottom that "the added cost should not change because $100 remains $100." If this is true, then the percentages would change dramatically at least for some of the fuels. I would urge that percentages be recalculated based on more current energy prices.

Response: The numbers have been updated as suggested.

COMMENTS OF ERIC HOLDSWORTH AND WILLIAM L. FANG

General Comment. On March 7, 2005, EEI submitted comments on the draft Prospectus for SAP 2.1, which was made available, together with two other prospectuses, namely, SAP 2.1 and

3.1, for public comment by the notice of 70 *Fed. Re*g. 5969 (2005). That draft said (p. 1) that SAP 2.1 "has two components. . .updating scenarios of greenhouse gas emissions and atmospheric concentrations (Part A) and a review of integrated scenario development and application (Part B)" and that Parts A and B will be coordinated with each other and with other "SAPs," "especially 3.2 and 4.5,"[1] but did not explain how and to what extent such coordination was to occur. It added that they "will enhance ongoing international efforts to produce scenarios and conduct scenario analyses," particularly by the IPCC.

In our comments, EEI questioned the wisdom of undertaking Part A and providing "new and updated global stabilization scenarios by the U.S. before the Part B effort has been undertaken and completed." We noted that "despite considerable recent criticisms" of IPCC's scenarios, the IPCC does not plan to address scenarios for the Fourth Assessment Report (AR4), but instead "will consider new scenarios" for the Fifth Assessment Report "once authorized after 2007." Since, of course, the IPCC has not yet finished AR4, it is premature to speculate as to if and when a subsequent assessment report will be undertaken by the IPCC. At the IPCC's 24th session, there reportedly was a consensus for the IPCC to facilitate only the development of new scenarios but not develop them.

Our comments then said:

> We understand that after the 10th meeting of the Conference of the Parties in Buenos Aires, Under Secretary of State Paula Dobriansky at a December 16, 2004, press conference said that the U.S. "has not favored mandatory" climate "steps, targets and timetables," that "it is essential to have a robust program and approach," that the U.S. is "committed to the ultimate objective" of the Framework Convention on Climate Change, and "[t]oward that end, our programs are geared toward effecting and addressing greenhouse gas emissions now, in the near-term, in the mid-term and the long-term." She added that "the very essence" of the U.S. approach is one that places a premium on the "development and the deployment of transformational technologies."
>
> We did not understand from the Under Secretary's remarks in support of the "ultimate objective" of Article 2 of the FCCC that the U.S. was on the verge of developing "new" global stabilization scenarios for the four levels, particularly in advance of the Part B efforts, the "intent" of which is "to inform preparation and application of future scenarios by the CCSP, the IPCC, the CCTP, and other global change research and assessment organizations." Proposed CCSP development of scenarios prior to learning the results of Part B seems very premature at best.

(Emphasis added.)

[1] The SAP 3.2 topic is "Climate projections for research and assessment based on emissions scenarios developed through the Climate Change Technology Program." The SAP 4.5 topic is "Effects of Climate Change on Energy Production and Use in the United States."

In our earlier comments, EEI also questioned the CCSP and DOE proposal to engage in the development of stabilization scenarios in order to "enhance ongoing international efforts to produce scenarios and conduct scenario analysis." That is not a proper role for either the CCSP or DOE, particularly since the IPCC already had decided in November 2003 not to prepare new scenarios or to address criticisms of the IPCC Special Report on Emissions Scenarios (SRES) for AR4. Just as importantly, we specifically pointed out that the FCCC's COP has not even begun to consider when and how to address FCCC Article 2.

In response, the CCSP said that "[g]enerating scenarios is not a once-and-for-all activity, but must be repeatedly iterated and updated as knowledge advances and conditions change. Consequently, Part A can contribute to advance understanding of emission trends" and other "issues without needing to await completion of Part B." Nevertheless, **it would have been wise to conduct the review of scenario development and application before undertaking new scenarios, especially since there is no urgency for such new scenarios.** Moreover, that response did not address our comment about the CCSP engaging in the development of "stabilization scenarios in order to 'enhance' international efforts to produce scenarios and conduct scenario analysis." As a general proposition, while we might not object to the development of multi-gas stabilization scenarios or to defining stabilization in terms of radiative forcing if a need were fully demonstrated and if the issues that have been raised about relevant uncertainties have been addressed, we continue to question CCSP developing such scenarios in order to "'enhance' international efforts."

Response: (i) With respect to the timing of Part A and Part B, the comment is similar to comments received on the Prospectus, and the response remains the same. Generating scenarios is not a once-and-for-all activity, but must be repeatedly iterated and updated as knowledge advances and conditions change. Consequently, Part A can contribute to advanced understanding of emission trends and associated economic and technological issues without needing to await completion of Part B. (ii) With respect to international efforts, the comment refers to the Prospectus and not the Part A report that was put forward for public comment. However, language referring to benefits of these scenarios for international efforts has been removed. [November 13 Draft]

While Part A does not dwell on this enhancement concept, it is vague when discussing the purpose of the scenarios and particularly who may benefit. It states (p. 1-1) that the "primary purpose. . .is to serve as one of many inputs to decision-making for climate change," which is a very broad and open-ended purpose, and that the "intended audience includes" unspecified and unidentified "decision-makers and analysts who might benefit from enhanced understanding of the potential of stabilizing greenhouse gas concentrations at various levels" (emphasis added). However, the Part A draft explains (p. 1-2) that the scenarios "lack the level of detail local or regional decision-making, such as state or city planning or the decision-making of individual firms or members of the public." As for the federal government, the draft states (p. 1-2) that the "scenarios may also serve as a point of departure for further CCSP and other analyses, such as exploring the implications for future climate or examining the costs and feasibility of mitigation and adaptation options" (emphasis added). In short, the terms "decision-makers" and "analysts" in Part A is not informative or helpful in demonstrating or explaining who they are, at whom a

scenario (including this one) is aimed and in showing a need and purpose.[2] In short, the term "decision-makers" and several iterations thereof seem to be intentionally all-encompassing and vague.[3] This appears to make it difficult to ascertain who, in fact, are the real, perceived or expected users and, just as importantly, to focus the development of the emissions or climate-change scenario so as to meet their actual needs.

Response: See the general response above regarding users and uses of the scenarios. [November 13 Draft]

In our comments on the draft Prospectus, we also questioned the "coordination" between Parts A and B. The CCSP response was that this has been "clarified in the prospectus." The CCSP explained that it intends that "[c]ommunication and interaction between the two product teams will take place primarily through cross-participation in Part A and Part B." We are pleased to see that the final Prospectus includes in section 7 a statement explaining that such "communication and interaction will be ongoing," although our review of Parts A and B drafts do not indicate when and how that occurred. This should be so indicated.

Response: The Prospectus states that "communication and interaction between the two author teams will be ongoing, primarily through cross-participation in Parts A and B, along with cross-participation in meetings, conference calls, and other venues for planning and generating the two products." In practice, this has been the case. One author sits on both reports, the authors have communicated on a variety of conference calls, and there has been cross participation in professional workshops.

Section 6 of the draft Prospectus, titled "Review," has been revised as it will apply to the third Draft. The final Prospectus now states (pp. 5-6) that "Parts A and B will follow the process described in the Guidelines for Producing CCSP Synthesis and Assessment Products: . . . .(3) a third draft for final review and approval through a FACA [Federal Advisory Committee Act]

[2] Section 5.1 of Part B, in discussing the "[u]se of [s]cenarios in [c]limate-[c]hange [d]iscussions," states (pp. 113-16) that "[t]here appears to be a rapid increase in interest now underway in considering climate-change scenarios in diverse decision and planning processes" and that "[t]his trend is strongest for planners and decision-makers concerned with climate-change impacts and adaptation" (emphasis added). The section emphasizes that scenarios "can serve" the needs of "extremely diverse decision-makers," while noting that "[d]ifferent climate-change decision-makers will have greatly differing information needs from scenarios" (emphasis added). Also referenced as needing such scenarios are "[i]mpacts and adaptation managers—including both national officials and others responsible for more specific domains of impact," and "mitigation policy-makers" who are initially described as "national officials making national policy and participating in international negotiations," but they can also include "sub-national officials when they share mitigation responsibilities or undertake mitigation initiatives" (emphasis added). In addition, "[m]tigation decision-makers" (emphasis added) are referred to. Finally, this section refers to energy resource and technology managers as a "major group of climate-change scenario users" that are also called "decision-makers" (emphasis added). Many of these attempts to identify so-called group or individual "decision-makers" seem to overlap. However, the Executive Summary of Part B (p. 6) makes some effort to define and explain three groups of decision-makers, namely, "national officials," "impacts and adaptation managers" and "energy resource and technology managers," but in that effort too there appears to be overlap.

[3] Indeed, Part B states (p. 71) that a "basic fact about climate-change decision-making is that there is no single global climate-change decision-maker. Because the dynamics of climate change operate on a multiple spatial scale from the local to the global, it is not subject to unitary or coordinated decision-making. Rather, a large number of decision-makers with diverse responsibilities will affect and be affected by climate change" (emphasis added). Of course, there is the collective decision-making process of the FCCC.

committee and the CCSP Interagency Committee and the National Science and Technology Council (NSTC)" (emphasis added). Section 9 of the final Prospectus, titled "Timeline," states (p. 6) that the FACA meeting "will be June 06" and that the third Draft will be submitted to the "CCSP Interagency Committee for review" in "July 06." At least one commenter questioned the FACA involvement, and the CCSP response was that

> [t]he prospectus has been reviewed and modified to address FACA concerns. The prospectus now states that a FACA committee will be formed to review the final report and responses to peer-review and public comments before these are sent forward to CCSP interagency committee and the National Science and Technology Council (NSTC) for final approval and then dissemination.

(Emphasis added.)

While we have not reviewed the relevant FACA charter or the list of the FACA members and their affiliations, we do not agree that the final Prospectus adequately addresses the "FACA concerns." It is our understanding that the FACA role is an advisory one only and that it has no "approval" role. Yet the final Prospectus expressly provides that the FACA committee may not only "review" the third draft of Parts A and B, but also approve the draft along with the CCSP Interagency Committee and the NSTC. This is improper under the FACA statute. The CCSP needs to correct the Prospectus and provide an explanation of what exactly the role of the committee is regarding the third Draft of Parts A and B, and when and how it performs that role so that the public may observe its deliberations. Moreover, a more up-to-date "Timeline" for this SAP is needed.

Response: [November 13 Draft]

General Comment. The final Prospectus was substantially revised or "modified," particularly with respect to Part A. Some of the revisions give greater direction to the Part A and B teams, such as requiring the reporting of "reference cases along with each set of stabilization scenarios." Some of the most significant revisions are underlined as follows (pp. 1, 2 and 5):

> This product will contribute to and enhance the ongoing and iterative international process of producing and refining climate-related scenarios and scenario tools. This process has included, among others, efforts undertaken by the Intergovernmental Panel on Climate Change (IPCC), the Climate Change Technology Program (CCTP), and non-governmental forums such as Stanford's Energy Modeling Forum. Part A will contribute new scenarios to this process based on the evolving state-of-the-art in integrated assessment modeling and building on lessons learned in the previous scenario efforts. Part B will guide the development and application of future scenarios.
>
> * * * *
>
> Stabilization in the scenarios will be defined in terms of the radiative forcing resulting from long-term combined effects of carbon dioxide (CO_2), nitrous oxide

(N_2O), methane (CH_4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). To the extent that participating models have the capability to represent changes in the emissions of other radiatively important substances (e.g., aerosols, aerosol precursors, tropospheric ozone precursors) with a sufficient level of sophistication and integrity, this information may be made available by the individual modeling teams.

* * * *

Four stabilization levels will be considered as a basis for the stabilization scenarios. The four levels will be constructed so that the CO_2 concentrations resulting from stabilization are roughly 450, 550, 650, and 750 ppmv. The precise specification of the radiative forcing levels will emerge through the scenario development process. Exact CO_2 concentrations will vary among models because the contributions of other greenhouse gases (GHGs) to total radiative forcing at stabilization will vary among models.[4]

The scenarios in Part A will be constructed to represent meaningful and plausible futures that would be useful to decisionmakers and analysts. The scenarios will not be constructed and coordinated to span the full range of meaningful and plausible futures, and the likelihoods will not be assigned to the scenarios. However, as detailed explorations of futures that lead to stabilization, the scenarios will provide valuable insights into questions such as the following:

- *Emissions Trajectories*: What emissions trajectories over time are consistent with meeting the four alternative stabilization levels? What are the key factors that shape the emission trajectories that lead toward stabilization?

- *Energy Systems*: What energy system characteristics are consistent with each of the four alternative stabilization levels? How might these characteristics differ among stabilization levels?

- *Economic Implications*: What are the possible economic implications of meeting the four alternative stabilization levels?

Although the stabilization scenarios will be designed to lead to long-term stabilization, the study period for the analysis will be the period ending in 2100. For this reason, in many cases, total radiative forcing may lie below the stabilization target at the end of the study period.

* * * *

[4] In the case of the "Final Report" on SAP 1.1 regarding temperature trends, the glossary (p. 140) includes a definition of the term "greenhouse gases" that includes "water vapor." However, the definition with the word "includes" is open-ended and thus not a complete definition. Does the CCSP intend that SAP 2.1 Parts A and B include a glossary also? Will it define GHGs as used in Parts A and B in the same way, and will it also include "water vapor"? In short, there should be one universal definition of GHGs for this and all SAPs.

> All scenarios and associated reference cases will assume the continuation of the United States' greenhouse gas intensity target through 2012 and the first commitment period of the Kyoto Protocol, which also ends in 2012. The reference case will assume no policies focused explicitly on the global climate beyond these near-term policies. In the stabilization scenarios, these near-term policies will be followed by a notional policy in which all nations of the world participate in emissions reductions and the marginal costs of emissions reductions are equalized across countries and regions.
>
> Assumptions regarding land use and land-use change as both GHG sources and sinks will be presented and discussed in the final report. Because models have varying capabilities to explicitly consider land use and land-use change, however, such consideration will vary across models.

(Emphasis added.)

The above revisions, which took about 10 months to finalize, were very significant and quite substantive, particularly the spelling out of the above assumptions. Yet to our knowledge, the public was not given an opportunity to comment on these assumptions or any of the other revisions at any time during this 10-month period. That is both unfortunate and inconsistent with the requirements of the Global Change Research Act of 1990. It is also inconsistent with at least one of the "general principles" of the CCSP Strategic Plan, namely, "Early and continuing involvement of stakeholders," such as EEI and our members (emphasis added). It also is apparently inconsistent with another general principle, namely, "Transparent public review of analysis questions, methods, and draft results." According to the CCSP, it has "published guidelines" to "help adherence to these principles," which, among other things, "establish a broadly standardized methodology that will facilitate involvement of. . .the public" and that "encourage transparency by providing public access to information about the status of the products." Either such "guidelines" were not followed in the development of the final Prospectus for this SAP or the guidelines may be inadequate. While we welcome many of these changes in the final Prospectus, we continue to have some concerns, particularly now that we have seen draft Parts A and B.

Response: The comment is noted. The process of developing this product has included a public comment for the Prospectus, revision to the Prospectus based on the public comments, peer review of a first draft of the report, public comment on a second draft of the report, and a Climate Change Program Product Development Advisory Committee (CPDAC) Meeting, open to the public, to review a third draft of the report. Future CPDAC meetings to review additional versions of the report will also be open to the public. The authors have appreciated comments received during the reviews of the report and have made substantial revisions in response to these comments.

Regarding the assumptions, the Prospectus articulates them with no explanation of their basis or why they were chosen. For example, the first draft of the Prospectus and the final version selected four concentration levels with a range of 450 to 750 ppm, rather than, for example, five

levels and a range of 450 to 1000 ppm. At least one commenter on the draft Prospectus contended that

> [t]here is *no* justification for the draft Prospectus. . .to identify '450 ppm through 750 ppm' as 'the range of commonly discussed CO_2 concentration levels.' In addition to increasing the number of stabilization levels from four to five to accommodate 1000 ppm, it is essential to specify in advance the spacing of stabilization levels, as expressed in ppm of CO_2 concentration. That is a policy, not a scientific, decision, and it is necessary to avoid skewing the analysis by modelers later clustering stabilization levels around targets they choose, e.g., 450, 500, 550, 600, and 750 ppm.

In response, the CCSP said that the "prospectus has been modified to make clear the four stabilization levels will be designed so that the resulting CO_2 concentrations approximately track the four levels of 450 ppmv, 550 ppmv, 650 ppmv, and 750 ppmv," and that the "prospectus no longer includes language indicating that these represent 'commonly discussed' levels." Indeed, Part A states (pp. ES-3 and 4-2): "To facilitate comparison with previous work found primarily on CO_2 stabilization, these levels were chosen so that the associated CO_2 concentrations, accounting for radiative forcing from the non-CO_2 GHGs, would be roughly 450 ppmv, 550 ppmv, 650 ppmv, and 750 ppmv." They "were chosen for illustrative purposes only. They reflect neither a preference nor a recommendation. However, they correspond roughly to four of the frequently analyzed levels of CO_2 concentrations."

Response: The language regarding frequently analyzed levels has been removed from the report. [November 13 Draft]

With respect to the 1,000 ppmv level, the response was not to include it "in the set of stabilization levels, because, given the existing body of scenarios to date, stabilization at 1000 ppmv would probably not represent a meaningful deviation from the reference cases over the period that will be considered in this study" (emphasis added). That is not particularly persuasive.

As stated in the response to comments on the Prospectus, stabilization at 1000 ppmv would not require meaningful deviations from the reference scenarios in this century. The reference scenarios can serve those interested in scenarios that stabilize atmospheric concentrations at 1000 ppmv.

Moreover, according to Part B, the range of 450 to 1,000 ppm has been utilized in other scenarios (e.g., "WRE [Wigley-Richels-Edmonds] scenarios"), which "illustrated the large cost savings attainable by approaching stable concentrations through emission paths that initially rise and then decline steeply, rather than beginning a more gradual decline immediately." Part B adds (pp. 34-35):

> Although these were not strictly optimal (cost-minimizing) scenarios, they demonstrated that this qualitative shape of emissions trajectory would tend to reduce costs for four reasons. First, it allows more time to develop technological innovations that lower the cost of emissions reductions in the future. Second, it

> allows lower-emitting equipment to be phased in with normal capital turnover, avoiding premature abandonment of long-lived equipment. Third, it takes advantage of natural carbon-cycle dynamics, which gradually remove CO_2 emissions from the atmosphere and so allow more room for increases in earlier emissions than later emissions while still meeting the concentration target. And finally, by shifting mitigation expenditures further to the future, it reduces their present value through discounting.

(Emphasis added.)

These four "reasons" are very significant and appear to conflict with the above CCSP response. We question if and when the Part B team communicated them to the Part A team and the CCSP. Indeed, this raises a question as to what extent either or both teams were involved in the development of the various assumptions.

Response: As stated in the Part A report (see Section 4.2.4), the emissions trajectories in the stabilization scenarios are consistent with these general conditions.

In addition, concerning the "study period" of 2100 for "the analysis," Part A points out (p. 4-3) that "[t]here is a strong economic argument that mitigation costs will be lower if abatement efforts start slowly and then progressively ramp up, particularly for CO_2." However, the Part adds that "[w]hat constitutes such a cost effective 'slow start'" depends, not only on the "concentration target" chosen, but also on the "ability" of the affected countries "to make strong reductions later." Thus, while 2100 or 100 years is obviously a long time, Part A states that "it is not long enough to fully evaluate stabilization goals."

Response: As stated in the response to comments on the Prospectus, stabilization at 1000 ppmv would not require meaningful deviations from the reference scenarios in this century. The reference scenarios can serve those interested in scenarios that stabilize atmospheric concentrations at 1000 ppmv.

As to the issue of the identification of "policies," one commenter said that the draft Prospectus did not "require that the modeling groups specify what policies are used to achieve stabilization scenarios." The commenter noted that "[m]any policies (e.g., carbon taxes, tradable permits, technology or performance mandates like (CAFE) all have varying economic impacts beyond their narrow greenhouse GAS emission impacts. Unless the policies used to achieve stabilization are carefully identified and characterized, there is no basis to even ask for 'economic implications'" as called for in the draft Prospectus (p. 2). The CCSP response was, as quoted above, to assume not any such specific national policies listed above, but for the reference case to assume continuation of the President's intensity goal "through 2012" for the U.S. and for other developed countries, the Kyoto Protocol first commitment period, "which also ends in 2012" (emphasis added). According to the Part A draft, in the reference scenarios "these policies were modeled as not continuing after 2012" (p. 4-2).[5]

[5] We question the statement that the commitment period "ends in 2012" and the implication, at least, that the "near-term" policies are somehow not effective or continuing after 2012. It gives the impression that the Protocol commitment ends with the 2012 date and that there is no continuing obligation on the Protocol Parties. That is not

As to the stabilization scenarios, those so-called "near-term" policies are said in the Prospectus to be "followed by a notional[6] policy in which all nations of the world participate in emission reductions" (emphasis added). Part A, in fact, states that "these initial period policies were superseded by the long-term control strategies." The latter are unrealistic, particularly with respect to developing countries. Indeed, Part A states (ES-7) that "[a]lthough these assumptions are convenient for analytical purposes. . ., they are idealized versions of possible outcomes." In order for the "results to be a realistic estimate of costs," they "would require, among other things, the assumption that a negotiated international agreement includes these features." Part A points out (ES-9) that "each of the modeling teams assume that a global policy was implemented beginning after 2012, with universal participation by the world's nations" (emphasis added). However, Part A shows skepticism in stating (p. 4-3) that "it seems unlikely that all countries would simultaneously join such a global agreement," but states that "the assumption that all countries participate provides a useful benchmark." Thus, Part A explains (ES-7) that "it is important to view these result(s) as scenarios under specified conditions, not as forecasts of the most likely outcome within the national and international political system."

Furthermore, the Protocol's preamble refers to the Berlin Mandate, which expressly rejects new commitments for developing countries. Nevertheless, the notion appears to be consistent with the policy expressed by the Senate in 1997 when it adopted the Byrd-Hagel Resolution, S. Res. 98, which applies not only to the Protocol but "any agreement" under the FCCC. However, there is nothing in the FCCC proceedings to date to indicate even a glimmer of hope for such a policy.

Response: In this spirit of this comment, the report now includes prominent, bold-faced text that highlights the limitations and possible implications of the assumed perfect where, when, and what flexibility.

General Comment. In commenting on the draft Prospectus, one commenter asked whether "there have been sufficient scientific advances in overcoming the IPCC's assessments of the '[u]ncertainties in converting emissions to concentrations.'" The commenter added that

> [s]tabilization scenarios involve methodologies similar to those used in estimating atmospheric concentrations resulting from emissions scenarios, *TAR-Science*, p. 224, except, of course, that the process is inverse; emissions levels and their time paths are deduced for prescribed atmospheric concentrations. It necessarily follows that

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the case. Article 3 of the Protocol does not use that word "end." It provides that Annex I Parties shall "ensure that their aggregate anthropogenic" CO_2 "equivalent emissions of GHGs" listed in Annex A of the Protocol "do not exceed their assigned amounts. . .with a view to reducing their overall emissions of such gases by at least 5 percent. . .in the commitment period 2008 to 2012." The Protocol's obligation on the Parties is to reduce emissions by the specified amount. It gives the Parties the window of 2008 to 2012 to achieve the obligation or commitment. However, that commitment does not end in 2012, although the window closes for achieving it in 2012. Indeed, both the Protocol and the commitment remain viable and enforceable after 2012. Similarly, in the case of the President's "intensity goal," the 2012 date is when his goal is to be met. But the President's ultimate goal – to slow and, as the science justifies, stop and then reverse the growth of GHGs – continues beyond 2012.

[6] Random House Webster's College Dictionary (4th ed. 2005) defines (p. 987) "notional" to mean "1. . .expressing, or consisting of, notions or concepts. 2. imaginary; not actual. . .3. having visionary ideas; given to whims; fanciful.."

> stabilization scenarios suffer from the same uncertainties that attend projections of concentrations driven by emissions scenarios.

In reply, the CCSP said:

> Response: (1&2) There are multiple uncertainties in scenario generation, including those mentioned above and others, but CCSP believes that this product will be useful regardless of the uncertainties. A primary purpose of scenarios is to facilitate understanding in situations of uncertainty. We note that these scenarios do not include aerosol forcings and their attendant uncertainties. Radiative forcings are restricted to CO_2, CH_4 , N_2O , HFCs, PFCs, and SF_6 gases for which uncertainties are less severe than is the case for aerosols and dark particles.
>
> (3) GWPs will not be used in the CCSP scenarios. These scenarios will be generated by models that employ explicit representations of the atmosphere. Radiative forcing will be calculated explicitly as the sum of the radiative forcing from the individual constituents.
>
> (4) The Prospectus has been modified appropriately to make clear that one section of the final report will discuss the uncertainties that surround the development of stabilization scenarios. However, no attempt will be made to conduct a formal uncertainty analysis.

(Emphasis added.) [7]

Our examination of the final Prospectus shows (p. 5) that the final Part A report is to include "a discussion of key uncertainties surrounding the scenarios" as well as a "summary section that addresses issues important for interpreting and using the scenarios." That brief "summary" is apparently contained on the last page of Part A as follows (p. 5-12):

> 5.4.5 Decision-Making under Uncertainty
>
> Finally, the problem of how to respond to the threat of climate change is ultimately a problem of decision-making under uncertainty that requires an assessment of the risks and how a policy might reduce the odds of extremely bad outcomes. One would like to compare the expected benefits of a policy against the expected cost of achieving that reduction. By focusing only on emission paths that would lead to stabilization, we are able to report the costs of achieving that goal without an assessment of the benefits. Moreover, given the direction provided in the Prospectus, the focus was on scenarios and not on an uncertainty analysis. It is not possible to attach probabilities to scenarios constructed in this way; formal probabilities can only be attached to a range which requires exploration of the effects of many uncertain model parameters. The task is an important one, but beyond the scope of the study carried out here.

[7] There is no explanation given in the final Prospectus or in the above response as to why there is an absence of an "uncertainty analysis."

(Emphasis added.)

The CCSP Strategic Plan "sets forth general principles for the S&A Products," which include "[e]xplicit treatment of uncertainties." The above paragraph does not comply with that principle. There is no meaningful "discussion of key uncertainties," let alone even an indication of what they are. Yet Part B expressly states (pp. 100-01) that "[r]epresenting and communicating uncertainty is perhaps the most fundamental purpose of scenarios" (emphasis added). The Part adds, "In particular, the role of uncertainty in a scenario exercise is strongly linked to scenario complexity, richness and use" (emphasis added). **In short, it is critical that there be explicit consideration and discussion of "uncertainties."**

Response: The authors appreciate the value of uncertainty analysis. For this reason, the authors have, as stated in the comment, suggested an avenue for future research that would include exploration of reference and stabilization outcomes under uncertainty and explicit consideration of decision-making under uncertainty, and they have also suggested sensitivity analysis as an avenue for future research. Any of these efforts would constitute an expansion beyond the stipulated scope of effort of this CCSP Product. These scenarios involve the construction of scenarios for five specific conditions where the modeling teams were to choose assumptions (among many uncertainties) that they considered "plausible" and "meaningful", and the authors have taken care to make this approach to scenario construction clear in the report. In response to the concern of the Prospectus with respect to uncertainty the authors have also taken care to indicate where, among the varying results from the three models, there is evidence of key uncertainties that influence the outcomes.

General Comment. Part A indicates that the stabilization scenarios studied by the Part will have "implications" for energy use and electric power generation. In the case of the former, the Part points out (p. 4-10) that the "lower the radiative forcing limit, the larger the change in the global energy system relative" to the Part A's reference scenario, although "significant fossil fuel use continues in the all four stabilization scenarios." In the case of coal, its "growth potential" will apparently be curtailed "over the century," although the models "project coal usage to expand" under three of the four stabilization levels. In the case of the fourth (*i.e.*, Level 1), which is the most stringent, the "global coal industry declines in the first half of the century before recovering by 2100 to levels of production somewhat larger than today" (pp. 4-10 – 4-11). The Part also indicates that an important factor relative to the continued utilization of fossil fuels is that all of the modeling assumes that "CO_2 starts relatively modestly in all of the scenarios, but grows to large levels." Although the Part cautions that the availability of geologic carbon capture and storage (CCS) is "crucial," it indicates significant uncertainty with regard to CCS (pp. 4-13 – 4-14):

> Yet capture technology is hardly ordinary. Geologic storage is largely confined to experimental sites or enhanced oil and gas recovery. There are as yet no clearly defined institutions or accounting systems to reward such technology in emissions control agreements, and long-term liability for stored CO_2 has not been determined. All of these issues and more must be resolved before CCS could deploy on the scale envisioned in these stabilizations scenarios. If CCS were

> unavailable, the effect on cost would be adverse. These scenarios tend to favor CCS but that tendency could easily change with different assumptions about nuclear power that are well within the range of uncertainty about future costs. Nuclear power carries with it issues of long term storage or disposal of nuclear materials and proliferation concerns. Thus, either are viable options but both involve regulatory and public acceptance issues. Absent CCS and nuclear fission, these models would need to deploy other emissions abatement options that would potentially by more costly, or would need to envision large breakthroughs in the cost, performance, and reliability of other technologies. This study has not attempted to quantify the increase in costs of the reorganization of the energy system in stabilization scenarios without CCS. This sensitivity is an important item in the agenda of future research.[8]
>
> CCS is not the only technology that is advantaged in stabilization scenarios. Renewable energy technologies clearly benefit and their deployment expands in both the MERGE and MiniCAM scenarios. Nuclear power also obtains a cost advantage in stabilization scenarios and experiences increased deployment, particularly in the MiniCAM stabilization scenarios. The fact that no clear winner emerges from among the suite of non-fossil power-generating technologies reflects the differences among the modeling teams regarding expectations for future technology performance, market and non-market factors affecting deployment, and the ultimate severity of future emissions mitigation regimes.

(Emphasis added).

As to electric power generation globally, there is a projection of "substantial changes in electricity-generation technologies as a result of stabilization but relatively little change in electricity demand" (emphasis added). According to Part A, the "imposition of radiative forcing limits dramatically changes [to] the electricity sector." It states (p. 4-13):

> The IGSM model responds to the stabilization scenario by reducing the use of coal and oil relative to the reference scenario, expanding the deployment of gas and coal with CCS, and reducing demand. However, at low carbon prices, substitution of natural gas for coal occurs in the IGSM scenarios. MERGE reduces the use of coal in power generation, while expanding the use of non-biomass renewables and coal with CCS. The MiniCAM model reduces the use of coal without CCS, and expands deployment of oil, gas, and coal with CCS technology. In addition, nuclear and non-biomass renewable energy technologies capture a larger share of the market. At the less-stringent levels of stabilization, i.e., Levels 3 and 4, additional biofuels are deployed in power generation, and total power generation declines. At the more-stringent stabilization levels,

[8] In 2005, the IPCC issued a Special Report titled "Carbon Dioxide Capture and Storage" that "shows that the potential of CO_2 capture and storage is considerable, and the costs for mitigating climate change can be decreased compared to strategies where only other climate change mitigation options are considered." It places CCS "in the context of other climate change mitigation options, such as fuel switching, energy efficiency, renewables and nuclear energy."

> commercial bio-fuels are diverted to the transportation sector, and use actually declines relative to the reference.

In addition, "[e]lectricity-priced increases as a result of climate policy are smaller relative to those for direct fuel use because the fuel input, while important, is only part of the cost of electricity supply to the consumer" (emphasis added). The assumptions are that after 2012 there will be new climate policies affecting all economies, that the "same marginal cost is applied across sectors" (p. 5-5) and that costs will be spread out rather uniformly across such economies. All of these assumptions are not only overly optimistic, they are very unrealistic. Hence they skew the results, raising serious questions about the Part A discussion.

In the case of the U.S., Part A states that "adjustment of the U.S. electric sector to the various stabilization levels. . .is similar to the world totals," which is a very broad statement. The report adds (p. 4-15):

> It is worth re-emphasizing that reductions in energy consumption are an important component of response at all stabilization levels in all scenarios reflecting a mix of three responses:
>
> • Substitution of technologies that produce the same energy service with lower direct-plus-indirect carbon emissions.
> • Changes in the composition of final goods and services, shifting toward consumption of goods and services with lower direct-plus-indirect carbon emissions, and
> • Reductions in the consumption of energy services.
>
> This report does not attempt to quantify the relative contribution of each of these responses. Each of the models has a different set of technology options, different technology performance assumptions, and different model structures. Furthermore, no well defined protocol exists that can provide a unique attribution among these three general processes. We simply note that all three are at work.

The Part's treatment of consumption and technology is too abbreviated and general, and underscores a key deficiency of the scenarios and models.

Response: (i) The authors believe that the report provides expansive discussion of the elements of the study design to assist readers in interpreting the results. In addition, Chapter 2, and the discussions of the scenarios in Chapter 3 and 4 provide extensive discussion of the limitations and differences in the participating models that influence the final scenarios. (ii) To better communicate the details of the underlying models and assumptions at a level not possible in this report, the authors will make available to the public detailed documentation on the model versions, and associated technology assumptions, upon publication of the report. References to this documentation will be in the report where the technology issues are discussed. Such documentation will produce information at a level well beyond what would be feasible for the report itself, and interested parties will have the opportunity to understand at this level of detail the differences between both assumptions and the approaches to technology used in the

participating models. (iii) The authors have enhanced the text that describes technology and they have attempted to better highlight information already presented in the report that already gives indications of technology costs and performance.

General Comment. In its summary of the stabilization scenarios, Part A recognizes that the various "assumptions are convenient for analytical purposes," and that the scenarios present "idealized versions of possible outcomes" and are "not. . .forecasts of the most likely outcome within the national and international political systems" (pp. 5-5 – 5-6). However, Part A also includes a brief section 5.4.2, titled "Consideration of Less Optimistic Policy Regimes," which makes several broad statements about policy that should not be a part of the SAP.

While this section is couched in terms of sharing "among countries" the "economic burden of emissions reductions," it contains a brief discussion of several policies and policy instruments that do not appear to be appropriate for this Part A report. It also includes a brief comment about cap-and-trade legislation and states, in a convoluted way, that "no" such "policy. . .has actually been proposed by any legislature that has seriously taken up the issue of GHG mitigation." This is incorrect, as legislatures in the seven states participating in the Regional Greenhouse Gas Initiative as well as California have either enacted or are considering cap-and-trade legislation. In addition, Congress has considered and voted on two cap-and-trade proposals by Senators McCain and Lieberman. In short, we question the accuracy and value of such a portion of the report.

Response: The referenced text has been removed or revised.

Table of Contents. The table of contents format for Part A is not very useful and informative, because it does not provide the contents for the entirety of Part A, in contrast to the table of contents for Part B. The Part B format should be applied to Part A.

Response: The table of contents will be improved in the final draft.

Page 4-1, lines 45-46 and p. 4-2, lines 43-44. The first clause of the sentence that begins on p. 4-1, line 45 states "that there has been no international agreement on a desired stabilization target." Similarly, on p. 4-2, lines 43-44, the first clause states a lack of such "international agreement on the desired level at which to stabilize radiative forcing or the path to such a goal." While the statement about "no agreement" is correct in both clauses, there also has not been under the FCCC any discussion by the Parties thereto of what constitutes a "stabilization. . .level that would prevent dangerous anthropogenic interference with the climate system" or any attempt to reach such agreement, although some countries and groups of countries have made some comments or suggestions informally. We also question the use of the word "desired" in both clauses. Moreover, both clauses are unnecessary and somewhat misleading. Both should be deleted.

Response: Both clauses have been removed. [November 13 Draft]

Page 4-2, line 43 to p. 4-3, line 3. The statement about the lack of a "consensus" concerning the "sharing of burdens," with its reference to the phrase "common but differentiated

responsibilities" contained in FCCC Article 3 in the context of a report on stabilization scenarios, is inaccurate, particularly in light of the Kyoto Protocol's preamble reference to the Berlin Mandate decision, 1/CP.1, which developing countries view as precluding commitments by them to control or reduce GHG emissions.

Response: The phrase has been removed.

COMMENTS OF MOHAN GUPTA

What is the basis of relationship between projected emission scenario and corresponding concentrations of long-lived trace species over the next, say, 100 years given potential changes in atmospheric circulation, chemical interactions and, hence, the lifetime? How this correction is applied while creating concentration fields from emissions?

Response: The earth systems components of the models are described in Section 2.3 of the report.

COMMENTS OF CHUCK HAKKARINEN

Chapter 4, Page 4-28, Table 4.1. Stablization of greenhouse gas concentrations at each of the levels listed (750 ppm, 650 ppm, 550 ppm, 450 ppm) will require VERY SUBSTANTIAL reductions of annual emissions from the current levels of approximately 7 gigatons per year. For example, analyses with the MAGIC model of Wigley, et al estimate that stabilizing atmospheric concentrations at 550 ppm will require a reduction of emissions to 1 gigaton per year, which is the level of global emissions that existing in 1927. Put another way, reducing emissions to 1 gigaton per year could be achieved by reducing to ZERO the emissions from the 13 largest emitting countries in the world, and holding ALL OTHER COUNTRIES emissions constant at current levels (i.e., zero growth). Stabilizing atmospheric concentrations at 450 ppm would require even greater emission reductions, perhaps to global totals of 0.7 gigatons per year, or a 90% reduction globally from current levels. Stabilizing concentrations at 650 ppm or 750 ppm would require emission reductions from the current 7 gigatons per year to perhaps 1.5 or 2 gigatons per year, respectively. These points should be included in the chapter text, relevant tables, and the Executive Summary to the synthesis report -- these are the type of simple-to-understand numbers that will be most understandable to policy makers and general public alike.

Response: The authors appreciate the information on the requirements of stabilization that have arisen in other studies. This study, and its extensive discussion of emissions pathways and energy system changes required for stabilization, should be viewed as a complement to these other studies. This report provides, in great depth, a perspective of the issues raised in the comment.