Global-Change Scenarios: their Development and Use
US CCSP Synthesis and Assessment Product 2.1b

Comments by Prof. Garry Brewer, Yale University

Author team responses in italics:

You asked for "additional observations and reflections" from my experience, and I shall begin with some of these before turning to both general comments about the mss and specific suggestions keyed directly to the mss.

Comments are related to page and line in mss.

Experiences

1. A commonplace in scenario design and use is the failure to distinguish well enough between predictive and heuristic purposes for the method. "Discovery is not Prediction," is the way I tried to characterize this issue in a chapter I years ago contributed to a book on crisis management.[1] The failure is especially noteworthy when scenarios are employed by those trained primarily as scientists, for whom prediction represents the single and highest disciplinary objective. As a specific set, climate and energy models and modelers have demonstrated a consistent preference for predictive ends in their scenario activities.

A predictive end assumes that past trends will prevail on into the future and that the underlying and responsible generative systems, most particularly the human ones, will not experience structural or intentional changes. Physical systems are often exempted in these terms because they are immutable. The laws of physics are the laws of physics, more or less. However, in climate and energy problems, the human element is not so easily presumed or held constant, especially when the time frame of the analysis is long— say decades or generations in length. Humans are mutable and they are also "irrational," especially with respect to our personal, interpersonal, and political habits and means.[2]

The heuristic end favors consideration of creativity and innovation, as when one focuses on outlier or aberrant behavior that in time and with basic system change may prove "normal." It allows one to probe risk and uncertainty by posing and then analyzing the classic "What if?" class of questions to highlight the unknown. On rare occasions, the heuristic end may allow one to stumble onto some combination of elements and events that yields up an insight into a genuine "unknown-unknown."

Humans act intentionally and so affect natural as well as social system outcomes and effects. Intentionality is considered in our laws, decision processes, and related ac-

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[1] Garry D. Brewer, "Discovery is not Prediction," in Andrew C. Goldberg, Debra van Opstal, and James H. Barkeley, eds., *Avoiding the Brink: Theory and Practice in Crisis Management* (London: Brassey's, 1992): chap. 6.

[2] The so-called "human dimensions" efforts of Paul Stern, Tom Dietz, Lin Ostrom and a handful of others with and through the NRC comes immediately to mind here.

tivities and is clearly encountered within the range of normative social thought and theory. Humans are the causes of many natural and physical problems and we also suffer the consequences of our acts. Quite a bit of our plight can best be judged as irrational.

Human "irrationality" however is ordinarily considered within the confines of psychological or psychiatric theory and practice, if it is considered at all. The near total absence of social and behavioral elements in climate and energy models, analyses, and related considerations is a major shortcoming not readily resolved or mitigated by simple cutting and pasting of "human dimension" elements onto physical constructs and models.

The use of scenarios is one promising means to help redress this deficiency. Adopting a heuristic purpose may facilitate matters as well.

For instance, rather than trying to predict at what time the global mean temperature will increase by 1.0 C, and then wasting lots of time worrying about the spatial resolution or data quality used in one General Circulation Model versus another, suppose the analysis began with a stipulated end state at some agreed-to year in the future. The following simple hypothetical illustrates the point.

It will be 1.0 C warmer globally in 2075 than it is now. Regional differences will range both higher and lower than the global mean and can be assumed as follows [describe them.] Likely consequences following from these conditions are the following [postulate them.] Many of these consequences are costly in various human terms. Some however may be beneficial, as with the "winners and losers" economists are so fond of extolling.

Characterize more desirable or more acceptable end-state circumstances for the year 2075.

Under these conditions, how might we work our way back to the present and historical conditions to eliminate, reduce, or mitigate the unwanted or unacceptable consequences? What changes are required in existing human systems and arrangements to achieve a more acceptable end state?

Another way to engage human considerations, especially as a means to discover, is to rely on scenario-based games that mimic the classic "crisis game" known so well in military circles and analyses. The scenario in this case initiates a sequence of plays or responses meant to discover and explore various decisions and outcomes in circumstances never experienced before, e.g., thermonuclear war. The initiating scenario can be played by the same teams multiple times to elicit and generate different decision paths or it may be used by entirely different teams to explore and discover responses from different individuals, groups, or cultures. The so-called "A and B Teams" employed by the intelligence community at the height of the Cold War are illustrative. The "A Team" would operate in the business as usual mode, and often employed those responsible for that business, versus a "B Team" for whom decidedly contrary pessimistic or sometimes even optimistic views and assumptions about the world were featured.

The scenario in the classic crisis game "works" to the extent that it engages the human participants and helps them "think about the unthinkable," in the morbid turn of phrase attributed many years ago to Herman Kahn. That this approach and mode of

thought can be beneficial is attested by concrete decisions made over the years not to rely entirely on strategic bombers but to deploy ICBMs on the ground and in submarines, in decisions to secure nuclear weapons with Permissive Action Links (PALs) to prohibit the "Strangelove Scenario" from ever taking place, and in numerous improvements in Communications, Command, Control, and Intelligence C³I across the entire strategic force.

In my opinion, few if any of these constructive uses and means have been employed in climate and energy models or analyses—this despite the fact that no one has any idea whatsoever of what human systems or decision pathways will look like or exist in the future most of interest some 25, 50, or 100 years hence. Simple extrapolation of "business as usual," as was the case with nuclear warfare and intelligence estimates, is hardly satisfactory.

The key points in this are that "Discovery is not Prediction" and that scenarios can be usefully employed for an uncommon variety of different and appropriate purposes and reasons, especially when the subject is global climate change.

> *The revised draft provides more extensive discussion of the possibility of scenarios to serve heuristic and exploratory uses rather than more predictive ones. We agree with the reviewers' suggestion that while this can be a valuable way to use scenarios, there has been little or no use of global change scenarios in this way.*

General Comments

2. The report is excellent. It is thorough, pretty well organized, and written with unusual clarity—especially for a "group/committee" writing project.

> *No response required.*

3. However, the audience is not evident. Indeed there are multiple potential audiences for this report and no one of them emerges as *the audience*. Lack of specificity here means that different parts of the report appear to be for decision makers (of many different kinds), modelers and analysts (of many different kinds), "the public" (whoever they might be), and probably a couple of other discernible groups and individuals. No straightforward solution comes to mind, although you might consider doing something unconventional to resolve this key weakness: Write three or four different Executive Summaries that clearly identify different audiences and then select and pitch the material to fit each group.

> *We agree that the draft failed to make the audiences for the report clear, although we did have a couple of specific audiences in mind. In the revised draft, we have extended the introduction to make the intended audiences explicit, and have also made modifications throughout the text to maintain consistency with these intended audiences.*

4. For example, try to pull out the information that most relates and appeals to business people. The Global Business Network/Shell stuff is pretty well known; efforts by the insurance industry to cope with climate change are beginning to be known and could be elaborated. The insurance guys are in fact making decisions about climate change that have real and costly implications. Economic issues were mainly responsible for the political decisions that Bush and company made regarding Kyoto, and such issues could be culled out of the overall report with a bit of work. Tom Schelling's outstanding economic analysis in *Foreign Affairs* of how awful the Kyoto deal was for us is, on close reading, a scenario-inspired if not based, assessment. Now do the same for a couple of other key audiences: international decision makers; modelers—ecological, demographic, atmospheric, and oceanographic; high-risk populations; and so forth. The point of this recommendation/suggestion is to get more mileage out of the considerable efforts already expended in trying to cover the topic as this report does: both broad and, on occasion, deep.

> *Some of these actors fall within our definitions of the two classes of audiences for the report, although only in their discharge of certain specific responsibilities. While many of the arguments advanced in the draft could be of relevance to other users and decisions, we have decided not to extend it explicitly to additional classes of users, because this would further lengthen an already long report, and risk losing focus.*

5. Somewhere very early in the report you need to state the obvious that all models are in fact scenario based and dependent. This is just another way of saying that simplifications are inevitable as we trying to deal with enormous complexity of the sort found in the climate change topic. Similarly, there is no other way to think systematically about the future in such complex situations other than using scenarios. Finally, no one scenario can possibly capture everything of potential relevance, interest, or importance. All models (simulations, games, analyses) are simplifications. No one of them is necessarily "the best" for any and all situations.

> *We agree. These points are now made, both in the introductory material that defines scenarios and distinguishes them from models (among other things), and in the conclusions.*

6. Somewhere late in the report, by way of summarizing many of the valid and important limitations you note (here, there, and everywhere) you need to collect and interpret the limitations in terms of "research needs" that range from the most common to the more specific and esoteric. Don't shy away from trying to set priorities and, if you have the courage and time, assign responsibilities to fund the work needed. The socio-economic aspects have been neglected for instance; likewise, the individual-level, human dimensions of these problems have been given short shrift. The crucial importance of scenario and analytic management is touched on here and there, but is not emphasized nearly enough. Having a disparate group of analysts pulled together to do a big, one-time study

of virtually everything related to climate change is far different from having a small group of analysts who routinely work together over long periods of time trying to understand and resolve specific problems. Lots of other potential topics are discussed throughout the report, but they are not collected, summarized, and lined up against the always useful "So what?" question.

> *We agree, and have extended the conclusions to discuss the crucial need for more efforts in development of scenario-based and related assessment methods, as well as certain specific needs such as socio-economic scenarios.*

Specific Comments

[Keyed to page and line references – Numbering re-starts at 1]

1. Pg. 9, note at bottom: The role of "control" in the classic military crisis game is discussed in many of the open sources on military models, simulations, and games (MSGs). The problems related to who is in charge (is "God") are comparable for climate analyses, although they are not as readily apparent nor are they commonly acknowledged. Since all models are simplifications, who decides on what eventually is included (and what logically is thus excluded) from the analysis? Who is the referee when disputes and other signs that consensus is not happening occur? Who has the responsibility ("power") to end, redirect, or otherwise control the activities of groups involved in climate modeling and analyses?

> *The draft addresses this issue with respect to the need to involve identified users or their representatives in the development of scenarios, and the role of scenarios in coordinating and/or directing model simulations and research programs. We do not go more specifically into the processes by which the simulated responses to alternative decisions would be determined within a scenario-based exercise – i.e., the question of who is in charge – because this issue has not yet been engaged in climate-change scenario exercises, and is arguably less tightly connected to the creation of scenarios than is the case in military or security exercises.*

2. Pg. 11, bottom half: There is another question that is even more important than the ones identified here. Is the objective to have one basic story, one big-deal with some pretensions about consensus, or to allow lots of different stories to be told? One or even a few (four or less) scenarios and stories will still be a very limited set of the possible ways problems as complex as climate change can be told. A standard limitation concerns the underlying assumptive bases used to construct the models, and this may in fact be more important than the models themselves. Such a finding has long been recognized in the

literature, but it is still remarkable to see how few people in the climate modeling (energy, economics, and a couple of other fields do somewhat better) own up to this.[3]

> *There are two points here. Both are important, and the draft addresses both. The first concerns the structure of a scenario set – how many scenarios are included, representing how many uncertainties. This is addressed in section 1.2 and section 4.6. The second concerns the dependence of all models upon scenario-based assumptions, because no model can endogenize everything (or even everything except observable starting conditions). This is addressed in the introductory material and the conclusions, as discussed in our response to General Comment 4 above.*

3. Pg. 12, lines 13-21: Support for decision making. This needs emphasis. The technical guys go and "do their thing" and then someone at the end asks, "Who is the audience?" The answer to the question was actually presumed from the beginning to be "other technical guys like us." This conceit becomes an issue when the technical analysis is then publicized with exhortations that the "decision makers" do something to avert this or that awful forecast outcome. Lack of specificity about which decision maker and what possible decisions might any of them in fact entertain and make is not a particular concern for the technical guys doing the analysis. No wonder responsible officials, as one possible type of decision maker, look askance or just ignore all this stuff.

> *We agree, and have argued extensively in the draft for the importance of clarity on the specific uses and users to be informed by a scenario exercise. This may include specific identified decisions to be informed, but may also include providing inputs for model runs that meet certain criteria, or more exploratory uses.*

4. Pg. 19, lines 22-29: The importance of independent, competent, third-party MSG assessment is brought to mind with mention of Stanford's Energy Modeling Forum. In its original guise EMF was created and funded to serve this essential role, and it did a pretty good job for a while when EPRI was still well funded and could "afford" to support things like EMF. I fear that in recent times the independent, competent, third-party functions have been neglected at EMF in the interests of being one of the climate change modeling players. There is a serious need to create and fund for the long term a couple of places whose only job is to assess and make transparent climate models. Requirements for comprehensive model assessment are not mysterious and have been around for more than 30 years. [More on this in Pt. #21, below.]

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[3] William Ascher, *Forecasting* (Baltimore: Johns Hopkins University Press, 1978); Martin Greenberger et al., *Caught Unawares: The Energy Decade in Retrospect* (Cambridge, MA: Ballinger, 1983); and Paul Craig et al., "What Can History Teach Us? A Retrospective Examination of Long-Term Energy Forecasting for the United States," *Annual Review of Energy and Environment*, vol. 27 (2002): 83-113.

The text discusses the role of simple standardized scenarios providing a basis for model inter-comparisons. In addition, we have included a discussion of the need for providing comparison, explication, and quality control as one of the functions to be performed by the proposed new scenarios capacity.

5. Pg. 26, lines 9-23: Humans are mostly left out of the climate change stuff, and this makes for some real problems. This is not news: "The social and behavioral sciences provide an essential but often unappreciated knowledge base for wise choices affecting environmental quality. These sciences can help decision makers of all kinds to understand the environmental consequences of their choices and the human consequences of environmental processes and policies, as well as to organize decision-making processes to be well informed and democratic."[4] In short, humans are the cause and humans suffer the consequences of a goodly portion of what passes for the "climate change" problem. So where in the world are the humans in the majority of climate change MSGs?

In scenarios created for some climate-change purposes, human behavior is aggregated into emissions trends and their socio-economic determinants. We argue that this is likely to be adequate for scenarios to serve some purposes, e.g., informing decisions about impacts and adaptation. But for scenarios to inform mitigation policy decisions, it may also be necessary for scenarios to stipulate alternative choices or actions by other important actors – e.g., for EU mitigation policy to consider what the US does. Present global-change scenario practice does not include any examples of the latter, but the draft argues that scenarios of this type – including alternative specifications of choices by identified major actors – may be crucial for informing mitigation decisions by national officials or firms.

6. Pg. 28, Section 2.6: I believe that this section may be the most important one in the entire report if the main purpose of the report is to improve the use of scenarios in the climate change arena. If my belief is correct, then why bury this stuff instead of giving it much greater prominence? A reorganization of the existing text might help here.

This has been done. The section in question now appears at the beginning of section 2. Sections 4 and 5 have been reorganized in parallel.

7. Pg. 30, lines 2-8: Here is a stab at identifying some truly consequential audiences for this work. Given the obvious fact that we have few if any global decision makers, doesn't

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[4] Garry D. Brewer and Paul C. Stern, eds., *Decision Making for the Environment: Social and Behavioral Science Research Priorities* (Washington, DC: National Academies Press, 2005): 1.

it make sense to ask who does make decisions that seriously affect climate? On just the business side alone, this question once posed and answered yields an interesting collection of prospects—most of whom are never thought about except as an evil "They" whose profligate behaviors need to be reigned in or punished somehow to save the world.[5] Actually, there are some very interesting and constructive possibilities to identify and factor into the business-as-usual climate change scenarios and models.[6]

> *We agree with the comment, which does not appear to require any changes to the text.*

8. General Comment at Section 3: You have an "apples and oranges" comparison problem that suggests a partition into two separate sections, rather than this one where everything gets crammed together. There are the mainline ("usual suspects") scenario-based models: IPSS, US National Assessment, UK CIP, and MEA. These should be grouped together and concluded with a crisp summary of their main, common, and useful aspects as well as their individual and collective limitations and weaknesses. There then follow a number of "Odds and Ends" or even "Odd Ball" studies: GBN, New York, Columbia River, Ozone, Gulf of Mexico, NAPAP/EMAP; and the insurance industry. This set needs rethinking. For instance you might add energy models, which makes a certain sense because you've already got ozone and sulfur (acid rain) models. There is lots of relevant experience in the energy realm, as I've pointed out in a couple of other comments earlier, and so this addition might be helpful. Alternatively you could get rid of ozone and sulfur entirely. If you did this I would suggest that you also collect out GBN and insurance and make this a separate section on business and the private sector. It would need some elaboration, but the importance of this sector in the climate change problem merits this treatment I believe. Andy Hoffman's excellent survey, referenced at #7 above, is a good place to fill in the blanks, and since Andy is a colleague of Ted's at Michigan, he might even be prevailed upon to add a couple of paragraphs specifically tailored to this report.

> *The section has been reorganized approximately along the lines suggested. The small specialized cases have been moved to text boxes within Section 4, leaving the four more extended treatments alone in Section 3.*

8. Pg. 41, lines 11-23: There is a common tendency for those heavily invested in and/or responsible for a specific model to begin thinking and acting as though the model is the world rather than being a simple, frail representation of highly selected aspects of the

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[5] While not alone in his demonization of business and business people, J. Gus Speth, *Red Dawn in the Morning* (New Haven: Yale University Press, 2005), is both representative and symptomatic.

[6] Andrew J. Hoffman, "Business Decisions and the Environment: Significance, Challenges, and Momentum of an Emerging Research Field," in Brewer and Stern, eds., *Decision Making for the Environment*, op. cit.: 200-229.

world. The problem is clearest when lots of time and energy get invested in one or a few (four or less, again) scenarios or stories and where these scenarios depend heavily on lots of data that in turn depend on computer models. The problem, in short, is "the model is right, the world is wrong." It also allows competing technical and professional egos to play a greater role than is healthy in these analyses. The "God" problem of those who perform the control function in simple, free-form, scenario-based crisis games that I mentioned earlier is alive and well in the climate change world.

> *The draft discusses this issue in considering uncertainties in scenarios, and also in the discussion of the predominant influence of quantitative models in determining the contents of scenarios in the SRES and US National Assessments.*

9. Pg. 42, lines 16-23: This may be one of the most important paragraphs in the entire report. It merits more prominence—probably in the executive summary and also in the concluding comments.

> *This issue is highlighted more prominently in the revised draft, and called out in the conclusions.*

10. Pg. 44, section on "Clarity about Uses": The point is that increasing the number of participants in these exercises also increases the number of possible uses and misuses of the MSGs. I actually worried a great deal about this matter years ago for military and urban settings, but my concerns have been lost with the passage of time and especially for those who are rediscovering the issue in the climate change arena. Too bad, as it need not be so.[7]

> *The revised draft has separate discussions of the managerial difficulties involved in increasing the number of participants in scenario exercises, and the related problem of the difficulties that follow from increasing numbers and diversity of intended uses and users.*

11. Pg. 46, line 12: Consistency of terminology. Earlier GCM was defined as *Global Climate Models*, which I found strange (pg. 21, line 38, and elsewhere.) I thought it meant General Circulation Models, as is the case here. Perhaps consider a Glossary of Terms?

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[7] Garry D. Brewer, "Some Costs and Consequences of Large-Scale Social Systems Modeling," *Behavioral Sciences*, vol. 28, no. 2 (April 1983): 166-85; and Brewer, "On Duplicity," *Simulation*, vol. 34 (April 1980): 140-43.

The terminology for GCMs has been made consistent, and the revised draft has been scrubbed for explanation of acronyms and technical terms at first use. A glossary of terms has not been added yet, but is being considered for the final published report.

12. Pg. 50, lines 14-18: The gross deficiency of socio-economic and human dimensions in climate change modeling is noted here, yet again. It is a key, central, critical (what else can I say?) limitation of all the technical stuff that passes for analysis in this field. Humans are the cause and humans suffer the consequences. So where are the humans?

See response to comment 5 above. Some elements of human behavior are represented in scenarios, although there are many uncertainties and weaknesses in the representations. Other aspects of behavior, particularly the strategic choices by other identified actors, have not yet been considered in climate-change scenarios, and the draft presents some proposals regarding how these might be used, to what benefit.

13. Pg. 51, line 18 through pg. 54, line 31: This pretty much sums up the core problem with climate change studies and analyses in a couple of pages. So why bury it in the middle of a 133 page report?

The implications of this material are treated more prominently in the revised paper.

14. Pg. 62, starts line 5 "Concluding points on MEA": If one were to devise the worst possible way to do a study the MEA would be it.

The report is quite critical of the approach taken in the MEA, but also seeks to keep a focus on positive lessons for future scenarios practice, not excessively harsh criticism of past exercises.

15. Pg. 63, GBN illustration: (See previous comments about restructuring all of Section 3.) Andy Marshall created OSD Net Assessment in about 1974 and he still directs it some 30+ years later. He was a central war gamer at RAND in the 1960s and early 1970s, and he took what he knew about worst-case strategic analysis with him to the Pentagon. In the national strategic, nuclear realm there is a very high priority of this particular form of analysis. Not to prepare for the worst case and then to lose a war as a consequence is simply unacceptable. It is not clear to me that climate change is similarly burdened.

The revised draft includes more extensive discussion of worst-case analyses and interprets the GBN exercise in this light.

16. Pg. 80, Section 4.0: My previous question about possible audiences for the report looms large in this section. Parts of the draft are technical and designed for modelers, others are "text-bookish" and possibly aimed at students, and a few other parts are possibly of relevance and interest to "decision makers," although various kinds of them are not identified. [Pg. 97, lines 12-44 is a pretty good start for this last audience, generally speaking.]

We agree. The revision of this section has cut the elementary pedagogic material, to focus more consistently on the two identified audiences.

17. Pg. 98, lines 10-11: Your own ambivalence about inclusion of acid rain and insurance shows up at this point. You need to think about and then resolve the inclusion/exclusion of examples question for Section 3.

This has been resolved in the revisions. The draft retains these two cases, but relocates them as text boxes near discussion of a relevant issue in Section 4.

18. Pg. 99, lines 26-35: "Who should be involved?" is a huge question. Those efforts that involved a "cast of thousands," e.g., MEA, were a mistake obviously. Those efforts that were one-time, define the world and give three examples (scenarios) did not fare much better. What we have not seen so far is a dedicated group that is constituted and guaranteed funds for the long-haul of say 20-50 years to do this kind of work. The Energy Modeling Forum had some desirable characteristics, especially in the first decade of its existence, and it may be a good prototype upon which to design and construct something in the climate change arena. [Discussion on pg. 101, lines 16-27, flirts with some of the generally misunderstood and disastrously handled management issues.]

The revised conclusions stress the need for such an institutional capacity to review, compare, and critique scenarios.

19. Pg. 104, lines 4-14: The managerial issues related to scenarios may well be among the most important and under-appreciated of all the things you talk about in this report. There are some "lessons learned" in the community now, mainly learned the hard way and through trial and error, not by connecting to other previous experiences in other subject matters and fields. Incidentally, where does one go to learn how to design, run, assess, or manage scenario-based analyses? Those who do it have learned by the seat of their pants. As far as I know, there has been little effort to collect, codify, and then con-

vey these lessons to the current and upcoming generations of climate modelers. Naki and Arnulf Grubler learned this stuff mainly by hanging around IIASA when there was still a strong RAND influence on the institution. They did not learn it in a European university. So where would the current and aspiring generations of climate change analysts learn their trade?

The revised conclusions and recommendations address these points extensively.

20. Pg. 104, line 41 through pg. 105, line 5: The normative uses of scenario-based models, simulations, and games (MSGs) finally get recognition, almost as an after thought, on pp. 104-05. As I stated at the onset, this may in fact be the most important use of all given the complexity, values stakes and conflicts, scope, sweep, and scale of the climate change problem.

The revised draft gives more extensive discussion of normative scenarios and their distinction from the other cases we discuss.

21. Pg. 105, lines 15-21: The scenario assessment requirements are not any different than those required to evaluate and improve models, simulations, and games used for other kinds of applied problems. There are distinctive theoretical, technical, ethical, and pragmatic norms and standards to be applied in any case. That they seldom are is partly explained by the lack of communication that has historically existed between practitioner groups responsible for different substantive problems—such as urban, military, energy, and more recently environmental ones.[8]

The revised conclusions stress the importance of critical comparisons and development of scenarios methods.

22. Pg. 113, line 43 through pg. 114, line 3: State the obvious here. There is no global authority to make climate change decisions. Furthermore, the standard political cost-benefit calculus militates against and even prevents those having less-than-global range in responsibility to be disposed to taking the kinds of actions climate modelers and analysts want them to take. The political cost-benefit calculus: "Benefits now, for my constituents to be paid for later by someone else."

The revised draft makes this point.

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[8] G. Brewer, *Politicians, Bureaucrats and the Consultant: A Critique of Urban Problem Solving* (New York: Basic Books, 1973); G. Brewer and Martin Shubik, *The War Game: A Critique of Military Problem Solving* (Cambridge, MA: Harvard University Press, 1979).

23.   Pg. 122 and on, "Literature Cited": This relies heavily on a set of current technical studies where scenarios are sometimes hardly the topic at issue. The reference list is very thin on scenarios, scenario methods, model evaluation and use and closely related topics—especially when one realizes that these kinds of activities have been going on, often for years, in fields not linked to climate change. The lack of linkage in no way diminishes the usefulness or importance of what has been learned elsewhere.

    In the revision, both the text and the references cited have increased treatment of scenario methods and related topics.